# Manufacturing and Energy Supply Chains Office Best Practices

The Office of Manufacturing and Energy Supply Chains (MESC) in the U.S. Department of Energy (DOE) has developed a range of tools and guidelines that are of prime interest to industry. The "Best Practices" program includes a set of tools dealing with various aspects of industry, such as steam and its use, pump systems, selection of motors, etc. The program identifies opportunities to save energy and increase efficiency, with the use of new technologies and system improvements to carry out those opportunities. There are five main areas on which the Best Practices program focuses. These are some of the more energy consuming aspects of industry and also those that have the highest potential for better efficiency and energy savings. Tools are now available for the areas of motor systems, compressed air systems, pumping systems, steam systems, and process heating systems. Aside from what is available from the Industrial Assessment Centers, more information can be accessed at the MESC web site homepage at <http://www.eere.energy.gov/industry>.

**I. Motors**

Motors account for 65% of electricity consumed in U.S. industries. With such high usage, even some of the smaller changes can result in large savings. Some of the suggestions that MESC has regarding motors are simple, resulting in a better working system. The first is replacing V-belts with cogged or synchronous belts. Cogged belts can sometimes run on existing pulleys that V-belts use, but at cooler temperatures and with 2% more efficiency. Synchronous belts need different toothed pulleys that do not slip, require less maintenance, and are 5% more efficient compared to V-belts.

Elimination of voltage imbalances in motor systems can result in better motor systems. Voltage imbalance is defined as the maximum percentage deviation of the line voltage from the average voltage. Specifically, it is a hundred times the absolute value of the maximum deviation of the line voltage from the average voltage on a three-phase system, divided by the average voltage. This voltage imbalance creates current imbalances in the system, increases vibrations, losses, torque pulsations, mechanical stresses, and could result in motor overheating. Regular monitoring of this situation will increase the productivity of motors.

Optimization of the system that the motor is driving, e.g., pumping systems, will also decrease motor load. This will ensure that the motor is producing the proper amount of power and, for the load in question, that it is not being overworked or wasting energy.

Aside from these suggestions, MESC has other tools that are part of the Best Practices program: case studies with specific examples, publications relating to motors, and software. The software offered includes MotorMaster, which examines the energy efficiency of over 20,000 AC motors, along with protocols, to determine choices, such as replacing versus rewinding motors. MESC also offers training sessions specifically for the betterment of motor systems and their efficiency.

**II. Pumping Systems**

Industries use pumps extensively, and the optimal designs of the pump to the flow and head requirements are crucial for energy efficiency. As mentioned previously, the motor used for the pumping must also be matched using techniques presented in section I. There are two primary ways to minimize energy consumption in flow systems. The overall system head and friction in pipes (major and minor losses) can be decreased, and the size of the pipes for the flow can be optimized. Pipes that are too small or too large can result in overworking the pump or wasting energy. Reduction of the overall friction creates less resistance in the pipes and allows for more efficient and smoother flow of fluid in the system.

DOE has developed a software tool called PSAT (Pumping System Assessment Tool) for the optimization of flow systems. This software package assesses the efficiency of the pumping systems operation and provides ways to improve it. DOE also offers training sessions for using PSAT.

**III. Compressed Air**

Compressed air is used extensively in industry for pneumatic transport, power tools and many related activities. Gases are difficult to compress, and it takes a lot of energy to increase the pressure of a gas even under the most ideal (isentropic) conditions. Compressed air systems are one of the most expensive systems to operate and, thus, fixing problems can produce large yields in energy savings.

One of the ways to reduce costs of compressed air is to limit its usage around the plant. If there are applications in which compressed air is not entirely necessary, then replacing it with lower pressure blowers or fans will be more energy efficient. Leaks in compressed air systems are the biggest contributors to energy loss, wasting 20-30% of the energy input of compressors. Leaks are most likely to occur at couplings, valves, and pipe joints. They can cause pressure fluctuations and result in the system working harder than necessary, resulting in additional maintenance and decreased service life. Another area of energy loss involves part-load operation of the compressor and quite often includes even idling of the unit. Both modes of operation of the compressor are expensive and must be minimized with the proper management of the air storage system.

