

2. Energy Management

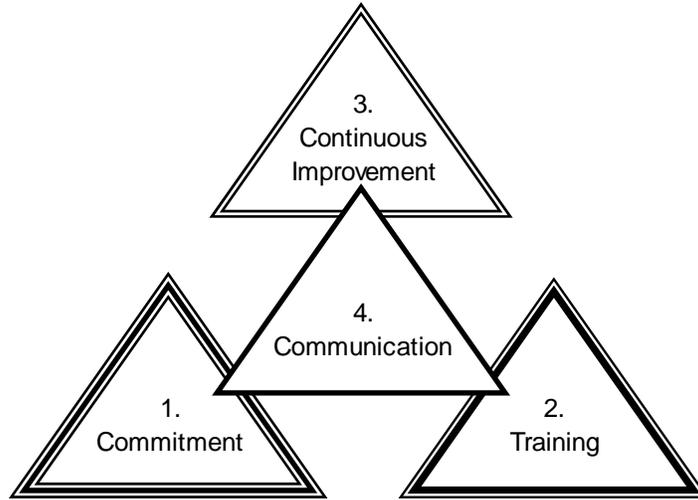


Figure 2.1 – Energy Management diagram

ENERGY SAVINGS

A strategic approach to energy management can result in significant energy savings for all types of businesses, including food processors. The management model, diagrammed in Figure 1.1, requires commitment (1) from leadership, training (2), continuous improvement (3) through strategic goals and action plans, and communication (4). This model draws on ideas from several existing programs, including the “Energy Star”¹ program developed jointly by the U.S. Department of Energy and the Environmental Protection Agency. The Energy Star Program has recently increased its participation in the industrial sector and has over 450 industrial participants including Anheuser-Busch, Ben and Jerry’s, Cargill, McCain Foods, Sargento Foods, and Weaver Potato Chip Company.

DOES EM CONFLICT WITH LEAN, TOTAL QUALITY, SIX SIGMA, ISO, ETC.?

Companies that are using management principles like Lean, Total Quality (TQ), Six Sigma, ISO 9000, and Theory of Constraints to achieve world-class performance may wonder whether an Energy Management (EM) program will work with their current initiatives. The answer, in *all* cases, is a resounding “yes.” EM will complement any initiative, regardless of a company’s place in the process. Whether a company’s just beginning TQ or well into ISO 9000, it will still benefit from a strategic energy management program.

Consider Lean. At least five of the seven forms of waste (and, arguably, all seven) usually involve energy waste. Overproduction obviously wastes energy, as do unnecessary transportation, inappropriate processing, and the production of defective

¹ For more specific information on the Energy Star for Industry, refer to http://www.energystar.gov/index.cfm?c=business.bus_index.

products. Waiting can also be a huge waste of energy if the process that is waiting for work-in-process to arrive is a continuous, high consumer of energy such as an oven or a dryer. Clearly, efforts to manage energy are consistent with reducing waste.

Similarly, there are parallels between EM and TQ. Both start with a commitment from the top, are data driven, and involve a cultural change for all of the employees in the organization. TQ provides many tools to make an EM program more effective.

Six Sigma is also data driven and focuses on improving quality of all processes. Similar to TQ, the tools of Six Sigma can and should be used to enhance the quality of an effective EM program.

ISO 9000 and ISO 14000 are also widely used in the food processing industry. These two standards will work with EM to simultaneously build high quality into the EM program and to improve the program as it develops over time.

Theory of Constraints is based on the concept that improving a few capacity constraint resources in a production system will have the greatest impact on the bottom line. In energy intensive industries like food processing, it is often the case that energy-intensive equipment, such as ovens or spiral freezers, are bottlenecks. When such equipment is truly a physical constraint, reducing energy consumption per unit by increasing the flow rate at that piece of equipment will significantly improve bottom line performance.

In summary, an effective EM program will complement current management efforts and will help improve company performance.

