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Using an Energy Management Strategy to drive improved business results and improve manufacturing operations.

1.0 Introduction

In today's manufacturing environment there is a strong recognition of Energy Management as a significant source of both social responsibility and cost savings. Energy typically represents the single largest controllable cost in manufacturing, and is under constant scrutiny by all levels of management. The challenge with any discussion of Energy Management is that it means many things, and dialogue on the topic is based on the role and expectations of the parties involved. Without having a clear understanding of the topic area, and the expectation of the audience, a discussion may evolve into different directions than expected. For example, improvements in Energy Management to an engineering manager could easily be understood as the replacement of an oversized motor with an energy efficient variable speed drive, while a plant manager would expect to hear about savings in the overall amount of energy consumed by his facility. In this paper we will examine the overall role and components of an energy management strategy, focus on the benefits of looking at Energy Management from a business perspective, and then examine the role that an effective program, either existing or new, can play in a collaborative manufacturing environment, and how these improvements can reduce energy requirements while maintaining, or improving productivity.

2.0 Defining the Energy Management Strategy

Virtually all manufacturers have some degree of formal energy management strategy in place today, and the more successful programs periodically examine their effectiveness and evaluate potential improvements. Successful strategies are typically driven from top management, and considered a strategic aspect of an overall manufacturing strategy; however, few strategies actually address how they could be incorporated in a future-looking manufacturing environment.

An organization's energy management strategy is typically structured into three steps:

1) Creating the Strategy, Policy and Targets that identify the goals and objectives of the strategic initiative
2) Identifying the Targeted Initiatives, or the tactical implementation of the strategy and

3) Monitoring the Progress and Results, or the measurement of results and program effectiveness.

Figure 1 – A typical Energy Management strategy

The strategy normally focuses on these key areas:

- Energy purchase cost savings
- Energy efficiency improvements
- Energy reductions from process improvements
- Environmental sustainability
- Instantiation of the strategy into the corporate culture

2.1 Strategy, Policy and Targets

The steps to create the strategy usually start with accessing the current performance, then setting the goals and objectives and making the organizational commitment to the program. This step often starts by using internal or external resources to establish the “as is” baseline to measure progress against. This will include the analysis of current energy usage patterns and identify potential areas to save energy. A comprehensive strategy will also examine current usage against peer or competitive facilities, and set targets accordingly. The most successful programs are those that are not viewed simply as cost reduction exercises, but rather those that also reflect the corporate culture, including balancing the cost effectiveness of manufacturing with improving the safety and sustainability of the work environment, while maintaining environmental stewardship. As part of the corporate culture, the strategy is directed by a small team, while embraced by the entire organization.

This step will often identify the Key Performance Indicators (KPI’s) that will be implemented to establish the objectives and used to monitor and evaluate progress.

2.2 Targeted Initiatives

The second step, the tactical implementation of the strategy, will typically start with identifying the gaps between the current "as is" environment and focusing on the areas with the largest potential for both short and long term gains, creating an action plan that addresses these areas, and then implementing this plan. Some of the areas that are frequently examined include:

2.2.1 Equipment

This may involve examining energy efficient motors, variable speed drives, switchgear or breakers. In many, typically older, facilities motors that were initially installed were considerably oversized; energy effectiveness was not a critical factor at that time. Examining the differential between the energy requirements of the process and the existing equipment, then evaluating replacement equipment that uses modern technology to more effectively use energy and minimize losses, can lead to substantial savings in operating costs, and in overall equipment maintenance. This area is often the easiest to quantify and serves as the starting point in most manufacturer's energy programs.

2.2.2 Electrical Integration and Network Management

This includes savings available through IEC 61850 Automation and Electrical Integration, Supervisory Control and Data Acquisition (SCADA) or electrical network management systems. These savings reflect the improvements in operations, but may have a greater impact in the overall life cycle obtained by dramatically reducing signal wiring, using common engineering tools between electrical and process systems, and including the plant electrical systems as a key component in the overall manufacturing automation model. This will be discussed in further detail later in this paper.

2.2.3 Automation Power Management

This provides the infrastructure to manage the usage of energy in manufacturing, including the ability to implement an effective load-shedding process.

2.2.4 Process Optimization

This includes addressing the issues of stabilizing the process environment by effective control loop tuning and implementing Advanced Process Control (APC) to maximize throughput while reducing costs.

