Powering Up Existing Tools to Accelerate Efficiency in Industry

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ABSTRACT

Recent studies identify the potential for energy efficiency in industrial sectors at greater than 20% of current consumption, and yet the barriers to energy efficiency remain high at most facilities. Innovative programs, such as the DOE's Save Energy Now and Superior Energy Performance programs, the U.S. Navy's Resident Energy Manager program, and the Northwest Energy Efficiency Alliance's Continuous Improvement for Industry program, seek to overcome these barriers. The most successful programs build upon factors that have been identified by highly energy efficient companies. This paper compares these programs and their achievements with these success factors, which provides a basis for assessing effective directions for accelerating industrial energy efficiency. The paper presents conclusions based upon a review of early results and indicators from innovative and typical utility custom programs, as well as emerging codes and standards, both for equipment and energy management.

Introduction

Industrial energy efficiency historically has not been getting its fair share of attention from energy efficiency programs. Industrial energy is estimated to be 32% of energy usage nationwide (Quinn 2009) in the U.S. and energy efficiency potential savings have been estimated at more than 20% by 2020 (McKinsey 2009). Yet, most of the state and utility energy efficiency programs have focused on the easier-to-address commercial and residential sectors (Electric Power Research Institute 2009). Moreover, codes and standards have been developed for appliances and equipment for residential and commercial sectors, but few of these are relevant for industrial applications or equipment sizes (Waide 2010).

A number of national and regional programs are available for the industrial sector. This paper provides an overview of a range of programs, and then considers successful aspects across these programs, as well as what may be missing.

Industrial Sector Priorities and Barriers

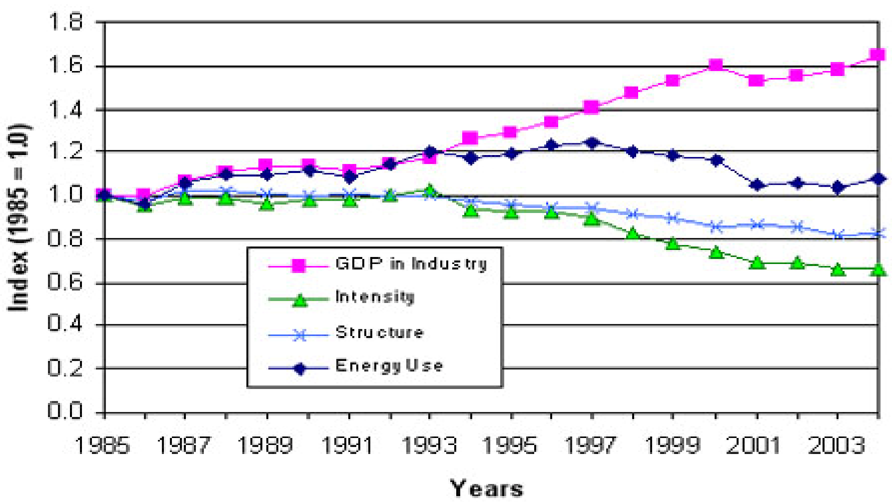
The priorities of the industrial sector need to be recognized before considering their energy efficiency. Based on the author's thirteen years of production management experience, the goal for plants is to produce products, while meeting internal and government requirements for production throughput, quality, safety, environmental and consumer protection, and cost-effectiveness. Even in energy-intensive industries, the priority for energy efficiency will nearly always take a back seat compared to quality, safety, regulatory, production and internal goals. In order for energy efficiency activities to make it to the top of the priority list, the advantages need to be clear, savings significant and implementation considered to be low-risk, compared to potential impacts to safety, regulatory compliance, product quality or production rates.

Energy managers and facility managers have identified barriers to energy efficiency in their organization. Common barriers include (Allyn and Brockway 2010), (Prindle 2010a):

- Lack of sponsorship of energy efficiency at all levels (executive, management, supervision, team)
- Organizational disconnects: responsibility of energy efficiency, communication of energy efficiency priority across the company
- Employee awareness and involvement
- Allocation of capital and staff
- Risk-averse approach: justification of projects
- Lack of staff time/expertise to develop projects
- Lack of knowledge of energy efficiency improvements

Despite these barriers, industry has been making major reductions in energy use and energy intensity, with energy intensity reductions at over 30% in 2004 compared to 1994 (U.S. Department of Energy, Industrial Technology Program, ITP webinar Sept 2, 2010). Energy intensity is generally defined as a measure of energy consumption per unit of production or per economic output. Thus energy intensity takes into account swings in production from year to year, and provides a more accurate barometer of savings achieved than the raw difference in energy consumption year to year.

