How a Well-Planned Strategy Can Help the Food & Beverage Industry More Effectively Manage Its Energy-Related Costs

As energy costs continue to rise, food & beverage manufacturers are taking greater control over these expenses to gain a critical competitive advantage. The key to reducing energy-related expenses is understanding where, when and how much is being consumed. Armed with this information, companies can proactively manage load requirements, improve system performance and reduce costs.

This paper highlights the primary areas of energy consumption in food & beverage production and details actions manufacturers can take to move toward more efficient operations.

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Introduction

The food & beverage industry consistently ranks high among manufacturing sectors in the U.S. in the category of energy usage. Surprisingly, energy expenditures historically have been among the most overlooked costs in a food & beverage plant. In the past, energy management was straightforward – manufacturers simply received a bill and paid it.

But today there's a different scenario. Increased competitive pressures, tighter margins and rising energy costs are forcing manufacturers to alter their methods of operation. Energy costs that include all components of energy (WAGES; Water/Wastewater, Air, Gas, Electricity and Steam) may make up as much as 20 percent of Cost of Goods Sold for food & beverage plants. To address these pressures manufacturers are adopting comprehensive energy programs. A comprehensive program requires balance between five critical components.

1. Energy Management Organization & Leadership (Establish goals, objectives, select collaborating companies).

2. Energy Management Training & Education (Equip personnel with how to assess opportunities and make improvements)

3. Energy Project Management (Effective project scoping, execution, and energy solutions)

4. Increase Energy Visibility (Establish an energy monitoring and base line, metrics; relate energy to plant activities)

5. Energy Performance Evaluation (Analysis, control, continuous improvement)

New ways of managing energy consumption and quality through sophisticated monitoring tools have emerged – providing the information that companies need to be able to take action to reduce energy use while considering energy as an ingredient of production and a variable cost. In short, effective energy management is no longer an option, it is a strategic business necessity.

The key to effective energy management is information and knowledge – information on what's happening and the knowledge to do something about it. More specifically, it's understanding where, when and how much energy is being consumed and having the ability to act. Finding the hidden energy costs can be a source of substantial savings for food & beverage manufacturers if they know where to look and have the ability to monitor in real-time. While many companies do have ways of collecting energy data and profiling it, most of these are unreliable, time-consuming manual processes and seldom relate to the real-time activities in the plant or the units of production output.

Smarter, more automated devices installed in the power flow, especially at the point where that power is converted to mechanical energy, can give users better data, and in turn, better power management.

By developing an integrated energy management program based on accurate consumption and spending patterns and demand profiles, companies can calculate power consumption costs between their energy base load and various utility equipment, production lines, or in the manufacturing of a specific product. With a more accurate determination of actual product costs, managers are able to make more intelligent business decisions.

Energy Leadership and the Value of an Experienced Leader

An important element of an effective energy management strategy is working with an energy management leader who understands industrial processes, can provide transfer of best practices from similar industries, and knows how to uncover energy savings opportunities. Without a competent advisor in the field of automation and power management to provide guidance through the selection and implementation process, companies can end up with the wrong type or an insufficient quantity of monitoring devices – a mistake that could wipe out the savings an energy management solution is intended to provide. By teaming with an experienced automation leader, manufacturers can leverage decades of industry process knowledge and technical expertise to help them make better decisions throughout the process, from selection and planning to installation and implementation. Often times small operational changes or sequencing the start-up of equipment after breaks, shutdowns or outages can significantly reduce energy demand charges.

This automation leader also can play a key role in helping food & beverage manufacturers understand their tariff structures and how energy bills are calculated. For example, if the utility is offering four or five different tariffs, which one best suits your particular process? A tariff analysis can identify alternative ways to save money and evaluating new supplier and tariff options. The analysis also can provide a detailed examination of energy bills, including a breakdown and explanation of all charges, the best ways to reduce energy costs under the current contract, and the best attributes to look for in a new supplier or contract.