MESC also has a particularly useful software tool entitled AirMaster that takes into consideration all of the issues discussed above. AirMaster assesses compressed air systems and includes molding capability and savings evaluation. The MESC website lists many opportunities for training available and publications for this AirMaster.

**IV. Steam Systems**

Steam is an indispensable commodity in industry and is used for many purposes, such as power generation, process heating and even cleaning. Over 45 percent of fuel consumed in industry is used to generate steam. As with many process devices, keeping boiler and steam equipment in proper working order and having newer, more efficient equipment can save up to 20 percent of energy and cost. There are four areas where improvements can be made to better a steam system. They are: steam generation, steam distribution, steam end-use, and steam recovery.

In steam generation, optimization of boiler combustion (excess O2 in the flue gases) can increase the efficiency of the boiler by 1 percent for every 15 percent of excess air. Even boilers that have scheduled preventative maintenance and checks routinely have improper air-to-fuel ratios. The importance of maintaining proper ph and water quality in the boiler cannot be overstated, and keeping the water and fire sides of the boiler clean creates better heat transfer. Optimizing boiler blow down reduces total dissolved solids in the boiler, and optimizing the boiler's control system keeps it running at optimum efficiency.

As steam is transferred throughout the system, it can lose some of its enthalpy. Insulating all pipes, flanges and valves, as well as having the correct sizes and shapes of all distribution steam traps, is essential for good efficiency. The boiler pressure must be matched to system pressure and all system components should be sized for minimum pressure drop. All steam mains must be properly drained and ventilated. Lastly, proper anchoring and connecting of the systems with allowance for expansion is necessary.

When the steam is transported to where it is needed, the equipment using the steam should be used to maximize the effective use and heat of the steam. Items to be checked include proper size, shape, and maintenance of steam traps for their specific use. Also, blow down of non-condensables from condensing equipment is critical because for every 1% of non-condensables in the fluid, heat transfer coefficient decreases by 10%.

Making the most out of the remaining steam and condensate is also important. Returning more condensate into the boiler will help save energy in the boiler and in the water treatment. The piping used to transfer the condensate should be well insulated and needs to be a size that can handle both liquid and vapor flow. If possible, the hot condensate should be sent to a flash recovery system for low-pressure steam needs.

To help calculate the needs and specifications for a steam system, MESC software is available from their website. The Steam System Assessment Tool (SSAT), the Steam System Scoping Tool, and 3E Plus are some of the software packages available that can be used to optimize a steam system.

**V. Process Heating**

Process heating accounts for approximately 17% of energy that is used in industry. It is the heat that is needed to produce basic materials and commodities. Having current equipment and technology is the easiest way to improve the efficiency of these systems. As in boilers, making sure that the air-to-fuel ratio of the burners is maintained at proper levels will keep emissions down and produce better combustion. Whenever possible, the air flowing into the combustion chamber should be preheated. This reduces the amount of fuel needed by the furnace, and fuel savings of 13−50% can be achieved. The Process Heat Assessment and Survey Tool is a program available from MESC to help increase the efficiency of the process heating systems.

**VI. Other Useful Information**

MESC offers many products and programs to help increase the understanding of various energy using systems to make industry more productive and efficient. There are many more software packages available than the ones mentioned above, which can be found at the MESC website (<http://www.eere.energy.gov/industry>). There are numerous training sessions available year-round and across the country. Many of these training sessions are system-wide and component specific. MESC has trained individuals to become qualified specialists with the assessment tools, and some of them can be reached through the IAC programs, including Lehigh University.

Additional information is available from IACs, Allied Powers, and NIMAP (National Inventory of Manufacturing Assistance Programs) on the MESC website, as well as listings in many industry publications. Another source for such information is through the MESC Clearinghouse by phone (1-800-862-2086), which can give answers to questions regarding services, publications, and products. A relatively small investment in this area could lead to potentially large savings.

