Dashboard Demystified: Making Sense of Industrial Energy Management Visualization Systems

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ABSTRACT

The convergence of sustainability pressures, rising energy prices, and insatiable demand will have profound impact on our relationship with energy and its effect on the macroeconomy. Today, there's no shortage of industrial users eager to turn crisis into future profits by taking the steps now to gain control over energy costs and consumption.

All this promise has generated a green-rush industry of "Energy Dashboard" providers, with hundreds of vendors offering data visualization products that claim to have unique features and attributes that enable the superior management of energy resources

This paper will categorize the different types of Energy Management dashboards and energy visualization systems which are specifically designed for industrial process applications, as contrasted with adapted dashboards designed for building management.

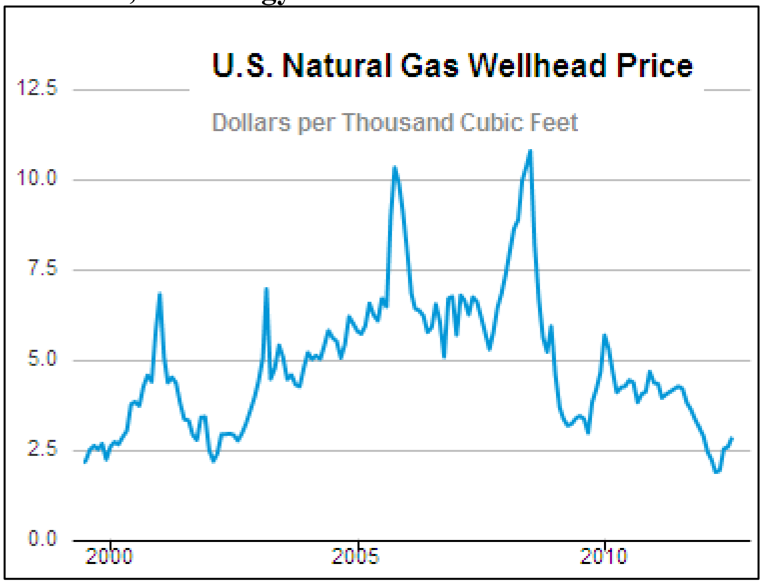
Introduction

Concern over energy use and sustainability policy in industrial manufacturing facilities has been expanding for some time, but never at the current rate. While industrial businesses strive to find fresh ways to build a competitive advantage, attract customers and skilled employees, and improve profit margins and share price, there has clearly been a shift away from ambiguous rhetoric to finding actionable ways of improving energy management.

The drivers of this trend are clear and can be categorized as follows:

- Energy cost and price volatility: Beyond the obvious economic benefit of reducing energy quantity to increase operational margins, a more significant benefit is recognized through reduced financial performance risk associated with short term fluctuations in energy prices. As we've seen many times in modern history, a foreign political or economic crisis can quickly stimulate an energy price change (see Figure 1 for example)—forward-thinking manufacturers understand that less dependency on a variable business cost can result in a more competitive position.

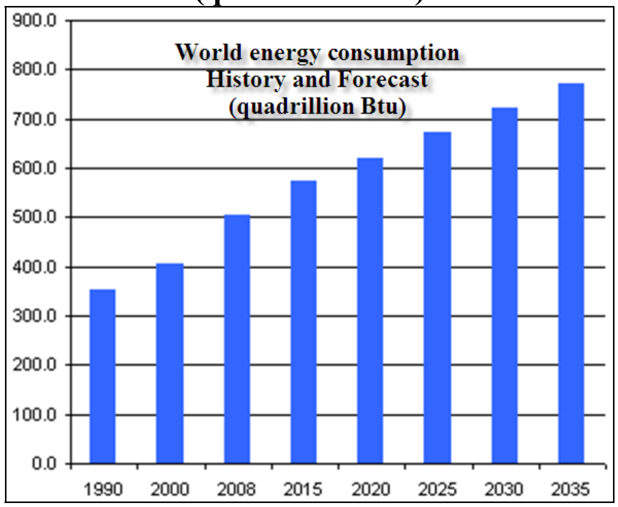
Figure 1. Volatility of US Natural Gas Wellhead Price, US Energy Information Administration



