Breakdown Barriers to Industrial Energy Efficiency Applied Technology and the Role of Industrial Energy System Assessment Standards

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ABSTRACT

After years of training and awareness building at the state and national level, industrial cross-cutting systems (motor-driven, steam, process heating) are recognized opportunities for energy savings. Management's commitment including key management systems and activities are necessary to drive success. Barriers can be found at every step of the process for improving an energy system, from energy system assessment to implementation of energy efficiency measures. Real or perceived risk, and past experience of unfulfilled expectations, can inhibit key management support.

This paper discusses these barriers and the positive effect that the newly published ISO 50001 Energy management system standard and the ASME American National Standards for conducting system assessments can have on these barriers. . Details are provided on ASME EA- 4, the compressed air standard, as an example of a proven road map for assisting industrial energy managers in overcoming these barriers.

Introduction

This is not a paper of facts and figures with charts and tables, to prove that industrial energy efficiency is successful and good for the bottom line. Rather it is a story about how industrial energy efficiency actually gets done- or not. It is written from the perspective of a compressed air system engineer and plant facilities engineer who worked together for years to improve the energy efficiency of a medium-size industrial facility. This paper includes a discussion of how previous efforts at the state and national level to promote industrial energy efficiency, while limited in their impact on industrial decision making, have had a positive impact on industrial energy efficiency for organizations that have utilized them, while also accumulating a body of knowledge and a set of best practices. It is this knowledge of what works that has allowed the recent development of two types of standards- energy management and system assessment standards- that have the potential to greatly improve the energy efficiency of US industry.

Background

During the first half of the 1990's the U.S. Department of Energy's Motor Challenge Program embarked on "A National Strategy for Energy Efficient Industrial Motor-Driven Systems". Information gathered shows that more than 70% of all industrial electrical energy

consumption involves motor driven systems. Process heating and steam systems were also identified as large industrial energy consuming systems. By today's estimates, energy systems including motors, pumps and fans, process heating, steam, and compressed air systems that are used throughout industry account for roughly 80% of industrial energy use. On average, 35% of that energy is lost – nearly 6 quads of energy every year. As much as 1.6 to 3.2 quadrillion Btu could be saved by improving the efficiency and reducing energy losses in these systems[1] (10-20% reduction in energy use).

As a result programs such as Compressed Air Challenge®, Steam Challenge and others were developed during the late 1990's to build awareness of the energy use and savings potential by improving Industrial Energy System Efficiency. After more than a decade training thousands of industrial plant personnel the technical body of knowledge is broadly developed and the success of the "systems approach" to industrial energy efficiency is well documented. However, many barriers still exist from the initial energy system assessment to implementation of energy efficiency measures.

Industrial Energy Efficiency: An Energy Champion's Perspective

This case study describes the experience of a plant facilities engineer working at an industrial facility over two decades who also assumed the role of energy champion for the facility. Although some of the experiences shared here were encountered as energy awareness and industrial energy efficiency programs were being developed, and may not fully reflect the current awareness and acceptance of industrial energy efficiency, this experience as it relates to the industrial decision making process remains largely valid.

Barriers to Managing Energy Efficiency in Industry

While industrial energy efficiency, energy training and awareness efforts have had success addressing the technology of industrial system efficiency, many barriers of 20 years ago still exist today. As the plant facilities engineer, the author faced numerous hurdles to sell the concept of energy efficiency for a 130 plus years old facility in heavy industry. Although the facility included energy intensive operations, energy efficiency took the back seat to production, quality, safety and environmental issues. The various issues can be broadly categorized as Organizational Infrastructure, Financial, and Sustainability barriers. The last section of this paper outlines suggestions to build on success and sustain the path to continuous improvement in energy efficiency.

Organizational issues. Energy usage and costs were not on the management's radar as it was not a visible element to focus on. Major portions of the plant energy costs were arbitrarily allocated using such criteria as square footage of the department or based on a percentage of the operating department budget. As a result there was no real accountability for energy usage on the part of the consumption departments.