# Energy Resources and Management

**Energy Management**

Most companies and plants tend to have a very short-term, price-driven view for managing their energy needs and resources. For the long haul, a corporate energy policy based on sound principles is a necessary ingredient for the economic operation of a manufacturing facility. Successful corporate entities manage not only their energy use and conservation, but also keep a close eye on their waste streams and their minimization, as well as on opportunities for improvement of productivity. Some of the important steps that should be part of an effective resource management plan are:

* Commitment of the Management
* Maintenance of good records and databases of existing practices
* Analysis of opportunities for conservation
* Implementation of plant modifications for conservation opportunities
* Systematic analysis and feedback to ensure the process is continued.

Programs for the management of energy must have the commitment of the management to be successful in the long-term and to improve energy efficiency. As can be expected, brief shows of support will result in only small and temporary improvements. The corporate executives must design the conservation program as part of regular, overall company management practices. As part of this practice, the plant personnel should be made aware of energy costs and the consequences of future energy shortages.

Most companies are aware of energy costs but may not be clear as to the costs associated with lack of a corporate energy program. Such a program should include a method of keeping up-to-date bar (or other) graphs of energy consumption and associated costs on a monthly basis. As utility bills are received each month, the new data should be included on such graphs. Such pictorial views of the situation can be very helpful when making good decisions. It is also helpful to track various energy streams (electricity, gas, oil, etc.) separately. The data available for your plant is depicted on the following pages. Trends and anomalies are easily viewed from a graphical representation, and thus conservation measures are more easily ascertained.

Use of a standard format and units for all energy streams (e.g., Btu or MMBtu), rather than different units (such as kilowatt hours for electricity, therms, or ft3 for gas, gallons for oil), also provides better data analysis and appreciation. One Btu is the amount of energy necessary to raise the temperature of one pound of water by one degree Fahrenheit. By comparing the cost of all energy streams using the same energy units ($/MMBtu), the true cost is easier to compare. The conversion factors for various energy units are:

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| --- | --- | --- |
| **Energy Unit** | **Energy** | **Energy Equivalent** |
| 1 kWh | 3,412 Btu | 3600 kJ |
| 1 Therm | 100,000 Btu | 29.31 kWh |
| 1 Decatherm | 1,000,000 Btu | 293.1 kWh |
| 1 Cu.ft. of Natural Gas | 1,000 Btu\* | 0.2931 kWh\* |
| 1 Mcft of Natural Gas | 1,000,000 Btu\* | 293.1 kWh\* |
| 1 Gallon of Propane | 91,600 Btu\* | 26.85 kWh\* |
| 1 Gallon of #2 Oil | 140,000 Btu\* | 41.03 kWh\* |
| 1 Gallon of #4 Oil | 144,000 Btu\* | 42.20 kWh\* |
| 1 Gallon of #6 Oil | 152,000 Btu\* | 44.55 kWh\* |

\* Varies slightly with source or supplier.

**Waste Management**

Effective waste management and waste minimization starts with a complete inventory of all plant wastes, both hazardous and non-hazardous, so as to understand the types and sources of all waste streams. Accounting for exact quantities and costs is important to this process. When this has been done, it is necessary to analyze this information from economic, legal and technical perspectives, and, finally, to prepare a comprehensive waste plan that addresses corporate concerns in the most effective way. The Environmental Protection Agency recommends the following four-step process for effective waste management.

Planning and Organization

* Establish management commitment
* Set overall assessment program goals
* Organize assessment program team

Assessment Phase

* Collect and process plant data
* Prioritize and select assessment goals
* Inspect plant and review plant data
* Generate and select options for study

Feasibility Analysis Phase

* Technical evaluation
* Economic evaluation
* Select options for implementation

Implementation

* Finalize funding for justifiable projects
* Install equipment
* Implement procedures for savings
* Evaluate performance.

