Energy Education and Technical Assistance for Industrial Facility Managers: Assessing Benefits and Energy Impacts

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ABSTRACT

Educational and technical assistance programs for facilities managers have proved very valuable for improving energy efficiency in buildings. Efforts like the Building Operators Certification program have trained thousands of facilities managers in the application of efficient technologies and methodologies. These efforts however have focused on building systems that are common to both commercial and industrial buildings with the main focuses relating to HVAC and lighting systems. While the energy usage for most commercial buildings is predominantly governed by these systems, industrial customers spend the largest portion of their energy budget on industrial processes. For this reason, energy efficiency education and technical assistance focusing on industrial processes has the potential to reap large benefits for the end user, efficiency program operators, and the public at large.

This paper will first briefly outline the industrial processes and facility systems that are large consumers of electricity and fossil fuels in industrial facilities. We will discuss key elements of industrial energy use, articulating how energy use in industrial plants differs from a typical commercial facility operation.

For industrial facilities, we will discuss several different education and training concepts, and we will also investigate the concept of comprehensive, educationally oriented energy audits and feasibility studies as a component of energy education. Our paper will discuss various models for educational efforts and their applicability to the industrial environment. For these endeavors, concrete examples of the potential energy and demand impacts will be provided. Mini case studies will be presented that illustrate the effect of the educationally-motivated changes of operational practices on both efficiency and productivity.

The proof of energy efficiency savings is often required for participation in efficiency programs supported through systems benefit charges. This paper will discussed the relationship between facility management education and technical assistance with efficiency results.

Introduction

The authors of this paper have had a long standing belief that there is true benefit to be had through development of program elements that educate and inform customers and end users, whether they are managing commercial or industrial facilities. Further, we believe there is a dire need for energy use and efficiency information by facility and plant management, and that their decision making processes would result in more effective use of energy resources with the proper information.

Based on our discussions with many in the industry, and our observations of an increased prevalence of training, circuit rider, and other technical assistance programs, we believe there is an industry-wide consensus that such programs do work. Thus, we must ask the question, "What does it really mean that these training and technical assistance programs are working?"

Fundamentally, it must be concluded that if training of facility managers is working, then there must be real, measurable energy savings or demand impacts that have been achieved. Finally, if impacts of education and technical assistance are measurable, then we should be able to differentiate between those educational and training endeavors that work well and those that have minimal impacts.

We do want to note that in this paper we have applied a broad definition of education, including formal training courses, expert technical assistance provided to facility managers or other markets actors, circuit rider sessions, and also energy audits and studies that are comprehensive and include training elements.

This paper is intended to be a first step in defining the value of energy efficiency education. We discuss the benefits and values of these efforts, which we believe have been instrumental towards changing practices among industrial plant managers. Clearly, while our focus here is on the industrial sector, similar claims can be made for the commercial sector. It is our hope that subsequent research efforts and evaluation work will be targeted towards accurate quantification of the impacts of a diverse range of educational and technical assistance endeavors, and will ultimately provide program managers with information that helps increase the value of these initiatives.

How Industrial Buildings Are Different

Industrial buildings and commercial buildings together are typically considered one sector by the developers of energy efficiency programs, including training programs. However, the buildings are quite different in their energy usage profiles, as the dominant energy usage is dedicated to the production of products, and not to the comfort of the occupants. Commercial buildings receive only a small percentage of their internal heat gains from equipment not intended for space heating, with computers, convenience refrigeration, and other plug loads contributing only a relatively small amount of heat to the space. Industrial buildings receive a far greater amount of heat from process equipment that is not intended, nor controlled, for space heating. Depending on the processes involved, a typical industrial building might receive 50 – 200% of its space heating requirements from waste heat generated by process equipment. Given this situation, even in the coldest climates, many industrial buildings experience year-round space cooling loads.