Additionally no comprehensive energy assessments were ever done as it was never given a thought. As the market for the manufactured products at this facility got increasingly

[1] Industrial Energy Systems, http://www1.eere.energy.gov/industry/bestpractices/printable_versions/systems.html, Industrial Technologies Program – BestPractices, U.S. Department of Energy -Energy Efficiency and Renewable Energy; accessed 03/18/2011

competitive the plant faced cost pressures and profitability declined. The company was on the decline as capital funding became more and more restricted. As plant facilities engineer the author decided the time was right to initiate a request to conduct formal energy assessment of the plant. With the help of funding available from Dept. of Energy and NYSERDA, plant wide energy assessments were completed reviewing the use of power, natural gas, steam, and compressed air. The various funding programs available at the time were Alliance to Save Energy, DOE Plant Wide Assessment, and NYSERDA funding under Flex Tech program, Energy Operations and other Program Opportunities. These funding opportunities to conduct comprehensive energy assessments were a tremendous help to kick start the process to initiate the steps that followed.

Infrastructure. Lack of sub-metering equipment also was another hurdle that was dealt with. As part of an energy services contract, the gas utility company helped subsidize the cost of sub metering of natural gas to the major points of use. Temporary metering to monitor power was provided as part of the energy services contract and installed to complete review of electrical usage.

Steam systems were also reviewed along with a comprehensive compressed air audit of the plant covering both supply and demand side of the system. External funding helped fund and expedite energy assessments by employing services of subject matter experts for each of the major utilities.

Once the studies were completed low cost/no cost measures identified were quickly implemented and reported to all levels of management. Development and reporting of metrics generated interest from management of the potential to save energy and the economic impact on operating efficiency. The use of outside technical expertise and trade allies where needed helped steam roll the process. This was important due to limited plant staff and added credibility to the objective, and ultimately the results achieved.

Financial roadblocks. As previously stated, the lack of funds to conduct comprehensive energy audits was quickly solved by obtaining funding from external sources previously mentioned.

In order to fund purchase of sub metering needed beyond the scope of formal energy studies, the author and his team negotiated an agreement with management to purchase two or three meters per month with capability for remote data access. Purchases were charged against departmental operating budgets over a couple of years until all of the major areas of the plant were sub-metered.

The next financial roadblock was addressing the internal system of financial reporting. This was seen as another roadblock only because even if energy could be metered and data collected, unless it is embraced by the plant financial system and appropriately allocated to the consumption departments the issue of accountability still remains. The author supported by efforts of his staff worked with the Plant Controller to establish accounting codes by type of utility (power, gas, steam, compressed air, etc.) consumed by each of the major departments. This data was initially collected by manual reading of the meters on a monthly basis and reported to the financial department who then posted the charges to the individual operating departments on their monthly cost reporting system.

The establishment of accountability had an immediate effect of generating interest in saving energy across the plant. Due to a continuous improvement program already in place, each department came up with ideas to save energy and used the energy information for tracking and making changes in operating practices to save energy. New projects were also proposed as a result of this new found accountability.

Sustaining energy efficiency efforts. Upon execution of the above measures, energy efficiency started to get the attention of management. Upon completion of energy assessments, projects were prioritized based on expected return on investment. Low hanging quick return projects not requiring any capital were completed first and savings reported and publicized throughout the plant as and when they were completed. Cross discipline energy teams were formed to work on implementing smaller projects and start realizing energy savings. All involved were pleasantly surprised at the outcome of this effort. The interest and successes grew rapidly. This helped with obtaining funding for capital projects with less than 2-3 year payback. Energy savings realized helped sell new capital projects.

