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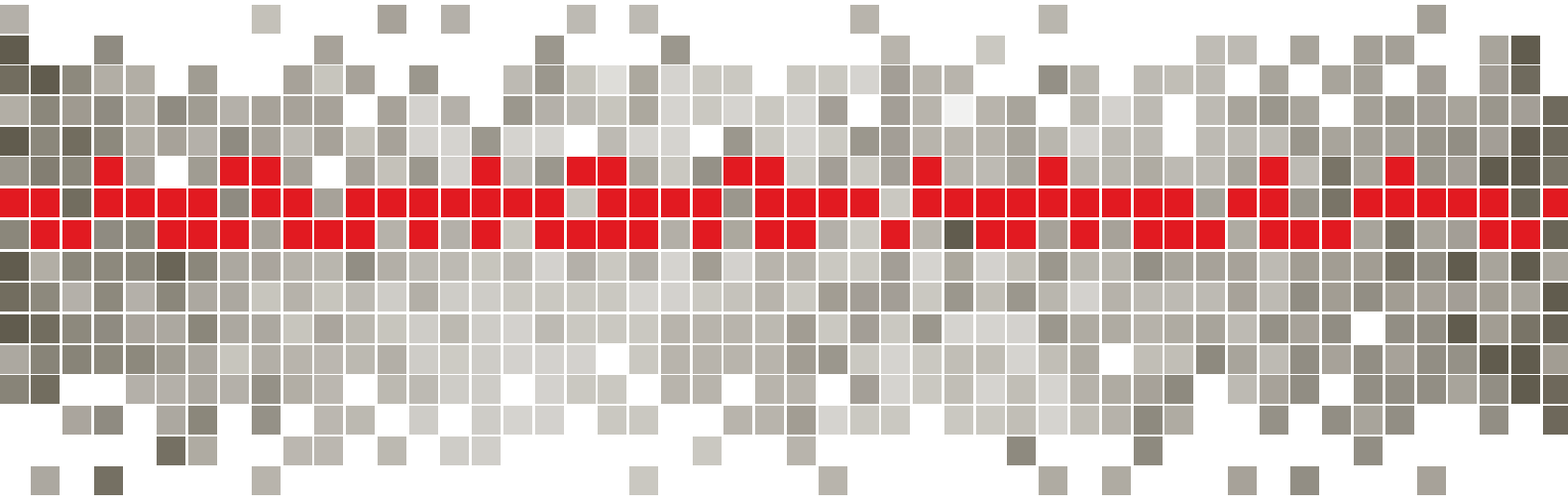
WHITE PAPER

by Mitsubishi Electric



Monitoring and Managing Factory Energy Use to Improve Operational Efficiency and Reduce Costs

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eco Changes

Whether manufacturing automobiles, packaging consumer goods, or distributing products, plants have the opportunity to reduce their energy consumption.

Introduction

Energy prices are on the rise due to many factors, including utilities' capacity issues, energy supply uncertainty, environmental regulations, aging energy grids, and competition for available energy supplies. At the same time, competitive pressures in factory automation demand higher productivity at lower costs. Most manufacturing companies and other energy-demanding businesses perceive energy bills as a cost they must bear, rather than one that can be managed. While many operational costs are fixed, energy costs can be managed to help businesses maintain a competitive edge.

Even businesses with difficult or demanding production processes can reduce energy costs without compromising production quantity or quality. In fact, companies that fail to reduce their energy consumption face a competitive disadvantage because they miss the opportunity to improve profit margins.

Some serious inroads are being made to make manufacturing a far more energy efficient industry. This is not solely an altruistic attempt to save the planet, but because it makes good business sense. Manufacturers of any size can make a big impact on both the environment and the bottom line by taking steps to control their energy usage.

Whether manufacturing automobiles, packaging consumer goods, or distributing products, plants have the opportunity to reduce their energy consumption. Focusing on energy efficiency not only has environmental benefits, but also can have a direct impact on profitability. The first step to proactively managing energy use is monitoring its use.

Why energy monitoring is necessary

Energy monitoring can help companies find potential for energy reduction, which in turn helps them determine required energy-efficiency improvements. Effective energy management requires identifying energy inefficiencies in the plant so they can be addressed.