Charting a Course

Before implementing the required energy management technology and underlying infrastructure, companies should first identify their overall business goals, and then develop an energy strategy that seeks to accomplish those goals. In this definition phase, the goals should be specific to the areas of energy costs that need to be addressed and integrated with other company strategies for cost reduction, quality, and productivity improvement targets (Everyone in the plant needs to own a piece of improving energy effectiveness, not just the plant or faculties engineer). Additionally, it's important to establish detailed base load energy metrics. Too many variables can cloud top line energy expense data (plant volume increase, rate structure changes, process changes, climatic changes). Without knowing these details it will be difficult to demonstrate the gains made and how energy initiatives are successfully being translated into operational and financial gains.

For example, are electricity costs the primary concern or does the strategy need to also consider consumption patterns related to water, air, gas and steam? Does the company have a specific cost reduction goal in mind? In most cases, the first step for a plant may be to simply define and understand the plant base load which is where and how much energy is being consumed when little or no product is being produced.

Often a plant is surprised to find that 60 percent-70 percent of energy is being consumed when no production is running. Getting a handle on the true base load or fixed portion of your energy consumption is a good place to start. What can be turned off or down when the process is idle? Millions of pounds of steam may be consumed per hour on weekends while the plant is down. Millions of SCFM of compressed air may be consumed on down days with all air compressors shut down. Think about how many hours it takes for the main compressed air storage receiver to bleed down. (i.e. Hours to zero pressure is indicative of the amount of air leaks in the system). Then, once those base load questions are answered, companies can be in a better position to formulate more specific cost reduction or efficiency objectives relative to the variable components of energy consumption. (Examples MM pounds of steam consumed per pound of production, MM CFM of compressed air consumed per pound of production).

Energy management goals typically can be divided into two segments. The first is consumption. Are you running your processes as efficiently as possible? Do you have high demand? How consistent is your load? Is it evenly distributed or do you have peaks where your load is excessively high? Can energy be reclaimed, recycled or reused? (Example: can waste heat be captured from hot water discharge or hot air sources and used to heat makeup water? Can once through process water (gray water) be captured from cooling equipment etc. and used for non-process non-critical uses such as landscape watering?)

The second segment is quality. How healthy is your energy (power)? Are power quality issues affecting production equipment and shortening life spans? Can power factor correction reduce utility penalties due to largely inductive motor loads? Can harmonic analysis be used to determine problems with high-value production assets? Is your process refrigerant being delivered to heat exchangers at the right temperature and flow or are production speeds being reduced to compensate for reduced levels of cooling?

Once the goals are identified and the energy strategy is determined, the next step is to put the technology and infrastructure in place to achieve the desired goals. The good news is that while electricity is the largest energy cost for most food & beverage plants, it also offers the greatest opportunities for saving. Moreover, compared to other cost cutting initiatives, energy management efforts often deliver the fastest payback.

Creating the Infrastructure

In the food & beverage industry, approximately half of all energy consumption is used to change raw materials into products, while the remaining is used for the processes required for product preservation and safety, such as freezing, drying, refrigeration and packaging. Knowing where energies are allocated refers to the various processes throughout the plant, such as mixing, blending, depositing, baking, frying, packing, refrigeration, and warehousing. Defining each of the largest energy consumers in the process is critical.

Underlying these processes are the motors, fans, heaters and compressors. How efficiently are they performing? Are the motors and pumps the right size and style for the application? Are they being maintained and operated properly? When are they running? Are they running at the same time or can they be staggered or controlled based on demand? Are motors, pumps, and air nozzles running while the process is idle? In many cases, simply applying the right motor control technology can have a dramatic impact on process efficiency. (See "Managing Your Motors") Are there significant leaks in the air or steam distribution systems? How often are air and steam trap audits conducted? Is compressed air distribution pressure too high? Typically compressed air is a food & beverage plant's most expensive and inefficient energy cost component. (A two psi reduction in compressed air distribution pressure can reduce compressed air electrical costs by 1 percent). Is there some limiting factor or specific piece of equipment that is causing the entire packaging plant to operate at 95psi vs. 85psi?

Once critical energy consumer's design or target consumption levels are defined, one then needs to be able to measure it. Once the underlying infrastructure is in place to understand where and how energy is being consumed, it will be easier to formulate a strategy that will allow you to transition into the three core steps of energy management: **Monitor, Analyze and Control**.