- Corporate responsibility and shareholder value: Building a "green image" is more than just boardroom banter, it adds tremendous value to brand identity that can be turned into real revenue and a sustainable market advantage, which shareholders recognize as future earning potential. A.T. Kearney found "in 16 of the 18 industries examined, companies recognized as sustainability-focused...outperformed their industry peers [during the recession] and were well-protected from value erosion (CDP 2010)". Furthermore, according to a study performed by Accenture on the topic of climate change, 64 percent of consumers are willing to pay a higher price for products and services that are produced in an environmentally sustainable way (ELN 10/2007).
- Regulatory pressures and supply chain mandates: Even for those locations without strict regulatory standards and carbon emissions penalties, it's becoming more common for large resellers and manufacturers to require specific sustainability measures of their suppliers. According to the Carbon Disclosure Supply Chain Report 2012, 4 percent of large corporations say they deselect suppliers who fail to implement formal environmental improvements and procedures, and 39 percent project that they will soon implement this policy in the future.

As the globe emerges from its recession, the re-generation of economic growth in emerging economies will serve as a wakeup call for those manufacturers who have not taken steps to adapt to this new norm of energy and environmental consciousness. The rising global demand for industrial energy resources, reflected in Figure 2, will predictably result in competitive pressures on all three of the drivers cited above.

Figure 2. World Energy Consumption History and Forecast (quadrillion Btu)

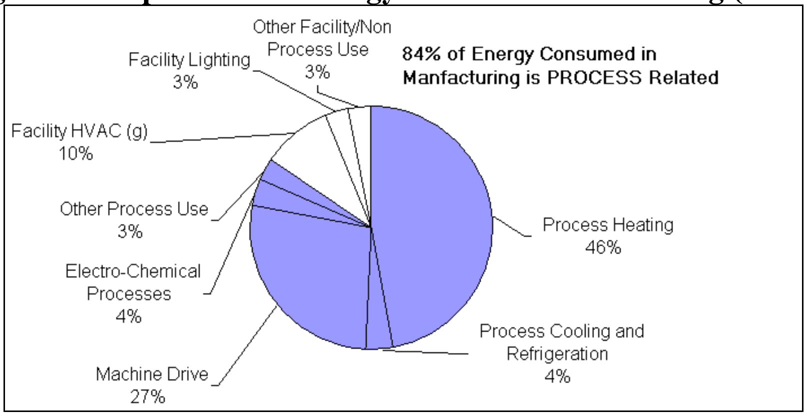


Today, there's no shortage of industrial users eager to turn crisis into future profits by taking the steps to gain control over energy costs and consumption. Such a strategy makes sound business sense, as the tools and processes associated with a credible energy management program can pay immediate dividends and in addition, also serve to establish a significant competitive advantage on a global stage.

Starting With Facility Systems

An energy management initiative in an industrial facility typically starts with the nomination of an energy manager, usually a part-time role of someone within the facilities, mechanical, or environmental health and safety staff. Eager to make a quick-turn impact, the first action taken is typically in the form of an energy assessment, followed by a number of energy mitigation efforts targeted to the building systems. These projects include lighting upgrades, HVAC adjustments, occupancy sensors, and boiler tuning, which directly affect the very systems that the facilities department directly influences on a day-to-day basis. Such efforts may be enough for a commercial or government building, such as an office, hotel, or school, but in an industrial process facility, the majority of the energy used, 84 percent on average, is in the process, not the building systems (see Figure 3).