2.2.5 Energy Optimization

This addresses the area of energy purchase and contract management. Significant sustainable savings can be achieved by implementing an effective energy balance strategy, discussed in more detail below.

An effective implementation of an energy management strategy will balance the short term gains that can be achieved by focusing on savings in the equipment area with the longer term, strategic gains that can be achieved in some of the other areas.

2.3 Progress and Results

The third step focuses on the real-time monitoring of the KPI's established at the onset of the program. Creating a platform to capture energy monitoring and reporting information is a key component of the overall strategy. While it is the final step in the strategy it is often implemented first, as it provides the basis for establishing the "as-is" conditions and measuring the effectiveness of the tactical implementation, and ensuring compliance with the program

As with all effective strategic initiatives, the program should be evaluated and adjusted as progress is made. In many cases, the implementation of the program will recognize opportunities not initially considered. The review may also identify areas that may not provide the return on investment (ROI) initially envisioned.

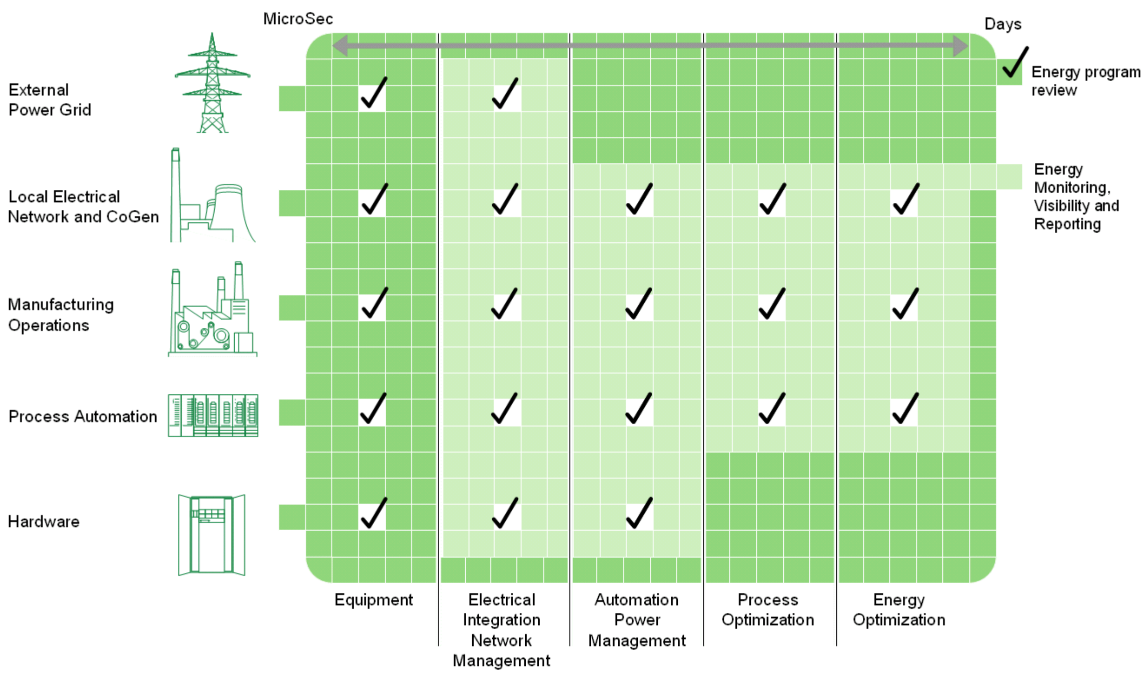

Figure 2: Components of Energy Management

Finally, the energy strategy should be viewed as one component in an overall manufacturing strategy. Including the areas identified above into an effective collaborative manufacturing environment, with a specific focus on the electrical integration, process optimization, reporting, energy optimization and monitoring will be examined in more detail in a subsequent section.