Often systems are installed to address the monitoring function with the expectation of expanding the system in the future to include analysis and control capabilities. Therefore, to help confirm a smooth and cost-efficient transition from one step to the next, it's important that the infrastructure be as flexible and scalable as possible.

For example, users may install a load profiling system to identify high-demand periods. To move to the next step, they would then want the ability to expand the system to include an automated demand management system that would allow them to purchase power when it is most economical and avoid demand penalties that occur when energy usage spikes.

Managing Your Motors

Motor systems are by far the biggest energy gluttons for manufacturers, consuming roughly 75 percent of all electricity in the U.S. industrial sector, according to the U.S. Department of Energy. As a result, it's clear that motors should be a key area of focus within any energy management program.

Fortunately, today's advanced motor management solutions are capable of yielding big results. For example, power optimization tools, such as variable frequency drives, energy-efficient motors and gears, motor controllers and software all can deliver immediate, measurable bottom-line savings.

Variable speed drives can significantly reduce the amount of energy used in manufacturing processes, particularly ones that involve fans or pumps with changing flow rates. High-horsepower, centrifugal loads, for example, lend themselves to huge amounts of energy savings, and the biggest drop in energy use comes from just lowering speed or flow by as little as 20 percent. If a small reduction in the flow doesn't impact the manufacturing process and the plant can use half as much energy doing so, then users can achieve tremendous cost savings.

In any manufacturing process that requires less than 100 percent of the designed speed, users should consider integrating variable frequency drives for both low- and medium-voltage applications. Not only can they significantly reduce energy costs, but when properly applied, they can help remove the need for valves, increase pump seal life, reduce power surge during start-up, and contribute to more flexible operation.

Step One: Monitor

At the core of an effective monitoring program is a network of digital power monitoring devices that capture and communicate energy consumption information. These devices are used to measure energy parameters associated with a specific system. For electricity, it may be a bus in a facility's electrical distribution system. This allows plant managers to gather detailed information on power consumption in different areas of their plants, on specific machines (such as refrigeration compressors) and even on individual product lines. In addition to usage data, managers have access to power quality information that can improve productivity and lengthen equipment life, further enhancing profits.

Examples: Various food & beverage plant (WAGES) monitoring systems:

Power Monitoring Systems: A major advantage of a power monitoring system is its ability to capture and log real-time data and events via a high-speed control or information network over long periods of time. If managers detect consistent differences in energy usage in the same department, among different shifts or between plants with the same product lines, they can analyze the operation to see how lower energy results were achieved and then apply the findings to other operations. Revenue-accurate power monitor also is useful as a backup system to verify the billing statements issued by electric utilities.

Common monitoring system functions include Load Profiling. In a typical load profiling system, the desired power parameters and energy data are measured and transmitted by the power monitors, installed throughout the plant, via the information network to the energy management software. A load profiling system generates large amounts of data very quickly. Information, not raw data, provides insight and understanding of power consumption profiles and patterns. Therefore, this mass of data must be analyzed, correlated, and reduced into useful information to predict, prevent and to react to power related issues. Developing power metrics that relate to the plant's real-time production output is an effective way to track and spot upsets in the system. For example tracking the ratio of millions of kWh consumed per shift divided by the plant's production in millions of pounds for the same shift i.e. (kWh/million pounds produced). Or for air compressors kWh/million pounds produced is a good way to detect air leaks or lines operating at too high of a head pressure.

Natural Gas Monitoring Systems: A flowmeter may record the MM-BTUs consumed by each process dryer or oven. When correlated to pounds produced per oven, it would allow management to track MM-BTUs consumed per pound of product produced versus a target level. This could alert management to sticking gas valves, burner maintenance issues or changes in baking procedures.

Water Monitoring Systems: A flowmeter may record the MM-gallons of incoming water treated at the plants main incoming carbon filters. When correlated to pounds produced for the same period, a control chart of MM-gallons/MM pounds produced could be charted. This could alert management to unnoticed water leaks, vales left open, or changes in cleaning procedures. Water consumption in food & beverage plants may be as much as 7-10 gal of water used per gallon of finished product produced. Given water shortages and escalating water costs this type of monitoring is becoming imperative for many food & beverage producers.