Commercial Buildings:

- Primary energy consumption: HVAC and lighting loads
- Heat gain associated with occupants, lighting, solar gain
- Seasonal cooling loads

Industrial Buildings:

- Primary energy consumption: Process loads such as Compressed air, motor loads, process heating and cooling
- Heat gain associated with process equipment
- Year-round cooling

Figure 1 presents an electrical end-use pie chart for a representative medium size office building in New England. Figure 2 and 3 illustrate the actual electrical end-use breakdown for two New England manufacturing facilities. The last chart (Figure 4) illustrates the end-use breakdown for natural gas for a traditional manufacturing facility in Ohio.

Figure 1. Electrical Energy Use Breakdown for Current (Computer Intensive) Commercial Office Building

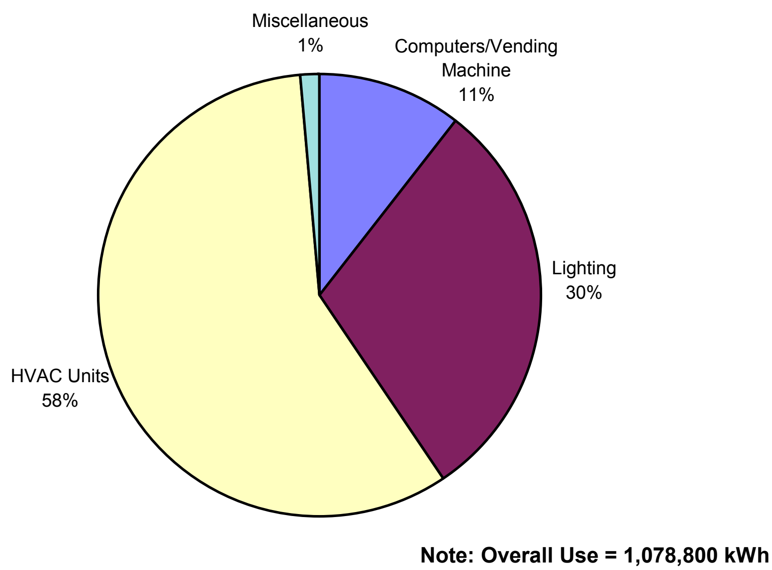


Figure 2. Electrical Energy Use Breakdown for High Tech Manufacturing Facility (Sapphire Crystal Growth Operation)

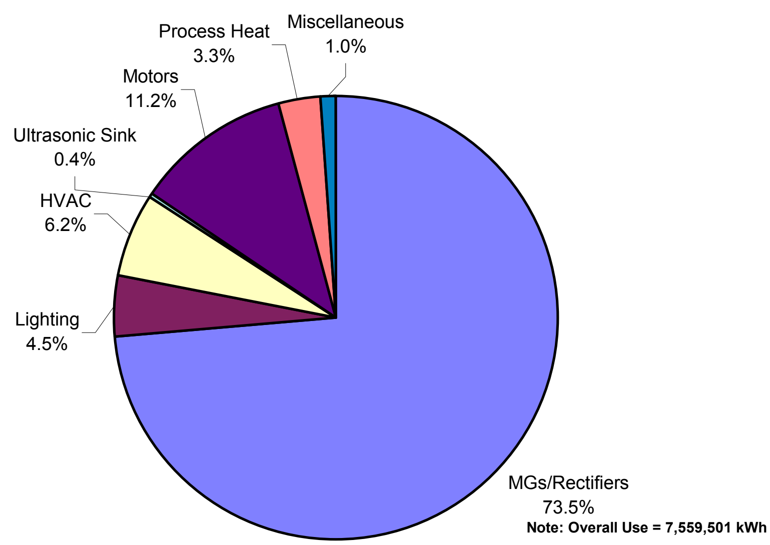


Figure 3. Electrical Energy Use Breakdown for Injection Molding Manufacturing Facility