With the more finite accounting for energy it also enabled development of more accurate manufacturing costs on key product lines. Product lines previously assumed to be profitable were no longer profitable as a result of correct allocation of energy costs and vice versa. Pretty soon it was evident that it was far easier to improve gross margins on product lines through energy conservation than price increases. Cost savings associated with energy efficiency are within the plant's control where as price increases are subject to market conditions and not always possible.

The notoriety gained with above efforts helped obtain funding to implement plant wide computerized energy monitoring system with capability to store data and ability to quiz energy use information on key departments for any period of time. The Chief Financial Officer was able to see energy usage on demand from his office with the implementation of the plant energy management system.

Besides having desktop access to energy usage information on demand, a side benefit that emerged was the ability to respond to utility initiated demand response programs. It was now possible to selectively shut down major high power demand equipment to take advantage of compensation available from the utility. Having the financial group work closely with Plant Engineering was an added bonus to help push the envelope. Over a period of five to seven years the plant energy efficiency was improved from 22% to 15% of manufacturing costs which equated to over $1,000,000 savings annually.

As a result of these efforts energy efficiency was ultimately integrated into three year business plans and finally got the attention it deserved. Lessons learned during this process were invaluable. Taking a heavy manufacturing plant that was over 130 years old from baseline conditions could only be achieved through a structured approach to energy management in spite of the road blocks along the way.

Sustaining energy efficiency is a continuous process requiring a dedicated team leading the effort. Recognition of contributors to this effort is a key component of a successful program. Continuing education in new energy efficiency technologies, participation in conferences for self improvement and partnering with a team of subject matter experts enable a methodical and structured implementation plan. Above all taking incremental steps starting with a vision and armed with a methodical approach can lead to satisfying results.

Lessons Learned

Once management became engaged in energy management, energy efficiency was integrated into three year business plans. It took more than 10 years for management to become fully engaged. Management's commitment came only after it was documented that over a 5 to 7 year period plant energy efficiency was improved from 22% to 15% of manufacturing cost, a savings of over $1 million per year.

Why did it take so long for management to get engaged? Energy costs were buried in operating budgets, arbitrarily allocated with no accountability for energy use on the part of the consuming departments. Energy was invisible to management and as a result was not on management's radar.

What did it take to get management on board? It takes information; good, well organized, and meaningful information about energy use and its impact on the bottom line. It became evident that it was easier to improve gross margins on product lines through energy conservation than price increases. Energy savings and cost reduction immediately improve the bottom line, while boosting the bottom line through increased product sales is more difficult and time consuming.

How did the information get to management? Energy data became embedded in the plant financial system. Appropriate allocation of energy use to the consuming departments provided finite accounting and more accurate manufacturing cost on key product lines. Accountability had the immediate effect of generating interest in saving energy throughout the plant.

Where does information come from? Data; energy data, plant production data, energy system performance data; it takes good accurate reliable data to produce meaningful information. Early in the effort reporting of energy metrics got management involved. However, the lack of sub-metering equipment to measure energy flow of electricity, steam, gas, and compressed air was a major obstacle. Management's agreeing to purchase two or three meters per month was hardly a commitment, but a step in the right direction.

When did the process get started? The process started when funding opportunities to conduct comprehensive energy assessments helped to kick start the process. Before that, energy assessments were never done as it was never given a thought.

The Co-Authors experience and lessons learned in this project are not unique. Many energy professionals from industry, utilities, universities, consultants, national laboratories, equipment manufacturers, and energy efficiency organizations who have pioneered industrial energy efficiency have had similar experience.

The benefits of industrial energy efficiency must be proven to management, before they are incorporated into everyday business operations and strategies. The newly created energy standards incorporate these lessons learned in the energy management process.