Armed with load profile data compiled from a power monitoring system, one company was able to renegotiate its agreement with its utility - saving up to 10 percent of its annual energy costs.

Wastewater Monitoring Systems: A digital monitor may record MM-gallons of caustic and acid added to the plants effluent neutralization basin; as well as wastewater flow at the plant discharge point. When correlated for the same time period it may show MM-gallons of treatment chemicals/ MM-gallons discharged. A deviation from target could indicate operational problems with excessive process waste being dumped to process drains or some changes in cleaning procedures. This type of monitoring can help avoid violation of discharge permits as well as help reduce chemical treatment costs.

Once a company's energy models of loads and trends are identified and charted, the possibilities are endless for manufacturers to maximize their energy savings. By tracking energy consumption patterns over time, a facility can use historical data to verify electric bills, negotiate a better rate structure and identify opportunities for demand management.

> *Case in point: One leading food & beverage manufacturer quickly found that negotiating the lowest electricity rate required precise information about its power usage patterns, such as peak power demand, time of peak power demand, and how often its various plants draw power at the maximum rate. Armed with load profile data compiled from a power monitoring system, the company was able to renegotiate its agreement with its utility–saving up to 10 percent of its annual energy costs.*

A second benefit of energy monitoring systems is the ability to more accurately allocate costs to specific production areas or units. Cost allocation is similar to load profiling, with added functionality that allows a user to allocate energy costs to a department, processor facility. The system also can generate the reports necessary to analyze and verify utility bills and tariffs. Significant successes can be achieved with small, non-critical adjustments in power usage with ROI achieved in a shorter period of time.

Electricity, for example, has various aspects of monitoring that can help allocate and reduce costs:

- **Sub-metering** is the practice of deploying power meters to monitor individual loads or work cells. A sub-metering strategy allows users to measure differences in power consumption from shift-to-shift or line- to-line to provide internal cost allocation. This gives companies the ability to reward a specific group or department within a plant that implements successful energy saving initiatives.
- **Distribution System Monitoring**: Distribution system monitoring provides operators and engineers with a centralized view of the entire facility's power distribution system, including information for trending, alarming and targeting. By monitoring a facility's power distribution system, engineers can identify equipment approaching failure, reconfigure electrical system topology, and manually limit demand by shedding loads or increasing generator output.
- **Power Quality Monitoring:** The power quality data can be used to pinpoint failures of motors and sensitive equipment, negotiate better service from the utility and identify the need for power factor correction and harmonic filters. Power quality monitoring systems centralize power quality data from distributed power monitors. The system senses voltage excursions, momentary power losses, phase reversals, and harmonics then reveals this information in the form of instantaneous displays, trends, reports and alarms.

Step Two: Analyze

While monitoring systems provide the foundation for the accurate collecting and reporting of energy data, analyzing this information enables plants to make better decisions about controlling costs.

However, in order for this information to make a difference in operations, it must flow smoothly from the plant floor to the top floor. Therefore, the key to maximizing the benefits of an energy management program is coordinating the combination of power monitoring, control devices, communication networks and visualization technologies into a unified system that relates energy consumption to plant activities.

At the heart of this arrangement is an integrated architecture based on open standards that allows users to deliver energy information to wherever in the enterprise they need it. An important requirement of this architecture is the ability to leverage existing networks and devices.

The ability to communicate using a variety of open networks, such as Ethernet and DeviceNet™ via wired or wireless devices enables fast data transfer and easy integration with an existing network. For example, most facilities already have an Ethernet infrastructure in place, which helps reduce installation costs. Common communication interfaces also are critical to help verify speed of response, support of data and efficiency of overall system performance.

High-performance programmable automation controllers and advanced energy management software are also critical to providing the analysis and control components of the solution. The controllers provide a common means of bringing discrete inputs from breakers, switches and protective relays in the power management system. The controllers also work in concert with the personal computers running the human machine interface (HMI) and logging software to automate data collection and concentrate data.