MAKE THE COMMITMENT

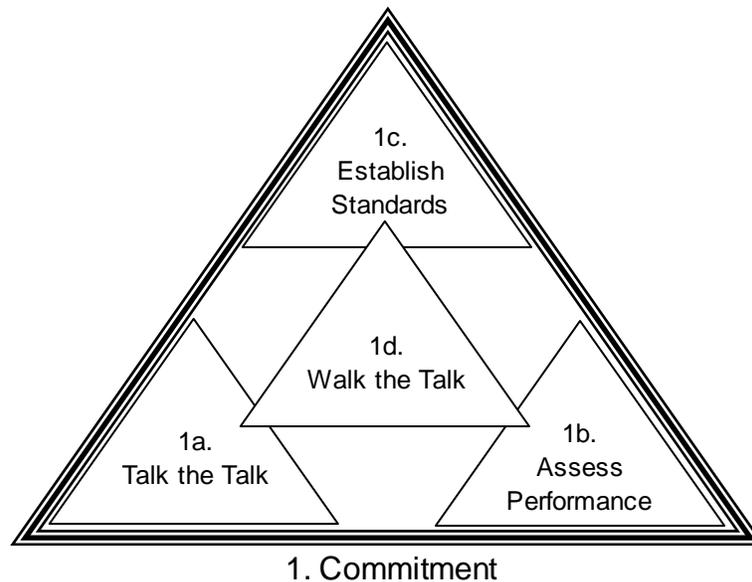


Figure 2.2 – Commitment diagram

Dr. W. Edwards Deming, an Iowa native whom many consider to be the founder of the Total Quality (TQ or TQM) movement, refused to work with an organization unless its top leaders were involved in the improvement process. Commitment starts at the top, he believed. So it is with Energy Management—an effective EM program starts with the support and participation of the company’s leaders. So, what constitutes real participation?

Talk the Talk (1a in Figure 2.2)

Company leaders must be strong advocates for an EM program. In addition to supporting a corporate energy policy, they should do the following:

- make EM part of the corporate strategic plan
- tie EM to corporate financial goals
- tie EM to corporate environmental goals

Assess Performance (1b in Figure 2.2)

An old maxim says, “If you don’t measure it, you can’t manage it.” The “it” in this case is energy performance. Once Energy Management is truly on the corporate radar screen, an initial measurement and assessment of energy performance is necessary. It should include the following:

- understanding energy cost structure
- understanding current energy usage and trends

Understanding the Energy Cost Structure

Utility companies generally determine the energy cost structure. Most utilities have multiple rate plans, which can complicate attempts to understand them. Customer service representatives work with businesses to ensure that the most favorable plan has been assigned. An onsite visit from the energy provider is one way to facilitate a discussion on energy needs and cost structures.

Chapter 3 of this publication contains detailed information about the various types of charges and cost structures that may be encountered.

Understanding Current Usage and Trends

Understanding current energy usage and trends goes hand-in-hand with understanding energy cost structures. Usage dictates the choice of rate plan, and the rate plan greatly influences cost savings strategies. As much as feasible, energy usage should be tracked by both:

- end use
- fuel type

End Use

An important step in EM is determining the exact sources of energy consumption. The Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADET) recommends establishing Energy Accountable Centers (EAC)² to facilitate this step of the process. These are production areas that are neither too small nor too large, in which energy consumption can be measured and reported independently. (It may be necessary to install meters.) For example, it may be revealing to monitor the energy consumption of a separate building, a central boiler house, or a specific production line.

Many of the details of the end-use patterns can be defined by a technical assessment or energy audit. There are many sources for these audits including private consultants, utility companies, and some government-funded organizations. For a case study of a very successful plant-wide assessment done in Iowa and facilitated by Iowa State University's Center for Industrial Research and Service (CIRAS), go to the DOE web site listed in the footnote below.³

Another valuable resource for energy assessments is the DOE-funded Industrial Assessment Center (IAC). The IAC provides free energy audits to small- and medium-sized facilities. The center that serves Iowa (and some of the area in surrounding states) is located on the Iowa State University campus. For more information about the program and eligibility requirements, check out the web site listed in the footnote below.⁴

² *Energy Management in Industry, Analyses Series 17*, Centre for the Analysis and Dissemination of Demonstrated Energy Technologies, CADET, 1995.

³ *North Star Steel Company: Iowa Mini-Mill Conducts Plant-Wide Energy Assessment Using a Total Assessment Audit*, http://www.oit.doe.gov/bestpractices/factsheets/steel_cs_northstar.pdf.

⁴ *Industrial Assessment Center*, <http://www.me.iastate.edu/iac/>.

Another resource for energy efficiency assistance is CIRAS. A field specialist will visit your site, help you assess your situation, connect you with the appropriate resources, and help you implement an EM program.