A New Role for Energy Standards

ISO 50001- Energy Management Systems

ISO 50001 is a voluntary International Standard developed by the International Organization for Standardization (ISO) and gives organizations an internationally agreed framework to manage and improve their energy performance. Targeting broad applicability across national economic sectors, including industrial plants, commercial, institutional, or governmental facilities or entire organizations, it is estimated that the standard could influence up to 60 % of the world's energy use.[2]

ISO 50001 will provide public and private sector organizations with management strategies to increase energy efficiency, reduce costs and improve energy performance.
The standard is intended to provide organizations with a recognized framework for integrating energy performance into their management practices. Multinational organizations will have access to a single, harmonized standard for implementation across the organization with a logical and consistent methodology for identifying and implementing improvements.
The standard is intended to accomplish the following:

- Assist organizations in making better use of their existing energy-consuming assets
- Create transparency and facilitate communication on the management of energy resources
- Promote energy management best practices
- Assist facilities in evaluating and prioritizing the implementation of new energy-efficient technologies
- Provide a framework for promoting energy efficiency throughout the supply chain
- Facilitate energy management improvements for greenhouse gas emission reduction projects
- Allow integration with other organizational management systems such as environmental, and health and safety.

ISO 50001 provides a framework of requirements enabling organizations to:

- Develop a policy for more efficient use of energy
- Fix targets and objectives to meet the policy
- Use data to better understand and make decisions concerning energy use and consumption
- Measure the results
- Review the effectiveness of the policy
- Continually improve energy management.

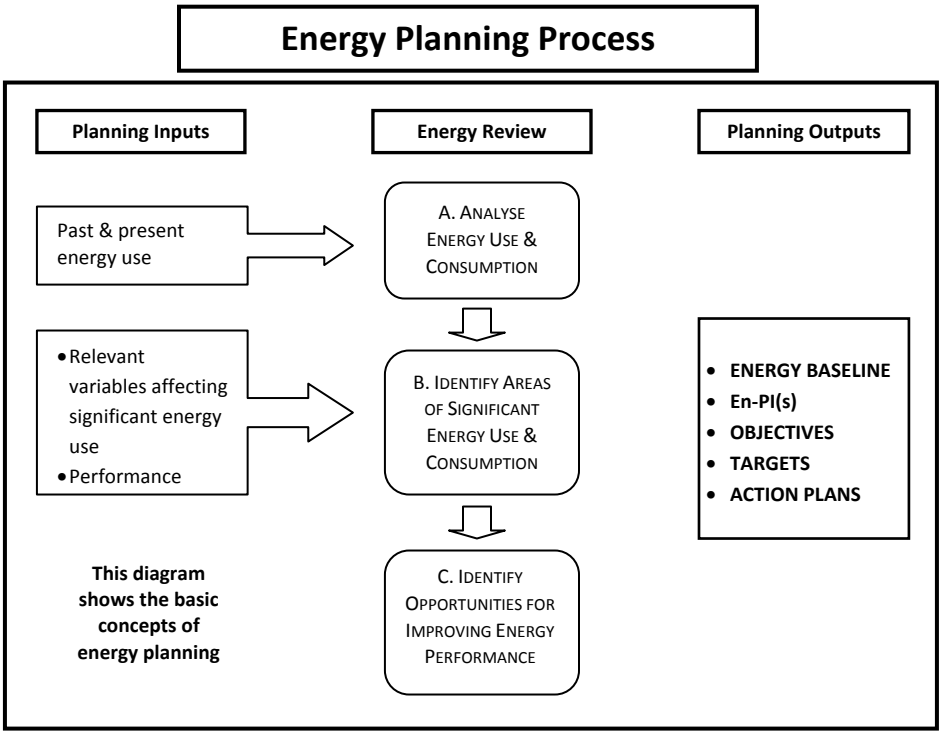
[2] Based on information provided in "World Energy Demand and Economic Outlook", in the *International Energy Outlook 2010,* published by the US Energy Information Administration. This cites 2007 figures on global energy consumption by sector, including 7 % by the commercial sector (defined as businesses, institutions, and organizations that provide services), and 51 % by the industrial sector (including manufacturing, agriculture, mining, and construction).