Identifying idle equipment, for example, can improve operational efficiency. Improvement of the equipment utilization rate, for example, can reduce unnecessary energy used by equipment waiting time and downtime, while reducing the takt time saves energy by decreasing the equipment operation usage while maintaining the same production quantity.

Action	Observed Savings
Installation of meters	0 to 2% (the "Hawthorne effect")
Bill allocation only	2-1/2 to 5% (improved awareness)
Building tune-up	5 to 15% (improved awareness and identification of simple O&M improvements)
Continuous commissioning	15 to 45% (improved awareness, ID simple O&D improvements, project accomplishment and continuing management attention)

Fig. 1, Observed savings from energy monitoring

Improving productivity efficiency by managing specific energy consumption should be a priority on the shop floor. Specific consumption refers to the amount of energy consumed to produce one unit of a product.

For the successful reduction of energy use, it is necessary to introduce energy-saving equipment to the plant floor.

The key to achieving this lies in linking energy information obtained from each piece of production equipment and device with production information. Then the production efficiency and manufacturing cost of each part, product, equipment, and work process must be assessed from an energy perspective employing production energy efficiency as an indicator of improvement.

The U.S. Department of Energy outlines the potential savings for measuring the energy assets. According to the table shown in **Figure 1**, up to two percent in energy savings can be realized with metering infrastructure in place.

Energy-Saving Measures

Once a manufacturing facility has made energy efficiency a goal, energy savings should be pursued in four steps:

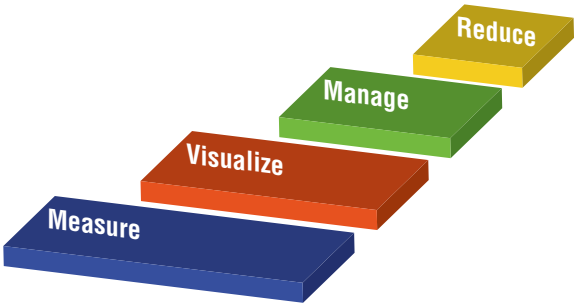


Fig. 2, 4 steps to effective energy management

An important factor of energy measurement is the collection of energy data in connection with production information, rather than simply gathering energy use data from the shop floor. Energy use should be measured in terms of production conditions and the operating status of the equipment.

In the visualization step, the energy and production information collected in the measurement step must be analyzed. Then that information should be visualized by part, product, and equipment.

For the successful reduction of energy use, it is necessary to introduce energy-saving equipment to the plant floor. High-efficiency equipment can have a significant impact on reduction of energy consumption.

In the management step, which pursues improvement by correlating energy information and production information, it is important to monitor the specific consumption and energy used by the facility and equipment. It's a continual improvement step.

Reduction of Energy Use through Energy-Conserving Equipment

Overall energy efficiency starts with energy-efficient equipment. Even using the latest visible technology and taking meticulous measurements of a shop floor's energy information will not boost energy efficiency if the production equipment itself is inefficient. Implementing equipment built for efficiency and energy conservation is the first step toward raising production efficiency while lowering energy consumption. One example is to optimize the energy consumption of the facility by using inverters, motors and other high efficiency drivers.

Products designed to regenerate energy, for example, can result in significant energy savings. Power regeneration is an action that yields great braking force by returning regenerative energy from the motor to the power source. One such example is a servo amplifier that uses a common bus with a power regeneration converter.

Energy-conserving inverters can deliver significant energy savings, especially for equipment that runs continuously. Also, using an all-in-one inverter with built-in power regeneration saves energy in machines that produce regenerative torque. The energy conservation effect can then be checked by a regeneration monitor.

The results are significant, with a reduction of CO2 emissions by approximately 11 percent and 27.3% reduction in specific energy consumption. In monetary terms, that is equivalent to nearly $1 million in annual savings.

Energy Conservation on the Plant Floor

Mitsubishi Electric offers a comprehensive portfolio of products and technologies designed to help factories achieve optimum productivity and total cost reduction through effective deployment of energy information. At the heart of these products are EnergyPAQ™, power meters, EcoWebServer III that are essential building blocks for e&eco-F@ctory.