Figure 1. U.S. Trends in Industrial Energy Intensity Delivered Energy 1985-2004



Source: U.S. National Academy of Sciences. 2010

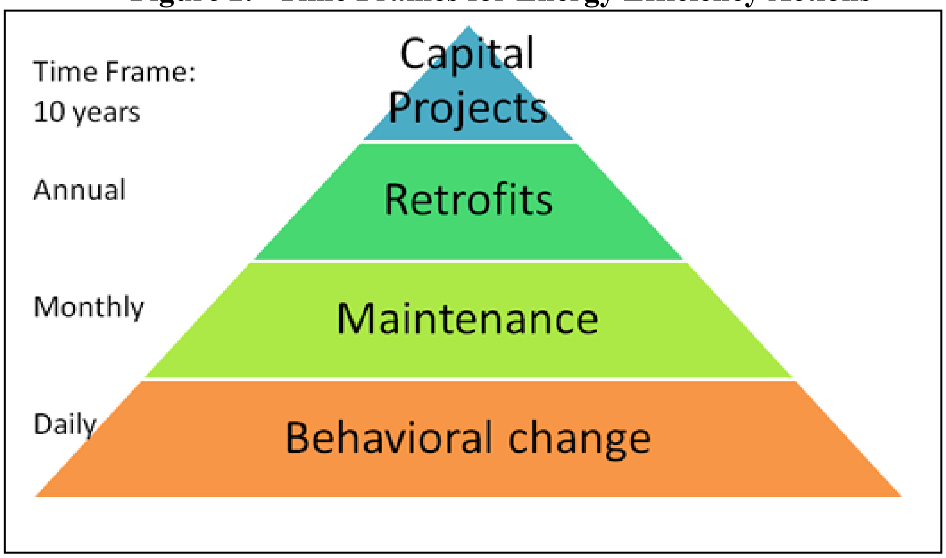
How are these gains achieved? In a recent study exploring best practices in corporate energy efficiency strategies (Prindle 2010a), seven key habits were identified at companies that were highly efficient. These are:

- Efficiency is a core strategy
- Real and sustained leadership and organizational support exists
- Company has effective targets and goals
- Tracking and measurement systems for energy are in place
- Resources for energy efficiency are substantial

- Energy efficiency strategy shows results
- Communication of results is effective

At a plant level, energy opportunities can be perceived in pyramidal structure (Allyn and Brockway 2010). At the lowest level are behavioral opportunities, such as turning off equipment not in use during breaks. These can be quickly implemented, as often as daily. Maintenance changes can also occur quickly, including repairs and adjustments to equipment, set points, and controls. Larger retrofits can be implemented less frequently, and will require funding. Capital projects may only happen every 10 years or so (Allyn and Brockway 2010). Thus a successful approach to improving energy performance must include all of these elements.

Figure 2. Time Frames for Energy Efficiency Actions



Source: Allyn and Brockway 2010

Although capital projects may get the most attention, the savings from shorter-term projects can be significant. DOE estimates that an initial energy assessment can identify 5 to 10% energy savings, of which 20% require no capital investment, only a change in awareness or practice. The remaining 80% have simple paybacks that average 1.5 years (Schoeneborn, 2010).

Capturing Energy Savings: A Survey of Existing Programs

Federal, regional, and state government agencies, utilities, and others have developed a range of programs to improve industrial energy efficiency. These include providing incentives, audits and technical assistance, and continuous improvement programs.

Utility Industrial Incentive Programs

Many investor-owned and municipal utilities and state agencies offer a range of programs designed to promote industrial energy efficiency, providing education, technical assistance and incentives designed to reduce energy consumption (Prindle 2010b). Educational and technical assistance programs assist customers to identify energy efficiency opportunities. Utilities also may provide energy audits to help facilities identify energy efficiency opportunities. Incentive programs provide financial rewards for implemented energy efficiency projects that meet the utility requirements.