A core concept of ISO 50001 is energy performance, which is defined as

"measurable results related to energy efficiency, use and consumption[3]*"*

This emphasis on measurement is an important concept of ISO 50001. It is not enough to have a well-documented management system - it must produce results in the form of continual improvement of energy performance. This requires that the organization have a system for collecting, analysing, and acting on energy data that allows for effective management of their significant energy uses. The process of gathering and analyzing this information is called the *energy review***,** which includes identifying opportunities for improving energy performance. This leads to the creation of an energy baseline and the identification of energy performance indicators (EnPIs) that are used to track performance improvement over time. Figure 1 below illustrates the connections between these planning processes and the resulting objectives, targets, and action plans. It is the implementation of the action plans that contributes to improved energy performance.

Figure 1: Energy Planning Process Concept Diagram



Source: (ISO FDIS 50001:2011)

While ISO 50000 provides a top level framework to manage and improve energy performance, the ASME standards listed below provide a well-tested proven approach for identifying energy performance opportunities for specific industrial energy systems. Getting those early big "wins" is important for building motivation for continual improvement and demonstrating the value of ISO 50001 to management

[3] ISO 50001:2011

ASME Energy Assessment Standards for Industrial Systems

ASME (The American Society of Mechanical Engineers) Energy Assessment Standards are a portfolio of documents and other efforts designed to improve the energy efficiency of industrial facilities. Initially, assessment standards have been developed for process heating, pumping, steam, and compressed air systems.

ASME EA-1 – 2009 Energy Assessment for Process Heating Systems
ASME EA-2 – 2009 Energy Assessment for Pumping Systems
ASME EA-3 – 2009 Energy Assessment for Steam Systems
ASME EA-4 – 2010 Energy Assessment for Compressed Air Systems

Other related existing and planned efforts include:

ASME guidance documents for the existing assessment standards provide technical background and application details to support the understanding of the assessment standard. The guidance documents provide rationale for the technical requirements of the assessment standard and give technical guidance, application notes, alternative approaches, tips, techniques, and rules-of-thumb.

A compressed air energy assessment meeting the requirement of the Standard should be comprehensive and complete if it is undertaken by an experienced assessor. A planned certification program for each ASME assessment standard will recognize certified practitioners as individuals who have demonstrated, via a professional qualifying exam, that they have the necessary knowledge and skills to properly apply the assessment standard.

Energy Standards Can Help Break Down Barriers

For Standards to reach their full potential by influencing management to act, they must be recognized as valuable tools with established creditability defining a proven process to achieve sustainable energy efficiency.

Twenty years ago selling the concept of energy efficiency to management left facility and energy engineers in an informational vacuum. There may have been a handful of case studies, and a few trade articles, but nothing like the National Programs, and Energy Assessment Standards that exist today.

Experience shows that many barriers are unrelated to technical issues and many barriers of 20 years ago still persist today. So how can newly created National Standards for Industrial Energy Efficiency help break down barriers to implementation of energy efficiency improvement? Understanding the Standards Development Process will help. As an example ASME EA-4 Energy Assessment for Compressed Air Systems is discussed here.

Knowledge and Experience are the Basis of Standards

The Standards Development Process leverages knowledge and experience of many skilled professionals in their area of expertise. Working from an expansive body of knowledge, Standards development teams leverage their years of experience and use a consensus review process to provide a Standard that represents the best collective successful experience.

Standards provide higher value to industrial facility management teams with greater transparency providing a well defined path to improve energy efficiency.

Standards Development Process and Project Teams

The Standard development process followed the ANSI-accredited procedures for ASME Codes and Standards Development Committees, which establishes consensus-building among subject matter experts along with procedures for obtaining public comment. A project team represents a cross section of industry utilities, universities, consultants, national laboratories, equipment manufacturers, and energy efficiency organizations.

Standards leverage the current body of expert knowledge. During Standards Development, committees work toward a consensus building process among all stakeholders involved with the Standard.