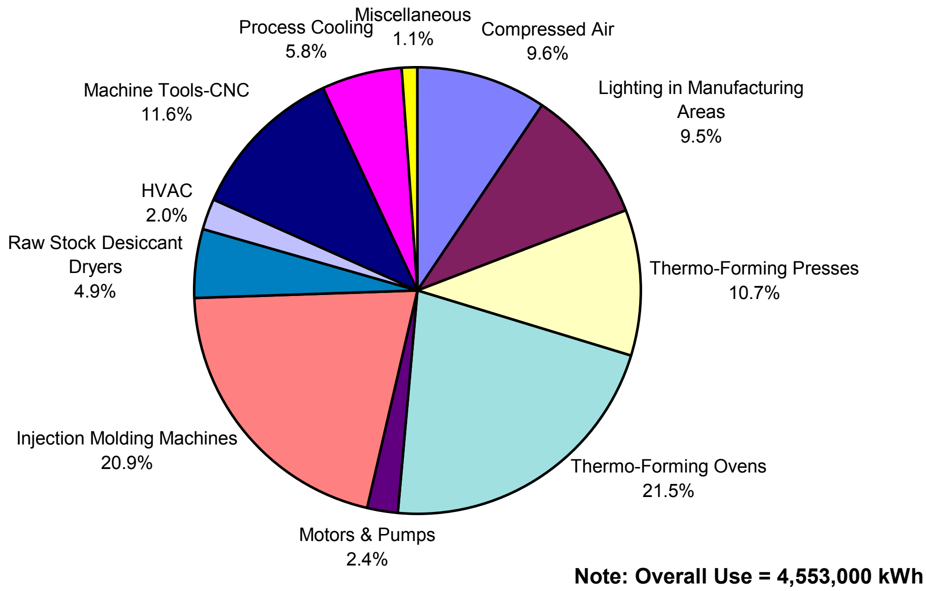
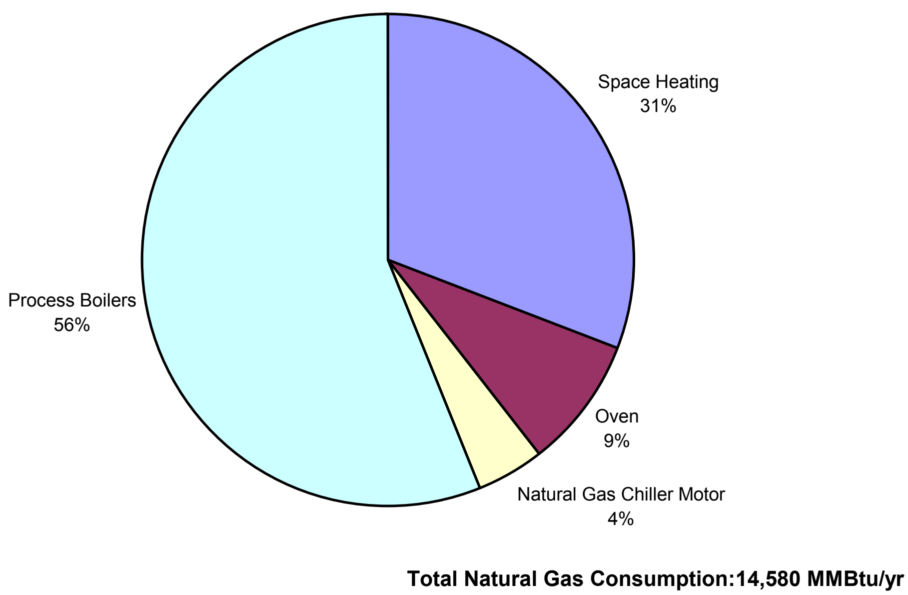


Figure 4. Natural Gas Use Breakdown for Manufacturing Facility



Industrial Facility Energy Efficiency Opportunities

Consistent with the end use breakdowns shown above that demonstrate that industrial facilities use energy very differently than typical commercial buildings, the energy efficiency measures for industrial sites are uniquely different. Measures may fall into several categories, as follows:

- ❑ **Crosscutting Process Systems and Technologies** – Such measures are associated with systems that can be found in many industrial facilities, such as compressed air, process heating, process cooling, refrigeration, process motors and drives, pumping and fan systems, steam systems, and materials handling equipment.
- ❑ **Process Specific Technologies** – Measures associated with this category are associated with highly specialized processes, which could include injection or blow molding for plastics manufacturing, melting systems for foundries, refining systems for pulp operations, crushing equipment for the stone and gravel industry, etc.
- ❑ **Facility Systems** – This category predominantly addresses facility lighting and space conditioning. Here, there are many similarities to commercial buildings, but there are frequently specialized illumination, temperature, or humidity needs for industrial spaces, and this can make technologies, usage, and measures very different than commercial buildings.