Figure 3. Proportions of Energy Used in Manufacturing (MECS)

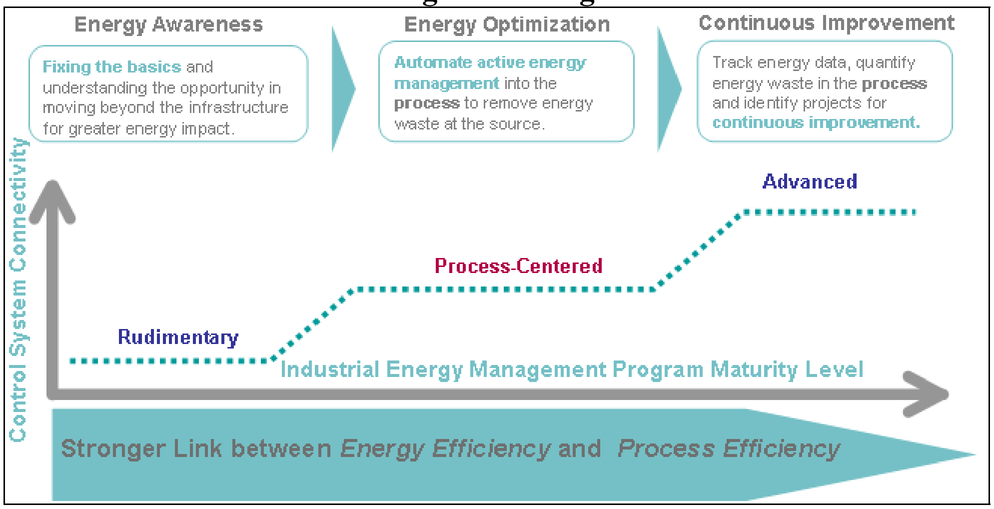


To make a significant impact on energy consumption and sustainability, an industrial facility must look beyond the basics of its facility and consider process modifications.

Energy Management Program Maturity

The model shown in Figure 4 represents three primary phases of energy management program maturity levels in a process facility.

Figure 4. The Three Maturity Levels of an Industrial Energy Management Program



On one end of the scale is the “rudimentary” level, where the building systems are the primary focus of the energy initiatives. In the “process-centered” stage, energy management initiatives move to the production area, but are primarily based on equipment modifications, such as machine-level metering, high efficiency motors, variable frequency drive integration, and idle state control. In many cases, some of these energy-centric modifications actually result in increases in process efficiency as well. For example, equipment that runs less often and at slower speeds than production schedules allow tend to break down less and cause fewer unplanned work stoppages.

The “advanced” level; however, is where the substantial benefits can be realized. In this phase, energy and process data are correlated to provide a unique visibility in which energy is measured in the *context* of production output, in units that resemble other production inputs, such as kWh per widget, or BTU per million gallons, or kWh per ton. This contextual energy is then tracked, trended and analyzed to support continuous improvement initiatives.

What’s key about the advanced-level energy management program is that it requires a strong technical and logical link with the process control system and when deployed, process and energy metrics are most effectively combined at the visualization system through what is typically called the “Energy Management Dashboard”.

Energy Management Dashboard Types

All this market promise has generated a green-rush industry of “energy dashboard” providers, with hundreds of vendors offering data visualization products that claim to have unique features and attributes that enable the superior management of energy resources. This array of choice is poised for continued expansion. Pike Research anticipates a 21 percent CAGR in this software and related services through 2020.

The field gets much simpler; however, when one considers the unique circumstances of the *industrial end user* in pursuit of energy efficiency, which enables the categorization of all of these offers into three levels, based on the types of decisions facilitated by each:

Enterprise Level Dashboards

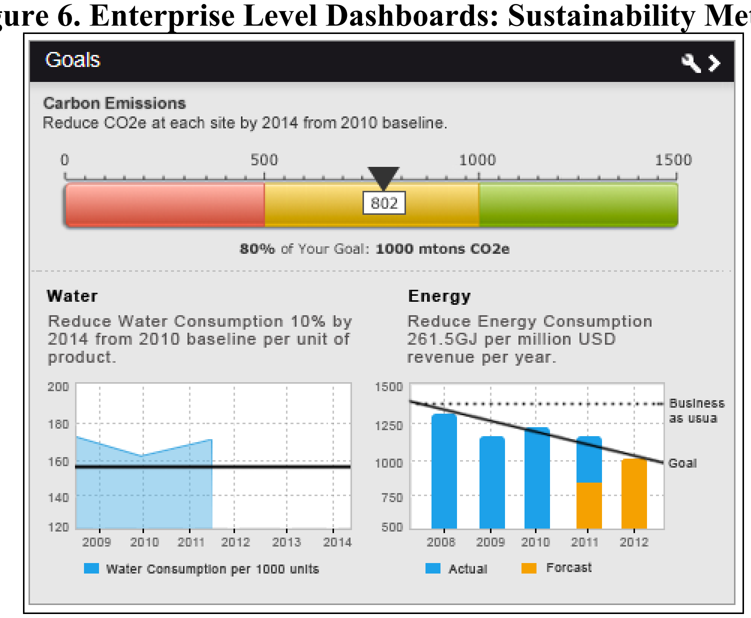
Enterprise level dashboards offer corporate purchasing managers a portal to make effective decisions based on energy market trends and their anticipated demand across all company facilities within a geography or companywide.

For example, a view of relevant energy commodity statistics, such as the one shown in Figure 5, would provide an indication of price trends that would influence buying decisions as well as consumption decisions. A projected rise in crude oil, as depicted, may prompt an action to store this energy resource at its current price or purchase oil futures. A longer upward trend in a specific commodity could also influence process decisions, to favor equipment fueled by less price-volatile sources, or could be used to justify investment in future equipment which uses alterative fuels.

Figure 5. Enterprise Level Dashboard-Commodities Purchasing Data

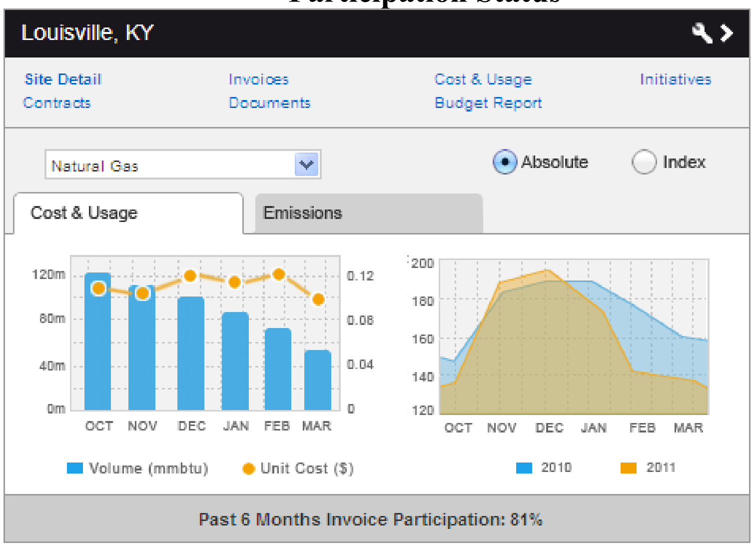
Environmental sustainability metrics are also compiled at the Enterprise level. For instance, Figure 6 shows an example of emissions, water, and energy profiles that are maintained for shareholder reporting or for environmental policy compliance. Note that in this example, the goals for each metric are clearly visible.

Figure 6. Enterprise Level Dashboards: Sustainability Metrics



Metrics associated with enterprise level decisions are further characterized by the frequency of updates required. At best, the types of decisions made at these levels require monthly updates, while often quarterly updates are a sufficient frequency. Because of this, it's often not necessary to automate the collection of supporting data from the various facilities if such an enterprise solution is cloud-based, thus, a company can depend on manually entered data. To ensure that data is updated by the facility personnel, it is a best practice to maintain participation metrics. In the example shown in Figure 7, cost and usage of natural gas is collected at a per-site basis and used for side-by-side performance comparisons between sites. At the bottom of this same figure is the Louisville invoice participation status, which shows for the past 6 months, the facility was 81 percent compliant with providing the relevant energy and emissions data by the 10th business day of the month.