Fuel Type

Businesses that use multiple sources of fuel (e.g., electricity, natural gas, oil, and/or steam) are encouraged to keep records of the amount of each fuel type consumed. It can be useful to measure the distribution of major energy forms such as steam in order to know the total amount of steam used to operate a cooker, for example. (Remember, if you don't measure it, you can't manage it.)

Establish Standards (1c in Figure 2.2)

As previously mentioned, Dr. Deming is considered by many to be the “father” of TQM. One of the things that he found most disturbing in management practice was the setting of what he called “arbitrary” numerical goals. “In God we trust; all others bring data,” he was fond of saying. The proper approach, according to Deming, is to use data to establish energy standards.

A system of energy accounting is needed in order to collect and track useful data. This involves defining the data to be collected and the measures to be generated. Each company should develop a customized prime measure to measure whether the energy purchased is being productively utilized.

Energy Productivity Index

The energy productivity index is a ratio of energy consumed, usually stated in British thermal units (Btu), to a chosen base unit. This performance measure is very important, so the base unit must be carefully chosen. Possible base units include:

- per square foot of space
- per piece manufactured or shipped
- per pound, gallon, or some other measure of output
- per dollar of sales
- per dollar of “value added”

There are advantages and limitations for each of these possible base units. For example, using square footage makes more sense when HVAC is the primary energy consumer but less sense when process energy consumption is significant. The shortcoming to using dollars of sales is that, over time, the figure is distorted by inflation. Using pounds, gallons, or some other appropriate measure of output/volume that has a logical relationship to energy consumed is often a good approach. It may be advisable to use a monetary unit that's directly related to business performance, like dollars of value added. Using both of these measures will give management two important views: how energy management is performing when measured by cost per unit volume of output, and how energy costs compare to the prices that customers are willing to pay for the value added to the products.

Energy cost index

One additional useful index is the energy cost index. It compares the cost of energy to some base unit (as opposed to the energy consumed). The base unit should be the same unit used for the energy utilization index.

Productivity Standards

Most food processors have standards for judging the performance of their production system over time. Similarly, it is recommended that standards be established for energy usage so that the performance of the EM system can be judged over time. Two basic approaches to establishing standards are discussed in the following paragraphs.

First, engineering data can be used to calculate energy and mass balances and the amount of energy theoretically required at optimal performance for the equipment in use in the plant. While this calculation is useful, the result is often not considered “realistic” or achievable “in the real world.” For this reason, some will reject using this as a standard.

A second method is to compile data on past energy consumption. These data should be segmented by EACs whenever possible. An average consumption over some period of time can be calculated and used as a standard. To be “realistic,” it may be necessary to consider factors such as time of year; the “standard” amount of required energy can vary greatly depending on outside temperature and humidity.

While using an average of past energy consumption has the advantage of providing a better prediction of probable energy consumption in the future, it does not give any indication of how efficiently energy is being used in each EAC. For this purpose, a combination of the two methods may be useful. The calculations based on the engineering data that show theoretical optimal efficiency can be compared with the average (or seasonal average). This will give an idea of the “money on the table,” or theoretical potential savings from improving efficiency.

Organizations may choose to set the standard at the statistical average or at a different point based on the theoretical optimum. In either case, performance can be monitored against the standard and variation can be managed appropriately according to each company’s chosen management approach.

Another possible source for setting a standard is benchmarking. This subject has strong supporters and opponents. To be effective, benchmarking requires enough demographic and quality information about another company to determine whether or not a comparison is appropriate. In other words, the comparison should be apples to apples, not apples to oranges.

It may be safer to benchmark against “best practices.” For example, DOE has developed computer-based tools that allow one company that uses steam to compare itself to another

company that also uses steam. These tools can be downloaded free from the Internet at the website in the footnote below.⁵

One of the basic tenets of Lean is “perfection.” Rather than being satisfied with meeting some benchmark, companies are urged to relentlessly pursue perfection or zero waste. Zero waste in energy consumption may be hard to define, unless the calculated theoretical energy balance point mentioned earlier is used. Opponents argue that perfection is not a realistic goal because it is impossible to achieve. On the other hand, advocates stress that it is the pursuit of perfection that forces managers to look for the breakthrough ideas that bring into reach that which was previously thought to be impossible.

Assigning Causes for Variation

Once energy accounting is established and standards are set, management should begin to compare actual performance to the standards. However, these comparisons do not themselves tell what is happening. There must be a thorough understanding of the complete set of measures in order to understand whether a variation is just a “normal” statistical fluctuation or something more significant.