A key benefit of the Rockwell Automation Integrated Architecture® system is that it offers users a choice of open technologies; an architecture capable of real-time control, communication and visualization; and an integrated control and information database that is both backwards compatible and capable of forward migration. Universal programming tools, common data structures, and execution models make external data access easier with no need for reprogramming of data acquisition systems if the control system changes. This architectural strategy also includes seamless integration with other Rockwell Automation products for faster, lower-cost design and start-up.

The energy management software serves as a centralized database for all energy parameters that can be accessed within a facility or across all facilities in various locations using a standard web browser. Being able to "see" a problem often lends additional meaning to the information derived from the raw data, and in turn, leads to the proper corrective actions.

This same software also enables companies to model their energy profiles by measuring peak demands and power quality parameters, determining demand patterns, correlating energy consumption to weather patterns, aggregating loads, and calculating energy costs by business group, department or site. This modeling approach saves a significant amount of money since solutions can be verified before committing capital expenditures to install new systems or equipment.

Step Three: Control

After analyzing the data, plant managers can develop an action plan and install automation systems to capture energy savings using a number of control system options.

The power monitoring system of one company gave it the hard data it needed to demonstrate that it had reduced its energy consumption over the long term. This information enabled it to qualify for an $80,000 rebate from the local electrical utility.

Demand management systems, for example, automatically project future demand to assure the peak limit is not exceeded. Load management systems can monitor the electrical consumption of selected equipment and turn them on and off in an operator-selected sequence to minimize peak demand. Loads are prioritized to allow the user to configure the order in which loads should be shed and restored. Load shifting maintains a more consistent level of energy use over time, which eases demands on utilities and avoids subsequent charges.

Case in point: At a large Midwestern beef and pork processing plant, meat is processed in a refrigerated facility that is kept within stringent government temperature limits. Refrigerating the 200,000 square foot plant constitutes a large portion of the connected electrical load and represents a substantial percentage of the plant's operating costs.

The company pays the electric utility a "base rate" for a given consumption of kilowatt-hours. If the plant exceeds the limit, the utility assesses a "demand penalty" of up to 50 percent of the base rate.

During shift start-ups, peak production times and hot summer days, electrical consumption many times exceeded "demand" thresholds, pushing the plant into the expensive peak demand range. The company needed to find a way to minimize expensive demand charges from the power company and reduce overall energy costs without compromising plant refrigeration requirements.

The company's refrigeration system was controlled by an "on/off" relay-based system that was difficult to maintain and left the plant few options for conserving energy and controlling costs.

To keep from exceeding peak demand thresholds, the company implemented a demand-side energy management strategy of load prioritization and load-shedding *to maintain a more consistent level of electricity usage. Approximately 50 percent of the plant's electrical usage comes from the centralized refrigeration facility, consisting of 12 compressors, that provides cooling for the entire plant. The new strategy was to reduce peak demand charges by shedding the electrical load in the refrigeration area and maintain peak demand below the set point.*

The company-integrated power monitoring capabilities into the programmable controller-based control and information system that manages the operation of the refrigeration units. Based on data from the power monitoring module, the controller monitors the refrigeration system and communicates to a computer.

If electrical consumption begins to approach the upper set point, the controller limits the load on refrigeration systems. If consumption continues to rise, the controller then begins shedding load by selectively shutting down refrigeration units, allowing the plant to use its "thermal mass" to coast through peak production periods and limit electrical consumption. Once demand drops, the units are automatically brought back on line.

As a result, the company has cut demand charges by as much as $2,000 a month. The power monitoring system also gave the company the hard data it needed to demonstrate that it had reduced its energy consumption over the long term. This information enabled it to qualify for an $80,000 rebate from the local electrical utility. With the savings and the utility rebate, the plant was able to payback the equipment investment within the first year.

Emergency load-shedding systems reduce the total plant load automatically to keep key plant processes operating on the remaining capacity in the event of utility or generator loss. These systems constantly observe power system topology and evaluate what loads would be shed if a source was lost. In the event of a loss of source, the system quickly trips breakers to maintain electrical system stability. The load-shedding capability balances the power supply and draws from on-site power generators when power outages occur. The automated shedding of electrical load shuts down non-vital machinery and allows the plant's vital machinery to remain powered up without risking damage to generators and transformers.