An environmental audit is an essential part of a waste management plan. The assessment described in this report and the recommendations described on the following pages should not be construed as a full-scale environmental audit. Despite that, some "common sense" waste reduction opportunities, such as eliminating excess water use, can be identified relatively easily. For less obvious measures, it is better to incorporate a more systematic process to gather the following information for each stream:

* Waste source
* Rate of generation
* Implement procedures for savings
* Physical characteristics
* Chemical characteristics
* Waste management methods
* Cost of methods being used.

As a general practice, waste streams should be segregated. It is better to reduce waste generation rather than recycle, and it is preferable to recycle rather than treat waste.

Progress towards conservation goals should be checked on a regular basis and goals refined when possible. Refinement of goals will be dependent upon opportunities uncovered as part of this continuing review process and associated data analysis.

**Energy Charges**

Charges for electrical energy can be broken down into administrative, generation, distribution, and demand charges. Energy charges include those pertaining to the generation of electricity and for the transmission and distribution of the energy. They are based on the number of kWh used by the plant and can vary with time of day and with peak and off-peak rates per kWh of energy used.

Demand charges are a way for the utility company to recover capital investment required to provide generation capacity during peak times. The demand is the highest usage (kW) peak averaged over a 15-minute period, so that very short spikes (such as the starting of motors, etc.) will not artificially raise the demand charge.

The monthly electric bill from the power company is based on consumption (kWh), billing demand (maximum KW during a 15-minute period during the month), power factor, (PF) and, of course, applicable taxes and surcharges. These data for your plant are listed below. Many utilities have different rates for a kWh in different usage categories. Traditionally, the higher the energy usage the lower the cost of electricity per kWh will be. These items may or may not be shown separately on your bill. Since an AR could affect any combination of the above parameters, **the** **actual dollar savings could differ from the estimated dollar savings shown in this report**. Note, also, that an AR involving only a reduction in demand (KW) or power factor (PF) improvement saves only dollars, not energy consumption (kWh).

Energy savings are calculated based on average costs. Average costs are the cost of a unit of energy purchased for the total usage. Marginal costs for energy are sometimes smaller than average costs since they do not include administrative and other fixed costs, and thus average costs are used.

The average natural gas/fuel oil cost is based on usage during winter and summer months. This data is also summarized below. Sometimes, the cost of gas/fuel oil is lower in the summer than in the winter months. In all of our calculations, involving natural gas or fuel oil, average values are used. We do not expect any significant changes in potential dollar savings for most of our recommendations involving natural gas or fuel oil.

Unlike energy, the data regarding waste streams and associated costs (disposal, handling, labor, and others) is generally not readily available. The quantification of data for waste streams is based on discussions with the plant manager and/or other appropriate plant personnel. In rare instances, subjective estimates of the necessary data are used.

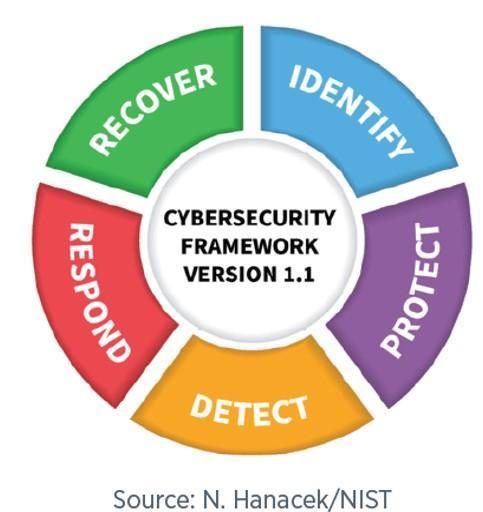
# Cybersecurity

Industrial Assessment Centers work with manufacturing clients to increase awareness of cybersecurity risks and potential mitigation activities. As part of facility site visits, IAC clients may elect to receive cybersecurity risk assessments to identify security and privacy deficiencies to the business infrastructure, with a focus on vulnerabilities associated with industrial controls systems.