As these broad technology and measure categories indicate, the diversity of measures for industrial facilities can be far greater than in commercial buildings, and facility and energy managers for such properties must have a broad range of knowledge in order to effectively manage usage and costs.

Education Programs Introduction

Educational programs have been common throughout the history of the energy efficiency and demand-side management industry. Such programs have addressed a wide variety of topics:

- ❑ Training on Specific Technologies
- ❑ Enhanced Operation for Energy Systems
- ❑ Fundamentals of Energy Use and Efficiency
- ❑ Energy Code Requirements
- ❑ Relationship Between Energy Efficiency, Productivity and Operations

There have been many key reasons that have motivated the development and delivery of such programs. Clearly, it has been the hope of the energy efficiency industry that a better educated, more informed industrial facility manager, will be likely to adopt energy efficient operational practices and to choose to install premium efficiency systems, either on a retrofit basis or for new system installations.

Educational and Technical Assistance Models

Several training program models were considered for developing a template for industrial facility training programs. The authors looked to programs that successfully train working professionals, rather than programs of a more academic nature. We also found that there were several programs within the broad field of energy efficiency that could provide model operational structures for industrial facilities management programs. The programs that provided the best insights were:

- The Building Operator Certification Program
- The Compressed Air Challenge
- Massachusetts Energy Code Training and Circuit Riding Program

Building Operator Certification Program

The Building Operator Certification (BOC) program was developed by the Northwest Energy Efficiency Council (NEEC), as a program to train and certify building operators in the efficient operation of building systems. The program is designed for the professional working in the field and stresses the practical aspects of building system operation and optimization. The program operates in 16 states: in the Northeast, the Midwest and on the west coast. The Northeast Energy Efficiency Partnership NEEP offers the program throughout the Northeastern United States.

Participants earn certification by attending live training sessions, completing project assignments in their facilities, and passing examinations for each technology topic. Training topics include: electrical systems, HVAC and lighting systems, indoor air quality, environmental health and safety, and energy conservation. Utility companies and government administered efficiency programs often sponsor the training programs or sponsor individual attendees. In addition to focusing on energy efficiency, compliance with environmental regulations, and building occupant comfort and safety are integral parts of the program.

The instructors for the program are selected from professionals who are working in the appropriate field, rather than relying on academia. The practical aspects of facility management are stressed and instructors and students are able to share "real world" experiences to facilitate the learning process.

Certification is offered at two levels: Level I emphasizes energy efficient building systems maintenance, while Level II focuses on equipment troubleshooting and advanced systems design.

Level I courses cover the fundamentals of building system design and conservation techniques with individual courses in HVAC, lighting, code requirements, electrical, and indoor air quality. Presently advanced level II courses are offered in the following areas: preventive maintenance and troubleshooting; electrical; HVAC; lighting; energy auditing; indoor air quality; motor systems; water efficiency. Certification is offered separately for each of the levels.

Compressed Air Challenge

The Compressed Air Challenge (CAC) is a multifaceted program that strives to improve the efficiency of compressed air systems through educational efforts that target both general awareness of the true costs of compressed air and the technical training of compressed air vendors and facilities operators. The program also participates in the development of software tools and published manuals that focus on efficient compressed air operations.

The main sponsor of the CAC is the United States Department of Energy; Office of Industrial Technologies with additional sponsorship supplied by electrical utilities and government operated efficiency programs.