For example, tracking the energy cost index helps management isolate one possible source of variation in the energy productivity index. If energy productivity has degraded in the most recent period of analysis, some, or all, of the drop may be attributable to an increase in energy costs.

Additional information may be gained by tracking the trend of energy cost per Btu. This will help determine whether an increase in the energy cost index is attributable primarily to an increase in the base cost of energy/Btu or an increase in Btus per chosen unit of output.

Following are other common, identifiable sources of variation in energy costs. The time period for all such assignable factors should be noted on the data records.

- seasonal weather changes
- increases in total output
- product mix variations
- physical changes to the system, such as the installation of pollution control devices
- use of an alternative fuel
- pilot programs
- specific conservation efforts

⁵ DOE Industrial Technologies Program, http://www.oit.doe.gov/bestpractices/software_tools.shtml.

Walk the Talk (1d in Figure 2.2)

The central component in the commitment diagram (Figure 2.2) is “Walk the Talk.” Company leaders must commit resources including time, talent, and money on an ongoing basis. Attention at the outset followed in a few months by a total disregard for EM will doom the EM efforts to mediocrity at best, and failure at worst.

Indications that senior leadership has an ongoing commitment to EM include the following:

- A corporate champion is named, and, in larger companies, a team is identified.
- Accountability is clearly established.
- EM is an agenda item at all regular leadership meetings.
- The energy policy is evaluated regularly and updated as needed.
- Adequate budget is provided annually for effective EM.

TRAIN PERSONNEL AT ALL LEVELS

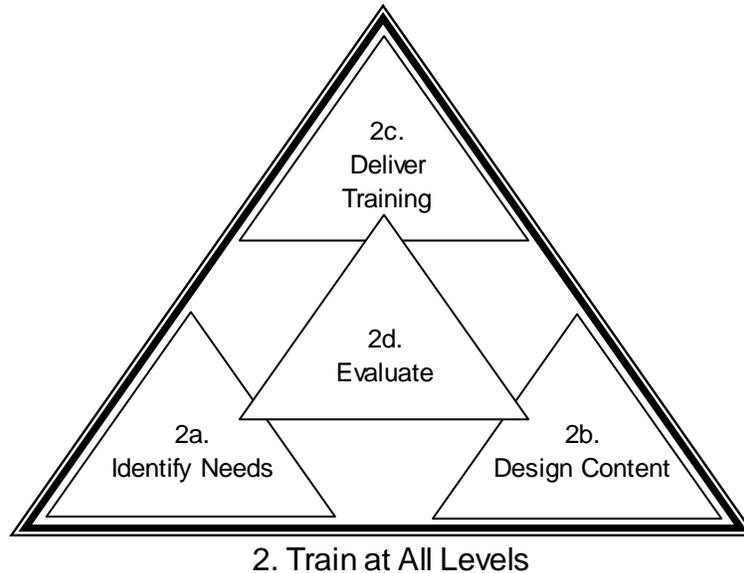


Figure 2.3 – Training diagram

After top leaders in the organization have made the commitment to an EM system and after current energy performance has been assessed and standards are set, it is time to provide training for all company personnel. Sharing information and increasing the knowledge level of employees is a prerequisite to a successful EM system. The opportunity to express personal opinions, ask questions and get answers generally increases the level of engagement for individuals. Feeling engaged is a prerequisite to being motivated.

Identify Needs (2a in Figure 2.3)

Initially, every employee will need some training on topics such as awareness of the corporate energy policy, current usage and trends, basic EM terminology, and energy measures. More specific topics such as “Boiler Management,” or “Assessing Return On Investment in Energy Projects” will be targeted to smaller groups. Be sure to take the time to identify the general and specific needs of the entire staff.

Design Content (2b in Figure 2.3)

In creating content, begin by identifying the specific learning objectives for the targeted individuals. The delivery methods and materials should be chosen to maximize the likelihood of reaching the learning objectives. Training that is specific to a company program will probably have to be developed in house. Training on more standard topics, such as “Boiler Management,” is commercially available from professional sources.

Deliver Training (2c in Figure 2.3)

Planning and good intentions don't move an EM program forward. A training calendar should be established, and all staff should be scheduled for the training that they need. Follow-through is critical in establishing in the minds of employees that EM is truly important to the organization. Training is best delivered during the staff's paid time, in a facility that is conducive to learning and that is free of work interruptions.