Standards are developed with transparency. By engaging many market participants Standards provide higher value to industrial facilities.

Project Team EA-4 – 2010 Energy Assessment for Compressed Air Systems

Each of the industrial energy systems has its own unique requirements and stakeholders. Using Compressed Air Systems as an example, committee members have extensive experience in compressed air system energy efficiency. Close coordination with other compressed air system energy efficiency activity included participation by representatives of the Compressed Air Challenge™ and Compressed Air and Gas Institute on the project team.

A Draft Standard for Trial Use was completed in late 2008, and the draft Standard was introduced to the compressed air systems community during a series of webcasts. Comments from the trial use period were addressed in spring 2009. Revisions were made to the draft Standard and Guidance Document based on the comments from the trial use period.

Testing of the Draft Standard for trial use. The Texas Pilot Project on Manufacturing Plant Energy Efficiency Certification[4] was conducted from July 2008 through Feb 2010. This project was designed to implement and test all of the standards including the Management Standard for Energy and each of the four system Energy Assessment Standards. Feedback from participants in the trial use was incorporated into the final Standards.

Having the Standard and Guidance Document developed, reviewed, and tested by a diverse group of individuals representing the views of the various stakeholders that are potentially impacted by the Standard helped ensure that it produced the end result intended.

Overview EA-4 – 2010 Energy Assessment for Compressed Air Systems

Compressed air system energy assessments collect and analyze information on compressed air system design, operation, energy use, and performance. This information is used to identify energy efficiency improvements and optimize system performance. An energy assessment may also include additional recommendations for improving resource utilization,

[4] Ferland, K., 2009. "The Texas Pilot Project Tests for Success", *Energy Matters Summer 2009*, U.S. Department of Energy, Energy Efficiency and Renewable Energy

reducing per unit production cost, and improving environmental performance related to the compressed air system.