Like the BOC program, the Compressed Air Challenge offers two levels (Fundamental and Advanced) of training and certification. A series of training seminars have been developed for each level to provide guidance for the evaluation of compressed air systems and ultimately reduce operating costs. In addition to energy efficiency, the program strives to improve productivity, product quality, system reliability and business competitiveness through improved compressed air system operations.

The Fundamentals Session is a one-day workshop that provides an introduction to compressed air system operation and efficient system management. It is specifically designed to expand the technical background of compressed air system operators and system vendors. The Advanced Workshop is a two-day event introducing in-depth technical information on modern state-of-the-art compressed air systems; troubleshooting strategies; system enhancements; and the use of diagnostic tools.

The training sessions are conducted by experience compressed air system practitioners who focus on teaching practical techniques that attendees can put into practice at their facilities. The sessions are somewhat informal in nature and the instructors encourage student participation and actual experiences with compressed air systems. Unlike most compressor vendor sponsored workshops, the CAC emphasizes a total systems (both air supply and demand side) approach to compressed air, rather than simply focusing on the replacement of compressors and major related components.

In addition to the two courses described above, the CAC offers training in the use of AirMaster+ software. AirMaster+ is a Windows-based software tool used to analyze industrial compressed air systems for efficient system operation and allow the modeling of proposed efficiency measures. The 2 & 1/2 day training program includes classroom instruction, a practical exam testing hands-on measurement, and a written exam. Participants who pass the exam are recognized by the DOE as Qualified AirMaster+ Specialists.

Massachusetts Energy Code Training and Circuit Riding Program

During 2002 through early 2004 the Commonwealth of Massachusetts, funded by a DOE grant, offered a combination of formal classroom training sessions and "circuit riding" sessions in support of the newly enhanced Massachusetts Energy Efficiency Code (Chapter 13 of the Building Code). The training efforts were designed to assist the building design & construction community (architects, engineers, designers, contractors, vendors and code officials) in understanding the new code provisions and learning practical methods for designing and building code compliant buildings that performed as intended.

The entire program was designed around "peer-to-peer" instruction and guidance. In their wisdom, the program directors hired architects, engineers, and lighting designers as instructors rather than rely on code officials to provide the instruction. The result was a highly desirable "give and take" that both the instructors and participants were comfortable with.

The formal training was conducted first and was a prerequisite for participation in the circuit riding efforts. The training was broken down into 3 half-day sessions: building envelope; electrical and lighting; and mechanical and HVAC systems. The sessions were taught classroom style utilizing PowerPoint presentations as the main learning tool.

Circuit riding is a term that was coined to describe the practice of clergy traveling by horseback to various jurisdictions to conduct services. Small towns could not afford to hire a full time priest or minister, so a regional preacher traveled a circuit to spread the gospel. The circuit riding sessions in support of the Massachusetts Energy Code were scheduled with firms that had attended the formal training sessions. A team of architects, engineers, and lighting designers traveled the circuit assisting firms with energy code issues that were project or sector specific.

The circuit riding sessions were a very successful element of the training effort, as it was discovered that a majority of the firms lacked an understanding as to how the energy code could be best applied to their particular specialty or building techniques. Time and again it was found that professionals who had attended the formal training sessions were misinterpreting the code when it came to incorporating the code mandates in their own designs.

Educational Model Conclusions

All three of the models contain elements that would be valuable inclusions in an educational effort directed at making industrial buildings more efficient. The BOC with its emphasis on practical applications avoids the pitfall of facilities managers feeling that they are learning theories that they will never put into practice. The Compressed Air Challenge effectively mixes the impacts of compressed air systems on overall energy costs with practical methodologies for improving system operations. However, industrial facilities are so diverse in their operational characteristics that we feel that the combination of formal training and circuit riding that was used by the Commonwealth of Massachusetts is the ideal model for implementing and educational effort for the managers of industrial facilities.

Industrial Energy Audits and Site Assessments as Education

Traditionally, during the earlier days of the energy efficiency DSM industry, comprehensive energy audits or industrial facility feasibility studies did a highly effective job at providing the facility manager with an understanding of usage patterns and general efficiency opportunities. Unfortunately, many of these early audits were too general to serve as effective support for industrial site management that would like to pursue implementation of cost effective projects.