EnergyPAQ is a comprehensive monitoring solution that provides easy-to-read visual data identifying how much and where energy is being used by various building loads and processes. e&eco-F@ctory was created by merging Mitsubishi Electric's e-F@ctory – productivity improvement through visualization of the manufacturing floor and eco-F@ctory – energy conservation through visible management of energy.

EnergyPAQ – Scalable Energy Management Solution

EnergyPAQ monitors and collects usage data from all energy types – electricity, water, gas, compressed air, and steam. After determining problem areas within a facility, EnergyPAQ allows users to implement a viable energy savings plan to reduce consumption and demand through a dynamic demand control/response solution.

EnergyPAQ can also monitor multiple circuits, including wireless electric meters for main and sub metering. Mitsubishi Electric's ME96 panel power meter can be installed in the motor control centers and networked back to the EnergyPAQ system.

Energy information can then be retrieved and imported into a spreadsheet or logged to energy monitoring software, such as Mitsubishi Electric's AX Energy®. It can also be published via EcoWebServer III hardware, an energy-saving data collecting server developed by Mitsubishi Electric.

Mitsubishi Electric uses energy-saving initiatives at its own factories. The company's Fukuyama Works (Fukuyama City, Hiroshima Prefecture) implemented energy-saving measures at its facility based on data provided by the EcoWebServer. The results are significant, with a reduction of CO2 emissions by approximately 11 percent and 27.3% reduction in specific energy consumption. In monetary terms, that is equivalent to nearly $1 million in annual savings.

In addition to its own products and technologies, Mitsubishi Electric offers connections to complementary products through its e-F@ctory Alliance Program to create even greater energy savings. For example, facility managers can connect their EnergyPAQ data with Mitsubishi's e-F@ctory Alliance partner software to facilitate fine-tuned peak demand control, automated demand response, and dynamic pricing optimization. This allows users to manage demand charges and reduce energy costs. Spara DM uses the control capabilities in EnergyPAQ to manage electrical demand without compromising production.

Fig. 3, EnergyPAQ – Scalable Energy Management Solution

eco-F@ctory allows visible management of energy usage through the introduction of measuring equipment and technologies that meticulously measure power and energy usage.

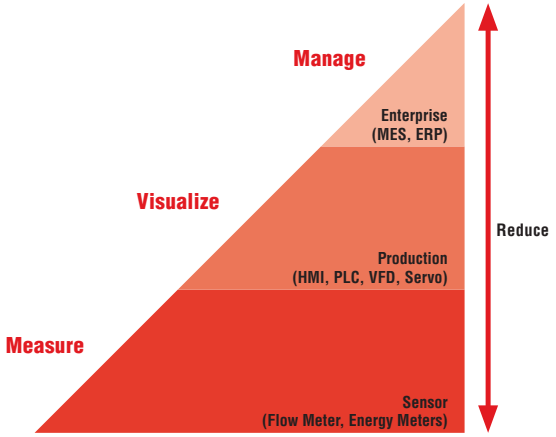


Fig. 4, Concept of Mitsubishi Electronic's total factory automation solution "e&e-F@ctory".

e&eco-F@ctory

e-F@ctory is Mitsubishi Electric's total factory automation solution for visualizing production by linking the shop floor and the information system, and for reducing total cost of ownership by driving the Plan-Do-Check-Action (PDCA) cycle. e-F@ctory can improve the performance of any manufacturing enterprise by providing three key benefits: reduced total cost of ownership (TCO), maximized productivity, and seamless integration.

e-F@ctory makes full use of leading-edge control technologies and network technologies to visualize production information, including quantitative and qualitative production data and equipment information. It links production equipment to higher manufacturing execution systems to allow production information to be incorporated into production plans and ensure quality traceability.

The concept of e-F@ctory is depicted in **Figure 4**. The programmable logic controller acts as the brain to control the operating sequence of production equipment. It is linked together with various devices, sensors and other factory automation products, via the factory automation network, to collect production information.

eco-F@ctory allows visible management of energy usage through the introduction of measuring equipment and technologies that meticulously measure power and energy usage. e&eco-F@ctory was created by adding energy as an element of the e-F@ctory solution. As previously discussed, the necessary steps for creating an energy-efficient manufacturing operation are measurement, visualization, reduction and management. e&eco-F@ctory drives energy saving by helping companies incorporate these practices into their production operation.