Many of today's power monitors can monitor designated field loads, power sources and build a "load shed table" based on the steady state conditions, the instantaneous electrical system topology, and priority table designated by the user. And, they allow configuration of load-shedding priorities based on production requirements.

Compressed air control and optimization systems deliver improved performance of a plants air system by controlling the starting, stopping, staging and blow off functions of a system of air compressors. This is often times accomplished as part of a larger plant air audit where other actions are also taken to reduce peak air demand requirements such as isolation of single high-pressure user from the main plant air system. With the installation of a smaller high pressure compressor it often times allows the rest of the plant air system to be reduced by 10-15psi thereby reducing the main plant air system electrical consumption by 5 percent-7 percent. Another action is to make food & beverage processing and filling equipment "energy aware" by programming equipment to turn off air supply lines when product is not being produced. Often equipment is idle or temporarily down and compressed air continues to be consumed, blow on conveyors, etc. when no product is present.

Pump Optimization solutions can significantly reduce energy usage by employing real-time pump dispatch for industrial sites with closed loop systems that are fed by multiple parallel centrifugal pumps to a common header. Typical applications include primary and secondary chilled water loops, hot water loops.

By deploying a pump optimization solution the customer was able to save 57 percent of their annual consumption on a single bank of pumps and the solution achieved a payback period of less than 9 months.

Case in point: A large poultry producer in the mid-west had a number of Clean in Place systems (CIP) that were being controlled by multiple centrifugal pumps. Those pumps had a total connected horsepower of 475HP and were running across the line 24 hours per day 7 days per week.

By deploying a pump optimization solution the customer was able to save 57 percent of their annual consumption on a single bank of pumps and the solution achieved a payback period of less than 9 months.

Another area often overlooked in food & beverage plants is the control of incoming city water booster pumps or sequencing of well water pumps. Often times these types of very large motors and pumps are run at constant speed are controlled via a throttling valve based on plant demand. A much more energy efficient method is to modulate the pump volume and sequencing using a VFD based on plant demand.

Reduction of steam/gas consumption can include a combination of methods such as reducing the need to use boiler steam to heat hot water. This was accomplished through installation of hot water heat exchangers in hot water waste streams to preheat incoming city water and Installation of heat exchangers in hot air exhaust stacks (that is, boiler stacks, process cooker stacks, oven stacks, etc.). Again, the waste heat captured was used to preheat incoming water for process uses.

Step Four: Sustain Gains

Sustaining energy gains can be an elusive effort. Many variables in plant operations can change the energy profile of a plant and mask the true gains made by a well-conceived program. Plant capacity can be added, shifts can be added to the production schedule, rate structures can change. If sufficient details and metrics are not tracked on an ongoing basis and related to plant production output, it may appear that investments made for energy conservation purposes are not paying off (that is, the total energy bill is greater this year than last). The following types of initiatives have been found useful in sustaining and keeping your energy program on target:

- Continue to reinforce energy as a priority in operational decision making
- Communicate program successes as they occur
  - Keep employees informed
  - Let your customers know
- Extend power and energy monitoring solutions to support continuous improvement efforts.
- Hold monthly reviews of critical energy KPIs
- Conduct an annual energy management system assessment to assure the program is following the ongoing plan set by management
  - Conduct cross plant audits and benchmarking of critical systems, policies and procedures
  - Publish an Energy Management Scorecard

Conclusion

In today's deregulated utility market, manufacturers increasingly have the ability to negotiate with multiple providers for their power and natural gas purchases. However, it's difficult to shop for better rates if companies are unable to control their power usage and don't know their energy consumption profiles. This is where having the right information can pay significant dividends.

While food & beverage manufacturers have large energy demands, they also have a large opportunity for savings. Technologies and expertise are available that allow manufacturers to take control of their energy costs and help protect their business from energy market fluctuations. Bottom line: energy costs are controllable. The key is identifying your energy management goals, developing a corresponding strategy, and putting the technology in place that enables you to accurately monitor, analyze and control energy consumption and quality.

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