Frequently, the typical efficiency program audit approach today tends to be focused on getting one or two projects installed. Often they are highly focused on a single project that is of immediate interest to the facility. Such efforts really have no focus on educating the facility or plant management, nor any real motivation to alter long-term practices.

In contrast, appropriately developed comprehensive energy studies and audits, integrating educational efforts, provide a path towards long term energy planning, and facilitate immediate implementation of key projects.

Introduction: The Audit Process as Education

The progressive and comprehensive, educationally oriented energy audit is part of an overall process that is intended to progressively change practices associated with energy use and adoption of efficient practices. Primarily the audit is developed to include sections that effectively explain the baseline patterns of usage and the rationale for installing systems and changing practices. As such, there are explicit, quantified information that supports the development of new projects, both immediately and as upgrade opportunities become apparent. The process includes interim and final presentations to both facility and corporate management, and focused trainings for plant staff that serve to better communicate key findings in the report. Key features, include:

- **The High Quality Educational Audit** – The energy audit in question is comprehensive, discussing in detail usage by all end use systems and the use relative to similar facilities, presenting a master plan for progressively reducing energy use over a multi-year period, and also providing specific plans for projects that can be acted on immediately.
- **Use of the Audit as an Educational and Planning Tool** – The audit must be coupled with other services that help put plant management on the path towards better practice. Audit report should become bookshelf fixtures that do not have value, but serve as real guides for improved energy use and better energy and facility productivity.
- **Follow Up Education and Support** – The support provided to the facility must not stop at the conclusion of a final presentation. Rather, a network of consultants, trainers, vendors, and other market actors, should be offered to the customer to support their initial and progressing steps as they act in a more energy conscious manner.

One example of a comprehensive educational audit process, focused on industrial facilities, is the US Department of Energy's Plant Wide Assessment (PWA) Program. The PWA program provides very comprehensive energy studies for highly energy intensive facilities. Studies describe current usage patterns, and articulate immediate and long term savings opportunities focused on energy efficiency, but also addressing productivity, waste minimization, and improved environmental practices. An additional key feature of the PWA studies are their address of replication potential. This considers the specific possibility of energy savings that may be achieved through similar projects and measures in like facilities, both in the corporate network and throughout the industry.

Case Studies Illustrating Education Benefits

The following case studies illustrate three different educational efforts and the impacts and accomplishments of those endeavors. It is a potentially difficult task to accurately quantify the energy and demand achievements of such educational and training programs. As these case study discussions show, we are confident that a properly focused evaluation of such programs demonstrate the resultant value and impacts of energy education for industrial facility management.

Case Study 1 - Efficiency Maine Compressed Air Training

As the technical consultants for the programs operated by Efficiency Maine (a governmental organization established by the Maine Public Utilities Commission), ERS designs and delivers many training sessions for Maine commercial/industrial electricity consumers. These trainings include general efficiency concepts, premium efficiency lighting, HVAC, compressed air, and others. This section of the paper will focus on compressed air training that is performed for Efficiency Maine's industrial customers.

Efficiency Maine offers no prescriptive incentives for compressed air measures. The program has been established this way because energy savings associated with compressed air systems are highly dependent on the process the air is utilized for, the manner in which the system is controlled, and other site-specific factors. Because of the custom nature of compressed air measures, Efficiency Maine decided to provide technical training for compressed air vendors and compressor operators.

The training sessions are segmented into two components: a classroom presentation and an in-plant session at a customer site.

1. **Classroom Session –** The focus on the classroom session is to look at compressed air plants as a system, rather than focusing only on the compressor itself. The topics covered include: the cost of compressed air; compressor types and their applications; dryers & filters; air storage; determining correct working pressures; ultrasonic leak detection and repair; and system controls.
2. **On Site Session –** A site is selected from session attendees that would like to explore specific compressed air issues at their facility, and the class visits the site discussing problems, opportunities and recommendations.