Utility incentive programs designed exclusively for industrial customers are far less common than commercial and residential programs. The Electric Power and Research Institute surveyed 480 programs in the U.S, and found only 3 of these targeted the industrial sector exclusively. Even those programs that have an industrial component tend to focus on end uses that have lower efficiency potential in industry, such as lighting and air conditioning. Utility incentive programs in the industrial sector that focus on custom projects have more opportunity to address the wide-ranging processes in the industrial sector. (Electric Power Research Institute 2009)

Although the common utility incentive programs assist companies in meeting goals and achieving savings, they do not directly address any of the seven factors associated with sustained successful corporate achievement. Typical utility programs address only a subset of the energy efficiency improvement opportunities, focusing primarily on retrofits and capital improvements, with less attention to behavior or maintenance.

Industrial Assessment Center Audits

The industrial assessment centers, although similar in concept to utility program audits, are not constrained by the need to demonstrate that savings are due to their programs and thus encourage a broader range of measures. The U.S. Department of Energy has funded university-based Industrial Assessment Centers (IAC) since 1981. Focused on small and medium size facilities (under 1 TBTU/yr), the IAC engineers audit facilities using a specific list of recommendations. The list includes approximately 350 recommendations for energy efficiency across 9 categories.

Typically, the IACs audit over 300 plants per year across the entire U.S., and identify site savings of 8 to 10% compared to current energy use (Schoenborn 2010). After 6 months, a follow-up interview is held with each site to determine which recommendations have been implemented. According to the IAC website, nearly 15,000 assessments were completed and over 111,000 recommendations made as of August 2010 (Rutgers University 2010). The results provide useful understanding of industry as a whole.

A review of the publicly downloadable IAC database of implemented measures shows a customer preference for implementing measures that focus on maintenance and behavior, rather than retrofit or capital improvement projects targeted by most utility incentive programs. Many of the most commonly recommended improvements involve some cost for equipment, including utilizing higher efficiency lamps, utilizing energy efficient belts, and using more efficient electric motors. The most frequently implemented measures often had little or no costs, such as establishing a preventative maintenance program, keeping equipment clean, and shutting of air conditioning in the winter (Rutgers University 2011). Basic repairs are both commonly recommended and implemented, such as eliminating leaks in compressed air lines and valves. The IAC program shows an industry preference for low cost improvements associated with no changes in existing equipment, rather than retrofits or capital projects.

Continuous Energy Improvement Programs

In the last several years, governments around the world, utilities, and private organizations have developed programs that focus on setting goals and targets to achieve continuous energy improvement (CEI) in industry. Internationally, an energy management standard (ISO 50001) is under development (ISO management standard for energy, press release 2011). National programs in the U.S. have been developed by DOE (Save Energy Now and Superior Energy Performance) and EPA (ENERGY STAR). The federal government has also set goals for the US Department of Defense, resulting in long term approaches to reducing energy such as the Navy's Resident Energy Manager program.

Regional programs have been developed under the Northwest Energy Efficiency Alliance, working with the Bonneville Power Administration and the Energy Trust of Oregon. California has identified CEI as an important aspect of its strategic plan (California Energy Commission 2011). Similarly, Wisconsin's Focus on Energy employs an internally developed tool called Practical Energy Management (Wisconsin Focus on Energy, 2011). Other program administrators are also developing CEI programs, including Ontario Power Authority and Pacific Gas & Electric.

International Management Standard for Energy (ISO 50001)

The international community decided in 2008 to develop an international standard for energy management. Known as ISO 50001, this standard builds on the existing ISO standards for quality management practices (ISO 9000 series) and for environmental management systems (ISO 14000 series) and on national standards for energy management systems. The goal of ISO 50001 is to stimulate substantial continuous efficiency improvements in energy management, just as the ISO 9000 and 14000 standards stimulate continuous improvements in quality and environmental management. But unlike these standards, ISO 50001 also requires the development and management of quantitative performance measures. The draft standard was issued in 2010, and ISO has announced the planned publication of the standard for third quarter 2011 (International Standards Organization 2011).