Evaluate (2d in Figure 2.3)

It is important to determine the effectiveness of the training. Evaluate each learning objective in each session. In addition, it is usually beneficial to ask participants about the following:

- effectiveness of the instructor(s)
- effectiveness of the delivery methods (videos, etc.)
- value of any handout materials
- quality of the training facility

Of course feedback is good, but it is not much good unless it is used! Use the feedback to make changes to training sessions. Re-evaluate and compare scores to determine if the changes are actually improvements.

CONTINUOUS IMPROVEMENT CYCLE

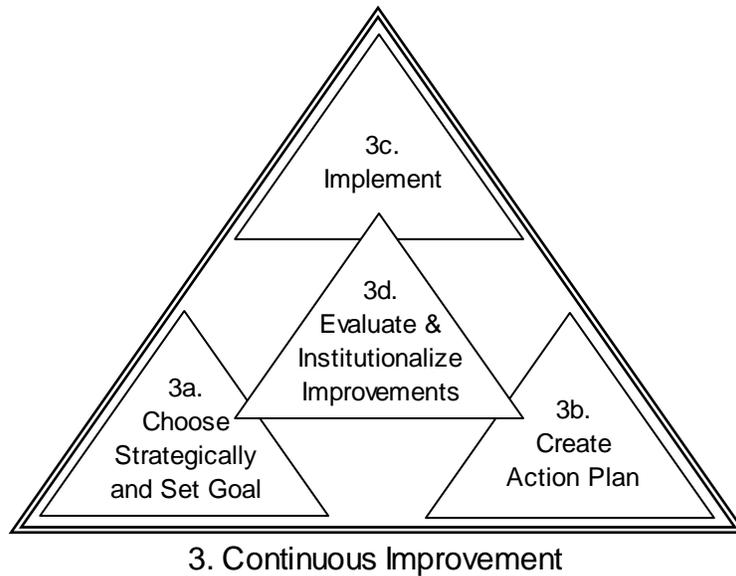


Figure 2.4 – Continuous improvement diagram

Figure 2.2 and Figure 2.3 show the steps required to start an Energy Management initiative. Once begun, the remaining steps can best be characterized as a continuous improvement cycle beginning with Choose Strategically and Set Goal (1), Create Action Plan (2), Implement (3), and Evaluate and Institutionalize Improvements (4). The cycle begins again as the next strategic opportunity is identified and a new goal is set.

Choose Energy Projects Strategically (3a in Figure 2.4)

Strategy is used here to encompass both the global corporate level as well as the EM program.

Consider the global corporate level. First, EM should be part of the corporate strategic plan. Second, EM projects should ultimately contribute to the non-energy-related portions of the corporate strategic plan. The latter may sound difficult at first, but it is actually quite simple. Energy costs are an unavoidable part of doing business, and any money spent on energy cannot be spent on marketing, personnel, etc. Reducing energy costs frees up resources for the non-energy-related components of the corporate strategic plan.

When identifying projects with the potential to save energy, be sure to solicit input from all employees. They frequently have ideas that are easy to implement and provide excellent results.

Now consider choosing projects strategically within the EM program. This requires comparing two important factors of potential energy projects: (1) the potential impact of a successful project to company finances; and (2) the investment required for implementation.

It is a good strategy to start with no- or low-investment projects that have moderate or high potential for savings. A significant portion of the savings generated by these projects should then be budgeted to finance the investment in more costly projects.

Assessing Financial Impact

This can be a very challenging but important component because it is the key to strategic choice. Although the merits of a project may seem clear to those who work in the effected area, it may be difficult to get buy-in from the boss or the financial officer. The challenges can be minimized if the case is presented in financial terms. Three common types of financial analyses are:

- payback period
- rate of return
- total life cycle cost

The *payback-period* analysis is commonly used, in part, because it is simple. To make the calculation, divide the cost of doing the project by the annual savings or return from a successful project. For example, if it would cost \$25,000 to implement changes and the annual savings are projected to be \$15,000, then the payback period would be 1.67 years (25,000/15,000). Most companies set a maximum that is acceptable for a payback period and reject projects that do not meet the test.