It has become clear from these sessions that specialized knowledge of compressed air systems is absolutely necessary if operators are to cost-effectively maintain system efficiency. The BOC program cannot practically incorporate compressed air training and training provided by compressor vendors, understandably focuses heavily on the compressor replacement and other important, cost-effective measures are overlooked. It is not uncommon for new larger compressors to be installed in facilities that suffer from leaking distribution systems, poorly maintained dryers and filters, and insufficient air storage. The Compressed Air Challenge certainly offers excellent training in this area, although it targets both compressed air vendors and facilities personnel. Due to time and expense, typically one staff person, at most, attends the course. The specialized training offered by Efficiency Maine seeks to hit the topics of the Compressed Air Challenge that are most valid for the attendees in a concise, cost-effective manner that encourages broader attendance.

Case Study 2 - Premium Audit with Training Session - N.H. High Tech Manufacturing Firm

This case study involves a project that combined a technical assistance study with training for the facility personnel. The client is a leading manufacturer of computer components and performs plating, etching, and assembly operations at the facility in question. The study focused on electrical consumption with the annual consumption for the facility averaging 8 million kWH per year with a peak demand of 1,500 kW. This relates to just under $1 million dollars per year in electrical costs.

This project began with an initial inventory of the electrical consuming equipment and initial research into possible measures for implementation. Following the initial investigations, a training session was held at the facility. The session was conducted by the ERS technical staff and the client’s Director of Facilities. The training session included the following topics:

- ❑ Overview of the facility energy use breakdown
- ❑ Compressed air basics and leak detection
- ❑ Building automation system software demonstration
- ❑ Energy usage in plating operations
- ❑ VFD basics
- ❑ Pollution control equipment
- ❑ Interactive discussion on specific facility issues/problems

Following the training session, ERS staff further investigated plant operations and made recommendations for efficiency measure implementation. Some of the measures recommended and their implementation status included:

- ❑ Reduce Compressed Air System Pressure - **Implemented**
- ❑ Repair Tagged Compressed Air Leaks - **Implemented**
- ❑ Install Additional 440-Gallon Compressed Air Receiver Tank – **Not Implemented**
- ❑ Replace/Fix Malfunctioned Variable Frequency Drives on HVAC Units - **Repaired**
- ❑ Monitor Plating Tanks for the Control of Fume Scrubber VFDs - **Implemented**
- ❑ Install VFDs on Cyclone Dust Collection Systems - **Implemented**
- ❑ Replace Metal Halide Fixtures with Fluorescent Alternative – **Pending Renovations**
- ❑ Replace Indirect MH Fixtures with Fluorescent T5 Indirect Fixtures - **Implemented**
- ❑ Install New 60-HP VFD Compressor with New Sequencing Strategy - **Implemented**

The above outlined measures represent a diverse collection of building operation measures and manufacturing process measures. With traditional building operator (BOC) training, facility personnel would certainly be prepared to tackle the HVAC and lighting measures. However, the process measures would likely go unnoticed and unchanged. This would result in an implemented project that ignored the items that produce the most energy savings, and likely have the greatest positive effect upon productivity. The combination of industrial specific training and technical assistance allows for all efficiency measures to be discovered and evaluated.

Case Study 3 – Premium Audit with Training – Osram/Sylvania Manufacturing Facility

This audit was performed under the U.S. DOE's Industries of the Future program. The program funds "Plant-wide Assessments for Targeted Industries. The targeted industry was glass manufacturing and the subject of the assessment was a lamp manufacturing facility owned and operated by Osram/Sylvania. The study targeted energy and resource efficiency measures (EEMs), and productivity improvements, addressing the industrial processes associated with the manufacturing lines and with cross-cutting technologies such as compressed air systems, lighting systems, motor & drive systems, and HVAC. The facility produces about 25 million lamps per year, consuming over 5 million kWH annually. The facility is also a large consumer of natural gas.