3. 0 The Business Value of an Energy Management Strategy

The traditional methods of evaluating the ROI for energy improvements focus on reductions in energy usage, as this is typically the simplest to quantify and directly correlates to lower operating costs. While the value of energy reductions should not be trivialized it is only one component that should be considered when evaluating the business, or shareholder value that can be obtained from an effective program. As shareholder consciousness of environmental issues increases, and worldwide legislation of energy and emissions increase, energy management is becoming another measure that financial analysts are evaluating when assessing manufacturers. An effective strategy must include short term considerations, or gains that can be immediately realized, but must be coupled with a longer term vision that incorporates strategies dealing with upcoming or potential financial and legislative changes. Some of the key components that should be evaluated in determining the value of the strategy include:

3.1 Social concerns

While largely considered intangible, there is a growing expectation from investors and portfolio managers that companies are going to treat the social consciousness of manufacturers as a consideration that complements traditional financial metrics. This is currently a group that represents a $2.1 trillion market, or $1 of every $9 invested in the United States. This is reflected in the trend towards corporations including environmental disclosure and commitments in annual reports, and highlights the impact that a comprehensive and successful implementation of an energy management program can have on the overall shareholder value. Additionally, studies have shown that there is a direct correlation between a positive environmentally friendly workplace and employee productivity.

3.2 Emissions management

Within manufacturing, improving energy efficiencies is considered critical to reducing carbon dioxide emissions. International companies that have operations in countries that are signatories to the Kyoto Protocol, as well as the emergence of a carbon trading market in the European Union are driving the implementation of energy and emissions monitoring, and for improving energy management in manufacturing. Conventional thinking is that carbon trading will become more global in nature, and several non-regulatory environmental based markets have already been established in the United States. Additionally, having the tools and processes in place to effectively manage this can lead to reduced business risk as new legislation is introduced.

3.3 Energy monitoring, visualization and reporting

The cornerstone of an energy management program is the capability to monitor, visualize and report energy consumption. Without this in place there is no mechanism to judge progress and program effectiveness.

While most organizations understand the necessity of energy monitoring, the basic process is not always well understood. In many cases, the implementation of a valid strategy has been postponed, or more often done as independent, uncoordinated smaller projects, because accurate metering was not in place. The addition of metering is often perceived as being of little operational value. In most cases, it is acknowledged that some metering is required, but by using a robust data collection and analysis backbone, a process historian for example, coupled with a robust plant energy model, it should be possible to use macro level information and supplement it with calculations to provide the drill down details on consumptions and usages. Using this approach, the monitoring platform can be implemented early in the process, and be expanded with more accurate metering as equipment is upgraded or replaced.

Energy visualization refers to the real-time display of information, typically the Key Performance Indicators identified as part of the program strategy, or the components that are fundamental to their calculation. These should be made available, in a role based fashion, to the various levels of operations, from the displays used by the shop-floor operators to management portal displays. Each role should contain the KPI’s that the can be directly affected, and their importance should be stressed, and become part of the normal operating culture. This becomes the center for improved operations. Without having this information immediately and constantly visible and used as a mechanism to evaluate performance, the plant operations will not consider the energy program to be strategic.

Energy reporting is typically after the fact, and is used to judge the effectiveness of changes made as part of the program. The reporting should provide sufficient detail that it can be used for operations management and process improvement, while still rolling up in a summary format to be used to judge progress and provide guidance for corrections to the strategy.

By the same token, it must be recognized that the monitoring and visualization of energy information is only one component in the overall strategy, and that the true savings come from how the information is utilized. Most implementations can use the information to identify high value improvements, but may not have the additional modules or applications to utilize the information to make process improvements, as described in the following sections.

3.4 Energy reductions

Most manufacturers recognize that there are significant savings, some analysts estimate up to 20% that can be realized by replacing existing motors, pumps and fans with modern energy efficient technologies, such as variable speed drives, and energy efficient motors. Additional savings can be realized by looking in non-traditional areas, such as inefficient lighting, or improvements in facilities management. Savings in these areas can have a dramatic impact on operating costs both in terms of lowering energy costs, but also in reducing maintenance and potentially improving operating performance.

3.5 Network Management

The obvious benefit from IEC 61850 Electrical Integration is in the area of wiring; using network based protocols eliminate the need for direct wiring, but there are a number of secondary benefits that also should be considered. The effective implementation can lead to:

- Reduced engineering and commissioning time for integrated projects
- Reductions in duplicate equipment
- Improved efficiencies of operation and maintenance staff by reducing training and complexity
- Effective operations and maintenance from the use of a common system for manufacturing asset monitoring.

Being able to use the electrical networks in the same fashion as any other manufacturing system is a key component in being able to provide increased visibility into the consumption and costs of energy utilization. It can also integrate these factors into a collaborative manufacturing environment.