By introducing the e&eco-F@ctory solution into their factories, manufacturing facilities can:

1. Detect unnecessary production processes
2. Detect inconsistencies in product quality
3. Ensure preventive maintenance of production equipment
4. Analyze manufacturing costs in detail

Companies can then manage the production efficiency (specific energy consumption) of each product and piece of equipment. As a result, a good balance can be achieved between improving productivity and energy efficiency, and reducing manufacturing and energy costs. This allows the plant to achieve a just-in-time approach to energy – utilizing energy only when and where it's needed and in the quantity needed.

With e&eco-F@ctory, the production information is stored in the programmable logic controller. By providing the energy data to the PLC, energy can be measured in terms of the interrelation between the production conditions and the operating status of the equipment. Consequently, Mitsubishi Electric offers an energy measuring module compatible with the Q Series PLC (**Figure 5**). This unit makes it easy to measure current, voltage, power, power factor, effective power demand, consumption and other information, integrating production and quality data with energy information, and leading to improved productivity, energy saving, and preventive maintenance.

MES Interface IT modules and EcoWebServer III form the core of e&eco-F@ctory to effectively link control system devices directly to the enterprise system.

MES Interface IT modules and EcoWebServer III form the core of e&eco-F@ctory to effectively link control system devices directly to the enterprise system. In the visualization step, after the energy and production information is provided to the PLC and analyzed, the MES Interface IT and EcoWebServer III transmit the production and energy statistics to the information systems. It allows for energy measurement of each piece of production equipment, preventive equipment maintenance based on real-time measurement, and the use of quality control indices linked to manufacturing information. This data identifies how much energy is being used by various loads and their contribution toward energy costs.

Mitsubishi Electric's GOT1000 human-machine interface (HMI) for production lines incorporates MES Interface IT and EcoWebServer III functions on the plant floor. It collects and displays electric power, water, air, gas, and fuel measurement data from a Q Series measuring module via CC-Link or Ethernet. It not only monitors energy consumption in real time, but it also facilitates energy management, quality management, and monitoring of equipment operations in accordance with shop floor information.

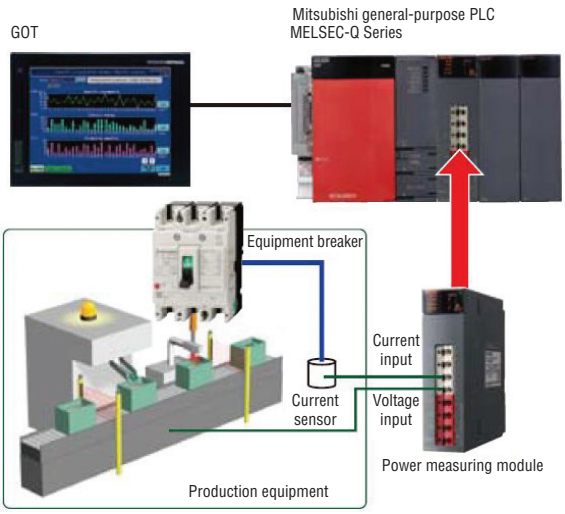


Fig. 5, Energy measurement by power measuring module

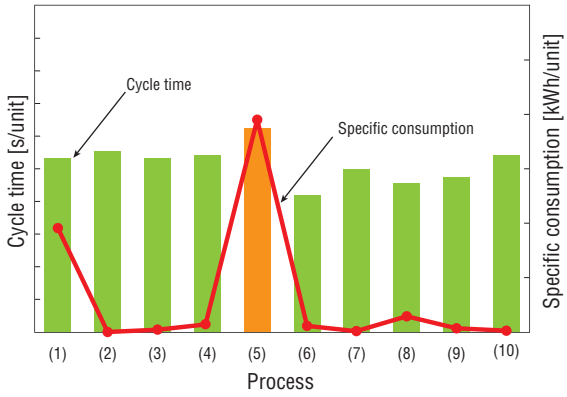


Fig. 6, Visualization using specific consumption by production process

Figure 6 illustrates an example of visualization. The specific consumption is displayed by process, showing that the specific consumption represented by the line graph worsens in process (5) in association with the change in product model. By overlaying the cycle time represented by the bar graph, it shows that the cycle time increased in process (5), which disturbs the balance in the production line as a whole. In this case, by improving the equipment in process (5) to reduce the cycle time, the productivity of the whole production line was increased and energy consumption as a whole was reduced, thus reducing energy costs.