ISO 50001 provides a framework for integrating energy efficiency into management practices. The standards require participants to first benchmark and measure their energy use. The standard also requires participants to document and measure the effectiveness of their energy uses, and provides a framework for evaluating and prioritizing energy efficiency technologies, behaviors and best practices. ISO 50001 is designed to be a tool for individual facilities, corporations, utilities, supply chain partnerships, and energy service companies to increase energy efficiency as defined in a way appropriate to the organization. ISO 50001 defines a metric for energy management, the energy performance indicator (EnPI). The initial EnPI for a facility or corporation serves as a benchmark, and subsequent improvements to the EnPI form the basis for demonstrating energy efficiency improvements. (ISO 2011)

Save Energy Now Leaders Program

DOE's Industrial Technologies Program developed Save Energy Now (SEN) as a national initiative to drive a 25 percent reduction in industrial energy intensity in 10 years (25 in 10). Over 100 companies have taken the pledge to at least meet the 25 in 10 goal to date (DOE 2010a). For companies that take the SEN leader pledge, DOE has provided technical expertise, through account representatives and technical account managers (DOE ITP 2010b). A series of webinars (DOE ITP 2010c) and a web portal highlight the steps DOE recommends to achieve the voluntary goals. DOE has provided tools and services to assist companies, including information resources, plant-system specific calculators to quantify savings, training and energy assessments. Between 2006 and 2009, DOE performed 878 energy savings assessments at 729 plants, with 25% of the assessment recommendations implemented through 2010. (Clemmer 2010).

The companies that agree to the LEADER program are required to establish baselines for energy use and other EnPI baselines, develop an energy management plan confirmed by executive management, and designate an energy leader or manager within 12 months of signing the pledge form. In subsequent years, the companies take steps to improve their EnPIs and report the results annually to DOE. DOE provides public recognition to companies for their energy management achievements.

Comparing the seven habits of energy efficient companies described above with the DOE approach shows a number of consistencies, suggesting that the SEN program aims to instill best practices that lead to energy efficient companies. The DOE program identifies these steps: creating a climate for successful project implementation, setting expectations, assigning responsibility and rewards, collecting and tracking measurements, developing metrics to show results, providing resources, communicating achievements and results. These steps are consistent with the seven habits, focusing on commitment at all levels, measurement, communication, and showing results to all. Firms participating in the SEN program have reported significant achievements, such as the SEN champion LEADER plants that were honored for achieving a 15% reduction in energy use (DOE ITP 2010d).

Superior Energy Performance Program

Initiated by DOE and guided by the U.S. Council for Energy Efficient Manufacturing (U.S. CEEM), Superior Energy Performance (SEP) is a voluntary energy efficiency certification program for industrial plants. Like ISO 50001 and SEN, SEP is designed to promote energy management as an integral part of plant operating practices and provides a mechanism for plants to maintain their focus on energy efficiency improvements. SEP goes farther than either ISO 50001 or SEN, incorporating accredited third party certification to the requirements of ISO 50001, and adding energy performance improvement requirements. Currently in the pilot stage, DOE plans to inaugurate the SEP program in the fall of 2011 after ISO 50001 is released (US CEEM 2010). SEP has the most demanding standards of all the programs reviewed in this paper.

A key difference between SEP and other programs is the certification process. Participant facilities must demonstrate compliance with the management standards of ISO 50001 and the energy performance improvement standards under SEP (US CEEM 2010b).

SEP has developed a measurement and verification (M&V) protocol to establish a consistent methodology for verifying the results and the impact of the implementation of the program over time. The methodology also provides a means to quantify energy savings from actions and projects, as well as to track performance improvements over time (US CEEM 2010c). The SEP energy performance indicator (SEnPI) is developed for a specific facility based on site-specific variables, such as energy consumption, production volumes, weather, and raw material characteristics. Each facility models their facility-wide baseline SEnPI for comparison to their SEnPI after a performance period (typically 3 years later), to determine their improvement (KEMA 2011a). Thus SEP captures all changes in energy use, from capital investments, maintenance, operational improvements and practices, and behavior. The certification process requires that the facility demonstrate their improvements in two ways, first, by SEnPI improvement, and second by a "bottom-up" cross-check of the energy reduction effects from itemized improvement activities (KEMA 2011a).

To assist facilities in model development, the Georgia Institute of Technology provided a model template. All of the pilot facilities were able to develop their SEnPI but found the process different from accounting or financial modeling. Facilities are used to working with data, but the SEnPI requires focusing more on the *process* of how energy is used, rather than on fitting the energy consumption data to a model (Desai 2011).