3.6 Process Management

Stabilizing the process environment starts with identifying poorly performing control loops, which are typically responsible for significant process losses. This results in higher energy consumption and losses to compensate for the reduced performance. Identifying and properly tuning these loops, can provide significant energy savings, and also reduce equipment maintenance and unplanned downtime while improving equipment life. In a typical manufacturing environment, the effective half-life of a well tuned loop is less than 6 months, which underscores the need to incorporate tools to audit and maintain loops at their optimal levels.

With a stable process environment in place it is possible to provide significant process improvements, while dramatically lowering energy cost, using Advanced Process Control. Additionally, it is possible to use APC as the basis for decision support, making real-time decisions on fuel consumptions based on economic models of the plant operating environment. Implementations of APC based optimizations have resulted in production improvements in the range of 3%-5%, while having a corresponding reduction in energy usage by a similar amount.

3.7 Contract management

One of the most underestimated components of an energy management strategy is the management of energy contracts. In an increasingly deregulated market, with growing volatility in the price of energy, it is common for manufacturers to deal with multiple energy providers, and many manufacturers have additional capacity for internally generating power (co-gen). The contracts with most providers are several hundred pages in length and contain numerous schedules that outline pricing based on consumption rates and time of day. Effectively managing against a single contract, even at a macro level, is a time consuming and manually intensive exercise that is often maintained by a single, experienced, individual within the organization. Additionally, there are seldom resources available to validate energy usage after the fact, and reconcile the usage invoiced from the supplier with the contract terms. Adding in additional suppliers exponentially increases the complexity of the problem.

Any long-term energy management program must include systems that can manage the usage schedules from energy utilities or providers to ensure that the contractual obligations for energy purchases are satisfied in the most cost effective way, avoiding excess usage or peak time tariffs and penalties. These systems can easily save 2-4% of the overall purchase energy price, and in addition to serving as a core component of a long-term strategy, often can provide a return on investment of well under a year.

3.8 Energy forecast

An effective energy plan should contain the capability to accurately model the energy consumption inside the facility, to understand how energy consumption relates to changes in the production plan, what additional energy providers can be made available, and what subsystems can have power shed if needed. Having this model is especially critical if there is the possibility to have significant swings in energy, if parts of the process can be run at reduced rates, or if multiple energy sources are available. Having an accurate model is critical to being able to manage production against an energy plan, and to effectively balance energy usage against contracted amounts.

3.9 Energy balance

Possibly one of the most critical uses of energy information is to balance contracted energy with energy used inside of manufacturing. In many operating environments, typical in a deregulated market, energy is contracted from the utility or supplier in advance, normally 24 hours. At this time, the manufacturer supplies the utility with a planned consumption. The following diagram illustrates the three situations that typically arise:

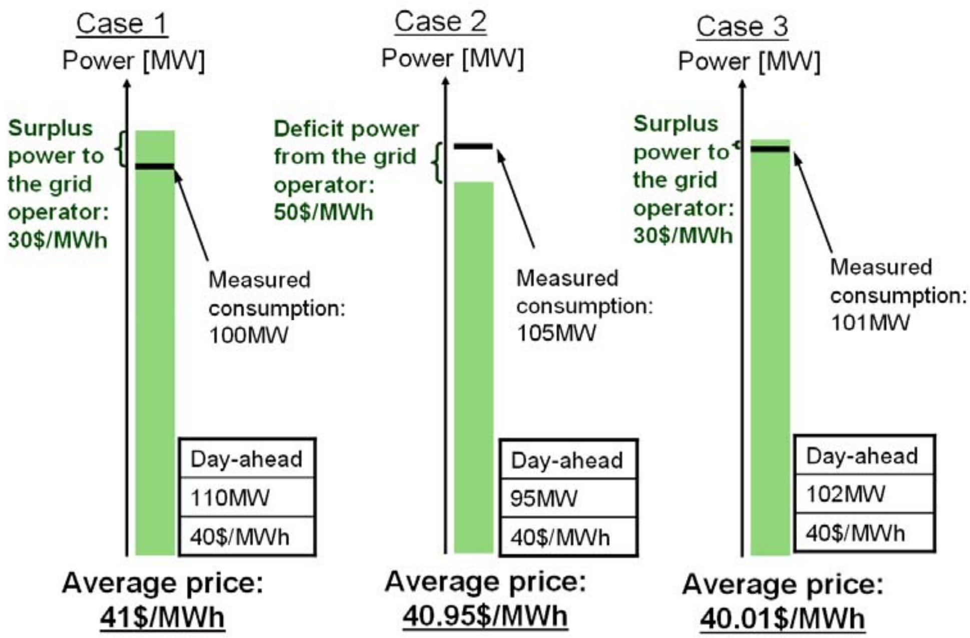

Figure 3: Energy balance scenarios

In the first case, the manufacturer has requested 110 MW of electricity from the grid for a specific time period and has received a price of $40/MW Hour. In this case the actual consumption is less than the contracted amount, and the utility will buy back the excess, but at a much lower price than it was purchased for. In this example they will buy the power back at $30/MW Hour, resulting in an average price of $41/MW Hour.

In the second case, an estimate of 95 MW was provided, but 105 MW is actually needed. The additional energy is provided by the utility, but at a higher rate than the initial contract. Additionally, it is common that penalties are assigned in this case, and can be substantial. Excess penalties are ignored for the sake of this example, and the average price is calculated to be $40.95.

The third scenario represents an optimal case which includes a reliable estimate of energy, coupled with accurate monitoring. In this scenario, the plant has used the available information to manage against the load plan provided, and has very little excess to sell back to the grid. The result in this case is an average energy rate of $40.01. While the differential in average rates does not seem to be significant, the overall savings between case 1 and case 3 results in approximately $800,000 of savings on an annual basis.

The above sections illustrate how the tactical improvements identified in the energy plan can lead to significant savings in overall energy, and provide business results that drive shareholder value.

4.0 The Future State Collaborative Manufacturing Environment

One of the significant benefits of a well planned and implemented energy program is that it can greatly extend the value of an overall manufacturing strategy. Typically, the energy program is viewed and measured on its own merit; but as we have seen in the sections above, the energy strategy should have some of the basic elements that allow an easy connection to other manufacturing systems. Core elements, such as collecting the information required for energy monitoring are typically in place. Integration of electrical and automation systems extend the capability to interact, as do connections to other manufacturing systems. These lead to true value based integration scenarios. For example, to have systems automatically monitor and optimize energy balance there must be a tight coupling between the energy monitoring, the energy load plans sent to utilities, and the production planning system. These types of connections and the associated functionality are being used by manufacturers today, and provide a starting point for an improved collaborative environment.

While the capability for integrated systems exists today, in most manufacturers these are typically considered to be independent systems, with information passed between, but little or no actions being taken based on key criteria. For example, if unscheduled downtime is required on any key production asset, the production orders are seldom rescheduled to ensure that the orders that are being produced are those that bring the highest value to the organization. It is non technology issues, typically organizational boundaries that preclude this from happening.

Yet the future state of collaborative manufacturing is clear, and integrated energy management is a key component. Manufacturing systems are evolving to allow greater flexibility in the decision making process, and including a stronger emphasis on using cost and revenues as the key decision criteria, while the interoperability between various systems, manufacturing execution, CMMS and ERP is becoming seamless. With this type of infrastructure in place, production schedules will be optimized based on customer requirements, energy loading and costs, while maintenance downtime will be scheduled to coincide with peaks in energy costs.

5.0 Conclusions

Within this paper we have discussed the role of the Energy Management strategy in an organization and some of the key components. We have examined how the various elements affect manufacturing by looking at them from the business perspective. And finally, we have examined how a well thought out strategy can lend itself to a forward looking collaborative manufacturing environment. This, in turn, leads to improved efficiencies, in terms of energy utilization, cost savings and productivity improvements.

For most manufacturers, capitalizing on this is going to require some changes to existing strategies.

Few manufacturers, today, are considering systems integration, and automated functions such as contract management, energy and process optimization or energy balance as components within their energy strategy. Yet these are functions that can have a dramatic impact on financial improvements. In some cases, executives may believe that this functionality already exists, either in their existing ERP systems, or perhaps in home-grown energy management functions.

The challenge is to take a serious look at the benefits that this level of functionality can bring, and then look to see where it exists in their current technology portfolio. If it does exist, then the organization is ahead of most. If it doesn't, then they should start to ask the technology providers, both from the business system and automation/manufacturing suppliers what capabilities they have in this area, and what it takes to get started.