ERS considers facility operator training to be an integral part of plant-wide assessments as well as other premium audits. Early in the process, the relevant facility staff are identified for each process being assessed, and the audit/assessment is conducted in a participatory manner. Experience has taught us, that the implementation rates for proposed efficiency measures is much higher when plant personnel fully understand the measures and have participated in the assessment process. Additionally, persistence for the measures is also greatly improved.

Twenty-One (21) EEMs were recommended for implementation, including:

- ❑ Tag and Repair Compressed Air Leaks
- ❑ Install Blower Systems and Solenoid Valves at the Extruders
- ❑ Install VFD Controls on Process Cooling Pumps
- ❑ Reclaim Exhaust Heat from the Resize Area for Preheat Air

- Install Differential Pressure Based Pulse Control on Bag Houses
- Install New Smaller Compressors Following Efficiency Improvements

The calculated potential energy saved with the 21 measures is as follows:

- Electrical Consumption 1.3 Million kWH
- Natural Gas Consumption 5.9 MMBTU
- Annual Cost Savings $ 560,000.
- Estimate Project Cost $ 1,450,000

Implementation of some of the measures has begun, and the plant managers have recommended the remaining measures to national management for internal funding.

As a result of the combined training and auditing process, the facility operators fully understand the process measures and are comfortable with the projected results. No traditional training program could possibly focus on the specific processes involved at this facility. The PWA program allows a unique yearlong opportunity to focus on efficiency measures and operator education.

Conclusions and Recommendations

As we have clearly attempted to convey throughout this paper, education and technical assistance for the facility managers of industrial and manufacturing operations can and does provide a valuable impetus for changing practices regarding energy efficiency and implementation of technologies that enable more effective use of energy. As previously stated, we consider this paper to be a first step in an industry dialog intended to quantify energy and demand impacts of education and technical assistance, and to identify approaches for education initiatives that work best. As described qualitatively, we believe we have identified some programs that have demonstrated remarkable levels of success. The following points articulate actions that we believe should be taken to further the quantification of best approaches and their impacts.

1. **Education and Technical Assistance Evaluation** – In order to substantiate the savings benefits and impacts associated with education and technical assistance programs, impact evaluations should be conducted. To date, evaluations of these programs have largely been process evaluations, which have had no focus on energy or demand impacts, or have been anecdotal assessments, that are less defensible.
2. **Identification of Best Practices –** While there has been much recent activity intended on identifying best practices for energy efficiency incentive and market transformation programs, these efforts have not focused on education, training, and technical assistance. It would be invaluable to identify the characteristics of programs that have succeeded at impacting industrial energy efficiency.

3. **Incorporate Training Efforts into Audit and Commissioning Programs –** Our work as efficiency trainers, technical assistance auditors, and system commissioners has demonstrated that technical assistance that incorporates training for facilities operators show much improved measure implementation rates. Utility and government funded efficiency programs should make measure specific operator training a mandatory part of audit and commissioning programs.

With the above recommendations, the energy efficiency industry will be in a much better position to truly assess the effectiveness of the program elements and approaches under consideration. This will then facilitate enhanced efforts, with optimized energy efficiency education, training, circuit riding, and technical assistance, enabling facility and plant managers to most effectively act to reduce energy use and lower demand in their industrial operations.

References

Best Practices for Compressed Air Systems, William Scales, PE and David McCulloch, E.Eng. MI Mech, 2004 The Compressed Air Challenge

Air Master + Software and Instruction Manual, 2000, Washington State University Department of Energy *Industries of the Future Final Report on Osram/Sylvania,* 2004 – Yogesh Patel and Satyen Moray, Energy and Resource Solutions

Technical Assistance Final Reports 2004 ERS/Public Service of New Hampshire – Mark D'Antonio, Satyen Moray, Dan Birleanu, Energy and Resource Solutions

Efficiency Maine *Technical Training 2004 Final Report* – Mark D'Antonio, Energy and Resource Solutions

Building Operators Certification Manuals - Northwest Energy Efficiency Council