For the successful reduction of energy, it is necessary to introduce energy-saving equipment to the factory floor. Mitsubishi Electric offers a comprehensive line of energy-conserving equipment as part of its e&eco-F@ctory solution. These are just a few examples:

The F700 energy-conserving inverter uses optimum excitation control to reduce energy consumption by up to about 12 percent. It is particularly well suited to equipment that runs continuously, such as air conditioning, pumps, and fans.

Real-time monitoring of a plant's total and specific energy consumption is critical to linking production information and energy information, and then making improvements.

The A701 Series is all-in-one inverter with built-in power regeneration. Energy conservation can be tracked by using the regeneration monitor to check the amount of energy that has been regenerated. This helps save energy in lifts, cranes, centrifuges, winders, and other equipment that produce regenerative torque.

The MR-J3-DU Series servo amplifier creates significant energy savings using a common bus with the power regeneration converter. The regenerative energy of deceleration, which would have been consumed as heat in the past, is returned to the power source. So regenerative energy can be directly used as acceleration energy for another axis.

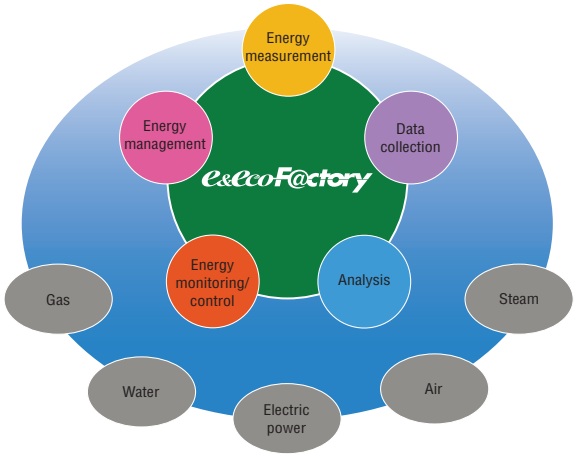
Summary

Production equipment in factories is responsible for a particularly large percentage of energy consumption in manufacturing industries. Proper assessment of energy usage requires precise measurements and the installation of numerous measurement points along the path from the power-receiving end to production equipment. Real-time monitoring of a plant's total and specific energy consumption is critical to linking production information and energy information, and then making improvements. This allows the facility to discover problems, find where to make improvements, focus on reducing consumption and decide what improvements to make. Mitsubishi Electric has merged the control and network technologies cultivated in the factory automation equipment sector with its measuring technologies developed through energy conservation activities in the power receiving and distribution sector. The result is a solution that simultaneously delivers superior productivity and total cost reduction by effectively leveraging energy information.

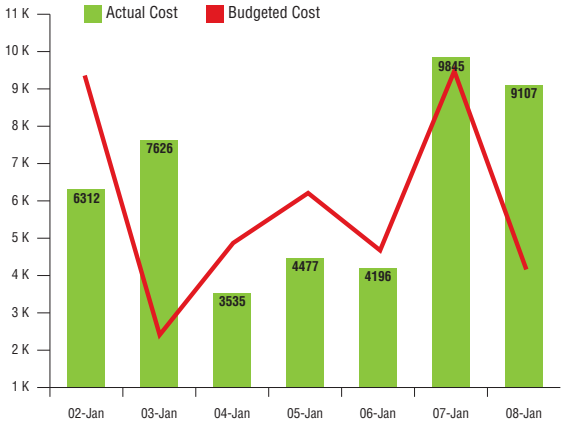
An e&eco-F@ctory is in operation at Mitsubishi Electric's Nagoya Works (Nagoya City, Aichi Prefecture) to specifically verify the efficiency and effectiveness of the innovative solution. The knowledge gained through these factory-wide energy conservation activities drives the ongoing development of energy-saving products and technologies.

Additional information on energy-saving products and technologies is available at www.meau.com, or by calling Mitsubishi Electric Automation, Inc. at (847) 478-2100.

Solutions That Make Energy Use Visible Are Powerful Tools for Your Energy Management Program.



Widget Production Energy Cost



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