Under the pilot program, four facilities have achieved certification as of February, 2011. These early facility certifications illustrated the challenge of quantifying energy efficiency improvement in manufacturing facilities. Production levels, product mix, and operating conditions vary over time. New equipment may have been installed, and production lines added or eliminated. The protocol for measurement and evaluation addresses these variations by requiring facilities to achieve a statistically valid model for SEnPI that demonstrates an "apples to apples" comparison between the baseline year and 3 years later. All facilities found the model development to be challenging. All were able to demonstrate at least a 5% improvement in SEnPI over the performance period.

EPA ENERGY STAR for Business

This U.S Environmental Protection Agency voluntary government program builds on the popular nationally recognized Energy Star brand. Developed in 1992, the Energy Star program has resources for energy management in buildings and plants. With an emphasis on energy management practices at the corporate level and building teams, this program is complementary to DOE's SEN program. EPA provides energy guidance, benchmarking and tracking tools, and communication resources to drive corporate behavioral change. The benchmarking tools are sector specific, allowing simple comparisons of energy use per unit of production between a specific plant and a reference plant with the same output. EPA also provides a forum for sector-specific energy efficiency discussion.

U.S. Navy Resident Energy Manager Program

The Department of Defense is required under executive order 13423 to reduce its energy use by 30% by 2015, to reduce its water use by 16% by 2015 and to obtain 25% of its electricity from renewable energy sources by 2025. With military bases with energy bills in the millions of dollars, the Navy has found it cost-effective to employ a full time Resource Efficiency Manager

(REM) from a consulting firm (Vetromile, 2008). With the twin drivers of an executive order and the need to reduce energy costs, REMs have been able to reduce overall energy and water use and increase Defense's renewable energy portfolio. REMs have managed initiatives ranging from no-cost measures to major capital projects to meet the energy and water reduction goals for military bases. The program tracks key categories including industrial facility efficiency improvements, combined heating/cooling and power plants, onsite electrical generation, reductions in electrical load and reductions in petroleum consumption, water usage, basic energy management practices, building energy monitors and the energy awareness program.

The energy savings that are generated by the onsite manager typically pay for the consulting firm cost with a 200% return on investment. For example, a pilot project to reduce pierside energy costs aboard active Naval vessels returned over $4 million in savings to the Fleet with a return on investment of over 10:1. Some bases have employed Resource Efficiency Managers for more than eight years, who continue to generate cost-effective energy savings (Vetromile, 2008). This program shows that energy savings can continue year after year with management and team motivation.

Northwest Energy Efficiency Alliance Industrial Initiative

Since 2004, the Northwest Energy Efficiency Alliance (NEEA) has collaborated with utilities, government, trade associations and industrial firms to develop and implement CEI in industry in the Pacific Northwest. Working with Bonneville Power Administration and the Energy Trust of Oregon, this work has resulted in two strategic energy management programs, High Performance Energy Management and Industrial Energy Improvement (NEEA 2011a). NEEA has assessed the results, and concludes that companies that adopt a management systems approach save energy at a higher rate than companies that do not (NEEA 2011b). NEEA also recognizes that industrial firms can achieve more as a cohort than if approached individually.

NEEA targeted two industries, pulp and paper and food, for CEI as part of their industrial initiative. NEEA has documented progress in market penetration in the food sector, with 36% of their target market participating in CEI in 2009 compared to 13% in 2004. The majority of the participants attributed their involvement due to NEEA's industrial initiative. NEEA's evaluator estimated that food processing facilities could save 3% annually of both their gas and electric consumption by participating in CEI (The Cadmus Group 2011). On the other hand, pulp and paper industry participation was limited, and savings goals were not achieved. The difficult market climate in this industry, with bankruptcies, consolidations, and buy-outs in recent years, likely has made the industry less engaged in energy efficiency (The Cadmus Group 2008).

In addition to working directly with industry, NEEA sought to engage market partners and trade associations. Utility market partner success was measured by the inclusion of energy management program plans in the Northwest Power and Conservation Council's Sixth Power Plan (The Cadmus Group 2011). The Northwest Food Processors Association, one of the market partners, established a goal for its members consistent with Save Energy Now, to reduce energy intensity by 25% in 10 years. NWFPA is also supporting members in collecting baseline data and conducting energy audits for members.