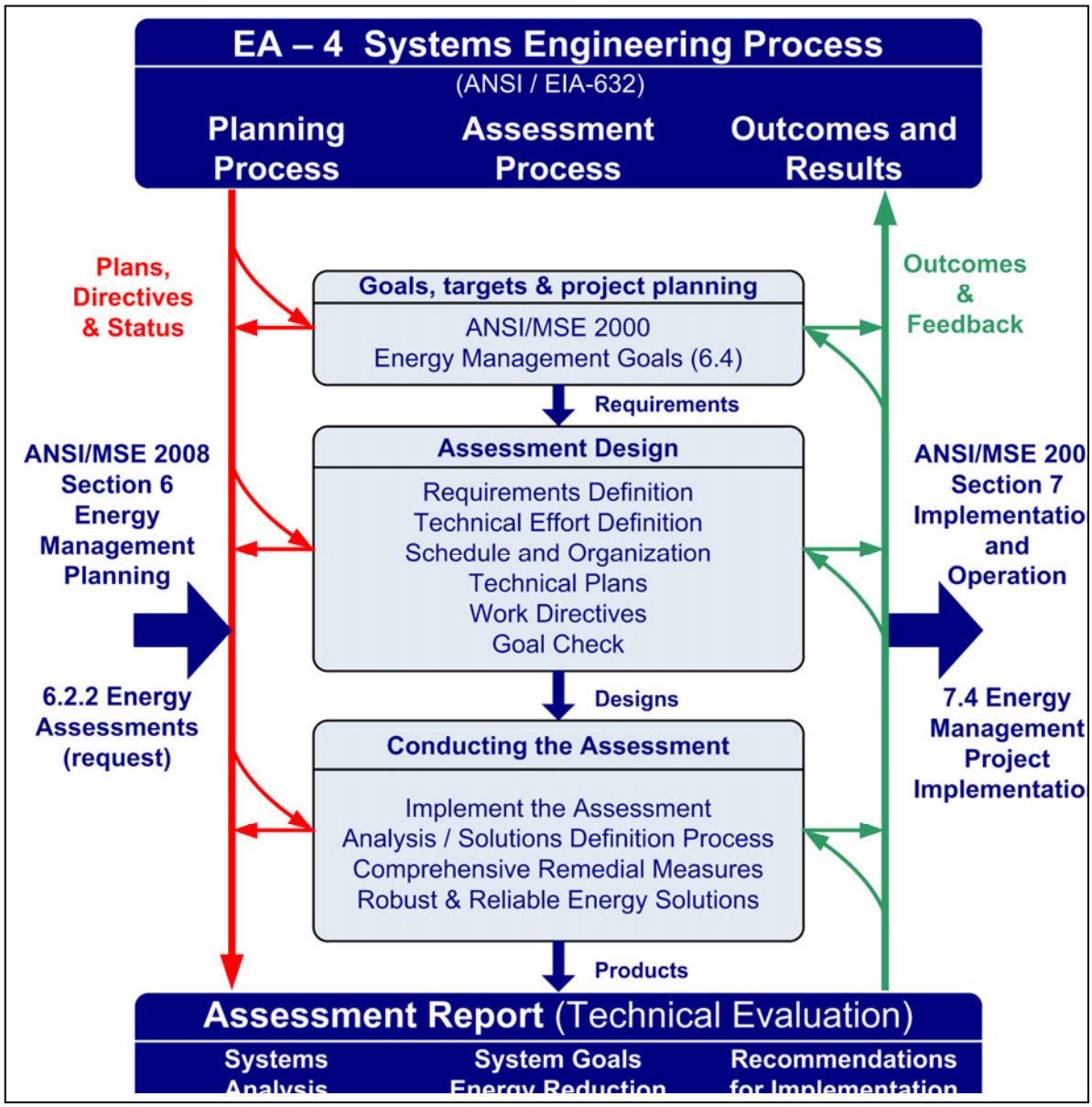
ASME EA-4 – 2010 sets the requirements for conducting and reporting the results of a compressed air energy assessment that considers the entire system, from energy inputs to the work performed as the result of these inputs. A compressed air energy assessment complying with the standard need not address each individual system component or subsystem within the compressed air system with equal weight, however, it must be sufficiently comprehensive to identify the major energy efficiency opportunities for improving the overall energy performance of the system.

The assessment process outlined in Fig. 2 applies the systems engineering process to compressed air system assessment. Compressed air energy assessment activities include but are not limited to engaging facility personnel and providing information about the assessment process; collecting and analyzing data on system design, operation, energy use, and performance; identifying energy performance improvement opportunities; and making recommendations for system improvement and energy-saving project implementation in a written report. The energy assessment report documents system design; quantifies energy operation and performance data; documents the assessment process; shows results and gives recommendations and savings projections; and improves the plant or facility personnel's understanding of the compressed air system energy use and operation.

Key benefits of applying EA-4 – 2010 energy assessment for compressed air systems. The value proposition to industrial plants for using the compressed air system assessment Standards as part of their overall energy management program includes the Standard:

- Provides a structure for identifying compressed air system energy efficiency opportunities that address the root causes of system inefficiencies and for making cost-effective recommendations to correct them;
- Provides assurance compressed system assessment recommendations are sound and produce predicted results;
- Increases a company's ability to replicate and document their compressed air system successes;
- Provides a mechanism for communicating to stakeholders about energy management progress; and
- Provides improved opportunities for utility and state financial incentives for energy efficiency as a result of using recognized assessment practices and measurement and verification protocols.

Figure 2 Overview EA-4 – 2010 Energy Assessment for Compressed Air Systems



Summarized from ASME EA-4 – 2010 Energy Assessment for Compressed Air Systems Fig. 3 also indicating connections with ANSI/MSE 2000-2008.