The *rate of return* method involves other factors and more complex concepts such as net present value, interest rates, and depreciation. A detailed explanation of these factors is beyond the scope of this publication. There are resources available to explain these terms and even to help make the calculations. For example, DOE offers several software packages that will take the information and calculate projected savings. These tools are available at the website in the footnote below.⁶

Although the *total life cycle costing* method is a complex way of evaluating projects, it is gaining support as a more accurate picture of long-term impact. Depending on the complexity of the model, total life cycle will consider owning and operating costs as well as such factors as environmental impact and costs, disposal/recycling costs, etc. For projects that may not meet the required investment threshold using other methods, this long-term look at cost may show that it is indeed a wise investment.

No matter what method of financial analysis is used, it is *critical* to carefully account for not only the savings that come directly from a project, but also any measurable “returns” that are caused by the project or made possible because of it. For example, before switching from a blast freezer to a spiral freezer, a food processor can compare the cost of the new equipment to its projected energy savings. If calculations show a payback period of 3.8 years, a 5% rate of return, and an unfavorable total life cycle cost, the project is likely to be rejected. However, if further analysis shows that using the spiral freezer in a continuous flow process would enable the same production crew to increase the daily output by 5%, which, in turn, could be converted to increased sales, the

⁶ DOE Industrial Technologies Program, http://www.oit.doe.gov/bestpractices/software_tools.shtml.

resulting increase in profits may well reduce the true payback period to a matter of months. So, be sure to consider all impacts when making a strategic choice of projects.

Set the Goal (3a in Figure 2.4)

Goal setting can be a controversial subject. Dr. Deming argued vehemently against what he called arbitrary numerical targets. “Substitute leadership,” he said. To arbitrarily say the goal is to “decrease energy costs by 10%” would probably be an example of what Dr. Deming objected to.

However, the Energy Star web site⁷ contains some excellent examples of companies that have set high-level goals for their Energy Management efforts. For example, the Food Lion grocery chain has set a long-term goal to “become one of the most efficient grocery stores in the world on a Btu per square foot basis.”

Dr. Deming is also quoted as saying, “In God we trust; all others bring data.” In order to reach their goal, Food Lion must take the actions outlined in this chapter. Steps 2, 3, and 5 are all part of the effort to “bring data.” Food Lion must assess and compare their own performance to their chosen standard of “one of the most energy efficient grocery stores in the world.” They must do some benchmarking to find out what is meant by world-class level of energy consumption for grocery stores. Armed with this information, they can set an informed numeric goal.

Benchmarking will help avoid arbitrariness. Also needed is a systematic approach to continuous improvement. To give people a goal that requires improving the underlying system but not give them the means to change/improve that system would be viewed by Dr. Deming as both arbitrary and de-motivating. The means to improve the system requires the authority that comes from the Commitment (1) of management and the Continuous Improvement (3) cycle in the EM model in Figure 2.1.

Create an Action Plan (3b in Figure 2.4)

The steps needed to achieve improvement should be carefully planned and, at a minimum, should include the following:

- clear statement of desired outcomes and success measures
- list of resources that are and are not available
- sequential list of steps involved
- list of key milestones or intermediate indicators of success
- expected completion date
- clear explanation of reporting requirements (frequency and scope)
- rewards if successful (if applicable)

Be sure to consider the potential negative impacts on product flow and peak energy demand. It is usually advisable to test proposed changes at the pilot level, if possible. For

⁷ Energy Star®: http://www.energystar.gov/index.cfm?c=performance_goals.determine_scope#success1.

example, if you have four air compressors, plan to make the changes on one and measure the impact.

Implement the Plan (3c in Figure 2.4)

Follow-through is the key to success. Execute the plan step by step. Monitor progress regularly. If progress is made, implementation should continue. Or, if the evaluation indicates a problem, adjustments should be made to the action plan.

Evaluate and Institutionalize Improvements (3d in Figure 2.4)

Evaluate the success of implementation against the goal established at the outset. If the project was at the pilot level and the implementation was successful, the changes should be institutionalized and implemented across the larger system. This may need to be done in phases, depending on the number of pieces of equipment and the capital costs involved. Data collected during the pilot phase should make the computation of financial return easier and justify the additional investment.

Continue the Cycle

As a project is completed, it is time to begin the next pass through the continuous improvement cycle. Go back to step 1: strategic selection of the next project and setting of the goal.