NEEA's efforts illustrate both the potential and the challenge of CEI and industrial energy efficiency. CEI can provide continuing savings, but industry must be willing to commit to the program. A supporting trade organization can provide a forum that keeps members engaged in efficiency.

Discussion

The drop in energy intensity shown on Figure 1, above, suggests that existing programs have reduced energy intensity significantly for industrial customers, despite the significant barriers in this sector. And as industry continues to innovate for quality, safety, and production needs, many of these innovations will result in reduced energy consumption as a by-product. The transition to computer-based rather than pneumatic control systems is a good example of innovation designed to improve quality and production efficiency that also reduces energy consumption.

The goal of the energy efficiency community is to increase the rate of improvement in energy intensity, tapping into the efficiency potential. Few states have achieved more than 1% per year (Kushler 2009). Yet the programs reviewed in this paper suggest that 2% annually improvement in energy intensity is achievable. SEN requires a pledge of 25% in 10 years (less than 2.5% per year), and 140 plants were honored for saving either more than 250,000 MMBTU in total energy savings or more than 15% total energy savings in 2010 alone (DOE ITP 2010e). The NEEA program found that participants were achieving 3% per year with savings expected to continue. SEP requires a minimum of 5% over 3 years; within the pilot program some facilities have achieved over 15% (Giampaoli 2011).

The companies that participate in these programs demonstrated commitment, consistent with the behaviors identified in the Pew study. This commitment may have started from a champion at the plant level (Allyn and Brockway 2010), or by a management commitment, such as by the US CEEM partners in SEP. But as the NEEA work with the pulp and paper sector shows, voluntary commitment is not enough of a driver, especially in difficult economic times.

So, what does it take to get industry engaged?

One answer is *regulation*, such as Executive Orders for the military or codes and standards. Industrial standards for equipment efficiency have been difficult to implement due to the heterogeneity of industrial end uses, but several types of equipment are being recognized as offering practical savings potential. ACEEE has been working on motor standards for larger motors (Elliot 2011). Codes and standards represent a largely unexplored opportunity for commonly used equipment such as boilers and compressors (Waide 2010). Similarly, in a recent roundtable meeting of utilities and water and wastewater energy experts, participants noted that their management responds to regulatory requirements but is very risk-averse about making other facility changes, even if significant cost savings may result. (KEMA 2011b)

Audits and energy assessments provide another mechanism to engage industry, as the IAC and SEN programs show. The NEEA program demonstrated that engaging with trade partners such as the Northwest Food Processors Association yielded a high level of participation in a particular industry (The Cadmus Group 2011).

Another key aspect of saving energy at the plant level is *measurement*. Understanding the plant energy use is the first step to identifying savings. For example, compressed air usage is often ignored as a significant energy consumer. The highly efficient companies identified the importance of both measurement and demonstrating success throughout the organization. Understanding the measurements and the achievements provides the momentum for continued improvement, as the Navy program showed.

Verified savings are more useful that simple observed energy reductions, which could have a number of causes. CEI savings that are measured and verified can be included in government and utility forecasting and planning. Accredited third party verification enhances the credibility of savings claims. The measurement and verification requirements achieved under SEP and ISO 50001 are designed to provide data at this level.

Finally, the CEI approach allows the inclusion of savings due to behavior, maintenance and retrofits, as well as capital projects. The IAC audit results showed that the first measures to be adopted were the lowest cost. For ongoing savings, doing more with what is already in place is the lowest cost and has the least barriers. Program designs that include these aspects have greater opportunities for success.

In conclusion, the potential for industrial energy intensity improvement can be tapped more thoroughly through the new tools, standards, and program designs that are now being offered. These changes should increase the breadth and scope of efficiency programs, with a commensurate need for resources by program administrators and regulators. All aspects of industrial energy consumption should be considered, including behavior, maintenance, small retrofits and major projects. An effective measurement and verification strategy is necessary to demonstrate the dependability of the savings and to fuel the commitment of the companies. Trade association support enhances success. Corporate commitment is needed. Programs that engage and reward companies accelerate the savings.

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