Market threshold EA-4 – 2010 energy assessment for compressed air systems. The market for compressed air system efficiency services has been providing a wide range of services that have been variously described as energy assessments, energy audits, energy surveys, and energy studies. The range and quality of work performed has ranged from simply ultrasonic leak detection surveys to complete comprehensive system wide assessments. Without a common definition for these services, and functioning in a "buyer beware" environment it is difficult to give management reasonable expectations for results.

Standards promote application of measurement technology. The Standard provides specific metrics necessary to quantify energy use and evaluate savings opportunities. Requirements of the

system measurement plan, instruments, techniques, along with identification of test points, and key operating parameters provide a simple road map to attain essential management information.

Management requires well defined performance metrics and financial reporting to move forward with the necessary investment to implement energy efficiency improvements. Performance measurement is essential to establish energy accountability and generate the desire to save energy throughout the plant.

Value to Industry of National Standards for Industrial Energy Assessment

While industrial energy awareness and technical expertise in system energy efficiency have increased significantly in the past decade, barriers from assessment to implementation still exist. When selling energy efficiency to industrial plant management, National Standards for Industrial Energy Assessment are valuable tools to establish credibility, and define a proven process to achieve sustainable industrial energy savings. Standards can help break down barriers to implementation of energy efficiency improvements.

- Standards development is an open transparent process engaging individuals with recognized technical and subject matter expertise.
- Balanced representation at the committee level represents all interested parties providing the broad range of knowledge and experience in industry provided by management, production, and technical personnel along with, experts representing energy companies, academia, regulatory agencies, and the public-at-large.
- The resultant standard is a thoroughly vetted document representing the present body of knowledge at the highest level of available experience and expertise.
- Standards provide a common definition for what constitutes an energy system assessment for both users and providers of assessment services.
- The result represents best practices in the field and a proven road map to success.
- Given the expert body of knowledge that is the foundation of the Industrial Energy Management Standards; top management can view the standard with the confidence necessary when making commitments to energy efficiency a means of achieving the company's financial, energy, and environmental goals.
- The Portfolio of ASME Standards provides a flexible framework that, when applied to the wide variety of industrial energy using systems, can help one accomplish an effective energy and performance assessment.
- When planning an energy assessment activity, the standards help to define and communicate the desired scope of assessment activity among all participants.
- Standards describe the application of measurement technology to identify system energy efficiency opportunities, address the root causes of system inefficiencies, and provide data necessary to recommend cost-effective remedial measures to improve performance and energy efficiency.
- Measured data provides assurance that system assessment recommendations are sound and produce predicted results.
- Standards are created with consensus of recognized assessment practices and M&V protocols and thereby improve opportunities for utility and state financial incentives for energy efficiency projects.

- Applied measurement technology provides management information essential to sustainable energy optimization increasing a company's ability to replicate and document their energy management success.

Summary

Using Standards for Industrial Energy Efficiency

The facilities and energy engineer using a Standard has a credible information resource providing increased support for implementation of system improvements that have been shown to improve energy utilization.

Presenting Energy Efficiency to Gain Management Support

The information contained in a Standard can be used with confidence by facility and energy engineers.

Industrial energy efficiency has evolved and grown during the past 20 or 30 years. In the past the path to success relied on energy champions who worked from the ground up to measure and analyze energy use, implement improvements, and report results to management. Once the success of industrial energy efficiency gains management's commitment; only then does energy efficiency become an integral component of the day to day business of the plant.

This approach is a slow process that with management support takes years to reach its full potential. To put the benefits of industrial energy efficiency on the fast track requires an upfront commitment from management. Can management be expected to make a commitment to a loosely defined process including services that have been variously described as energy assessments, energy audits, energy surveys, and energy studies? Certainly not.

National Standards Break Down These Barriers

Management's commitment should be directed toward implementing National Standards for Industrial Energy Efficiency that represent the collective knowledge, judgment, and experience of the country's top energy, manufacturing, management, academic, and regulatory professionals.

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