COMMUNICATION

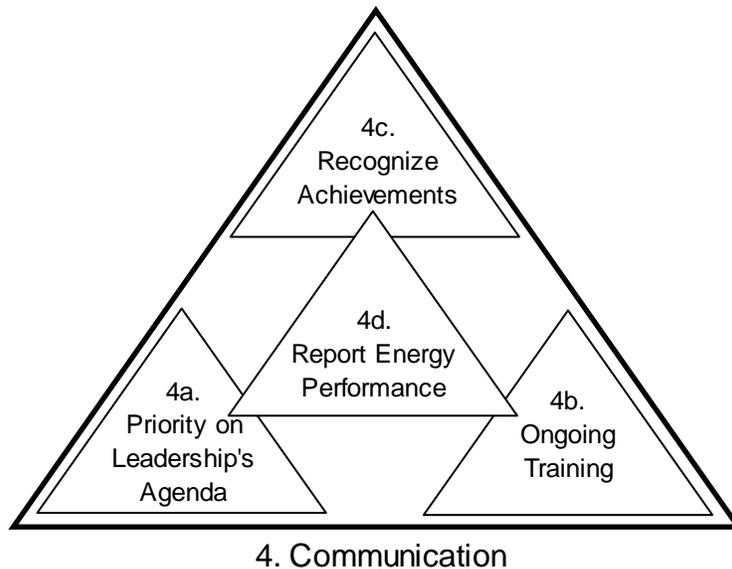


Figure 2.5 – Communication diagram

The centerpiece of the EM model in Figure 2.1 is communication. It is the lifeblood of a successful EM initiative. If Energy Management is not a regular topic of discussion in the company, it will soon be labeled as the latest “flavor of the month.”

EM is a Priority Item on Leadership’s Agenda (4a in Figure 2.5)

The commitment section pointed out that success starts at the top, and it must stay there. Energy should remain prominently on the “radar screen” of company leaders. Remember Dr. Deming’s advice to “bring data.” Company leaders rightfully expect and need the data that will help them make better decisions.

Ongoing Training (4b in Figure 2.5)

Just as management commitment must be ongoing, training must continue over time. The training mix will change as fewer hours are spent on general awareness and terminology, and more time is spent in specific and often technical training. Remember to adequately train new employees as they enter the system.

Recognize/Celebrate Achievements (4c in Figure 2.5)

Recognizing and celebrating the achievements of the EM initiative will bolster employee morale and continue motivation. Employees need to see that their efforts are appreciated and that they make a difference! In its comprehensive communications kit, Energy Star notes that “Communicating your achievements is important because it can motivate employees, enhance customer loyalty, demonstrate your corporate responsibility, build a

broad base of support for your energy efficiency initiatives, and make a lasting impact on the environment.”⁸

Report Energy Performance (4d in Figure 2.5)

The centerpiece of communication is reporting energy performance. Everyone in the organization should be continuously aware of the current facts and figures on energy performance. Communicate regularly using a standard, easy-to-understand, and accessible format.

Provide the appropriate information in the most understandable format to each level throughout the company. For example, senior management will probably require different information in a different format than will the engineers in the steam room.

Information on energy performance should also be shared with those responsible for planning training. This will help them identify what training is needed during the ongoing process.

⁸ *Energy Star: Business Improvement*, http://www.energystar.gov/index.cfm?c=ck.ck_communications_kit.

RESOURCES

Printed Material

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Wulfinghoff, D.R., Energy Efficiency Manual, Energy Institute, MD, 1999.

On-Line Tools

U.S. Department of Energy

DOE Best Practices in Energy Management: <http://www.oit.doe.gov/bestpractices/>

DOE Plant Wide Assessments: <http://www.oit.doe.gov/bestpractices/assessments.shtml>

Energy Matters: www.oit.doe.gov/bestpractices/energymatters/energy_matters.shtml

Software Tools: www.oit.doe.gov/bestpractices/software_tools.shtml

- Process Heating Assessment and Survey Tool (PHAST)
- Steam System Scoping Tool
- Steam System Assessment Tool (SSAT)
- 3E Plus – Insulation Thickness Computer Program

Energy Star for Manufacturers:

http://www.energystar.gov/index.cfm?c=manuf_res.pt_manuf

Organizations

Association of Energy Engineers: www.aeecenter.org

Iowa State University Industrial Assessment Center (IAC): (515) 294-3080 or www.me.iastate.edu/iac

United Kingdom Energy Efficiency: www.etsu.com