The IAC Industrial Control Systems Cybersecurity Assessment Tool includes 20 simple questions to characterize industrial controls systems and plant operations. The tool then provides a high-level assessment of risk (high, medium, or low). The companion User Guide provides additional context for the questions included in the tool, to help clients understand how certain business practices lead to cybersecurity risk. Upon conclusion of the assessment, the tool generates a customized list of action items associated with the risks identified. For additional guidance, IACs refer clients to additional technical resource materials available through the NIST Manufacturing Extension Partnership (MEP) and other organizations.

**Cybersecurity Fundamentals for Small and Medium Sized Manufacturers**

Most plant operations managers are not cybersecurity experts, but can benefit from a basic understanding of cybersecurity risks and mitigation activities. A guidance document provided by NIST, NIST Small Business Information Security: The Fundamentals, provides a thorough and easily readable overview of cybersecurity basics.

As a first step, organizations need to understand their cybersecurity risks, to determine where the organization is vulnerable and may be subject to disruption of systems and processes. Organizations can use helpful checklists from the NIST document, or other cybersecurity assessment tools, to conduct the following activities:

* Identify what information your business stores and uses
* Determine the value of your information
* Develop an inventory of technologies used to store and process information
* Understand your threats and vulnerabilities

When risks are understood, organizations can determine appropriate mitigation activities. Example activities are shown below, grouped into the five broad categories of the NIST Cybersecurity Framework:

**Identify**

* Identify and control who has access to your business information
* Conduct background checks
* Require individual user accounts for each employee
* Create policies and procedures for information security

**Protect**

* Limit employee access to data and information
* Install surge protectors and uninterruptible power supplies (UPS)
* Patch your operating systems and applications
* Install and activate software and hardware firewalls on all your business networks
* Secure your wireless access point and networks
* Set up web and email filters
* Use encryption for sensitive business information
* Dispose of old computers and media safely
* Train your employees

**Detect**

* Install and update anti-virus, -spyware, and other –malware programs
* Maintain and monitor logs

**Respond**

* Develop a plan for disasters and information security incidents

**Recover**

* Make full backups of important business data/information
* Make incremental backups of important business data/information
* Consider cyber insurance
* Make improvements to processes/procedures/technologies.

**For additional information, please visit:** <https://iac.university/cybersecurity>.

# Appendix: Rebates

Many utility companies provide rebates for energy efficient projects. Based on the availability of these rebates and discussions with Pennsylvania PPL and UGI Rebate Personnel, as well as PSE&G literature for New Jersey Clients, the cost savings for the recommendations for:

|  |  |
| --- | --- |
| * Switching to LED Lighting * Installing smart thermostats * Installing Variable Frequency Drives on electric motors and air compressors * Replacing old gas boilers | * Replacing old HVAC Units * Installing air/strip curtains * Replacing old heaters/heating HVAC projects |

are considered to be eligible for rebates. There are several categories of rebates relating to lighting, HVAC, and electric motors (these can also be considered “custom projects”). Each utility has its own rate regarding rebates. These rates are billed on the amount of annual energy savings shown below:

|  |  |  |
| --- | --- | --- |
| **Utility Company** | **Electricity Savings** | **Gas Savings** |
| PPL | $0.075/kWh + $215/kW |  |
| UGI |  | $2-10/MMBtu |
| PSE&G | $0.16/kWh | $35/MMBtu |

**New Jersey:**

<https://nj.pseg.com/saveenergyandmoney/energysavingpage/energyefficiency>

<https://bizsave.pseg.com/home/custom-energy-efficiency-solutions/>

**Pennsylvania:**

<https://www.pplelectricbusinesssavings.com/ppl-business/incentives/overview/>

<https://www.ugi.com/rebates-for-business/natural-gas/>

For the purpose of the calculations, a conservative value of the rebates will be considered as: $**0.075/kWh** for all electrical savings and **$2/MMBtu**. The rebate program should occur with the permission of the utility company. Some projects may have to be approved prior to the beginning of the work, with LED being the exception. Certain contractors are pre-approved by the utility companies to install projects that are liable for rebates, and there are also options to acquire a rebate for in-house installation. Note all projects must be submitted, with all documentation in good order, within 180 days of the project completion date. Incentives are capped at 50 percent of project cost, up to $500,000.