Figure 7. Per-site Energy and Emissions Measurements with Invoice Participation Status



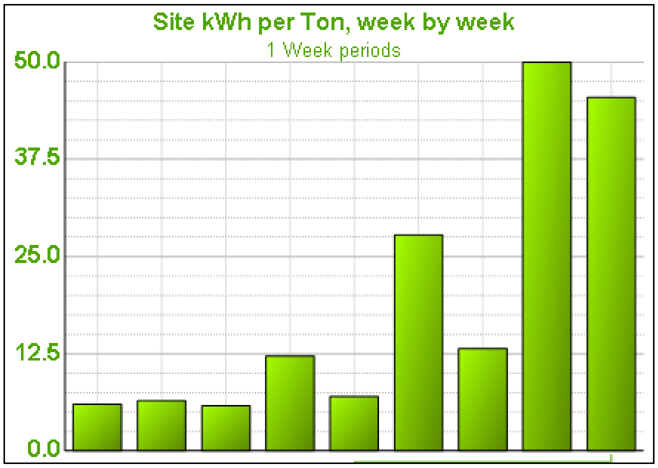
Operational Level Dashboards

While there's only so much that can be done with HVAC and lighting without compromising occupant comfort and safety, significant energy savings can be achieved with intelligent adjustments to production schedules, material flow, and process equipment, and these adjustments often result in production efficiency gains as well, truly achieving more with less. Taking advantage of this untapped potential requires an interface to the process equipment and production systems, not just meters. These systems give visibility and context to energy used in the production systems and can be classified as "operational level" dashboards, which are used by plant managers, process managers, industrial engineers, and site energy managers.

For example, in an energy-intensive process such as a mining operation, energy use can vary depending on raw material type, atmospheric conditions, work crew habits, equipment settings or any number of process variables. In this application, energy should be managed in a way consistent with other process inputs.

In the zinc mining operation example depicted in Figure 8, energy is expressed kWh per ton of material produced.

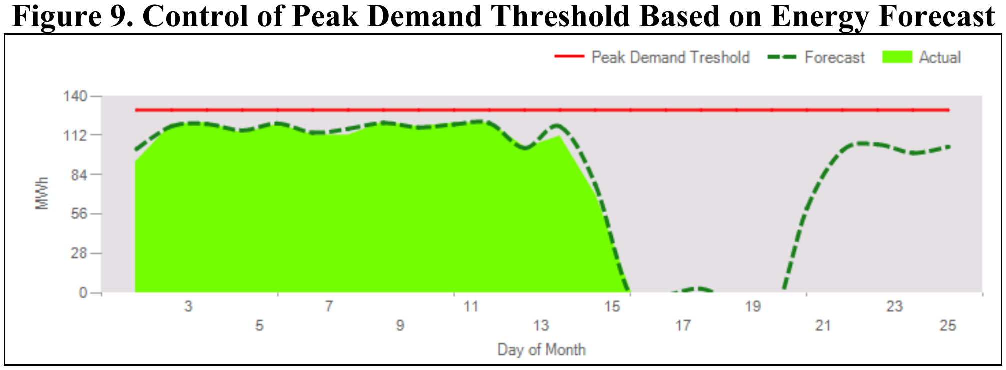
Figure 8. Operational Level Dashboard-energy in Context of Production Output



With this view, the energy manager can quickly and easily detect a problem which would not normally be apparent with standard energy metrics as more energy is being consumed, per ton of material produced, for the past 2 weeks than in weeks prior. The site's overall energy may actually be *lower* over this time period because production rates are lower, which would have normally prohibited this problem from being detected until the end of the fiscal year. With this view, it is immediately apparent. The energy manager can quickly diagnose the problem, using similar graphs to detect energy use by raw material source, work crew, or any other process variable.

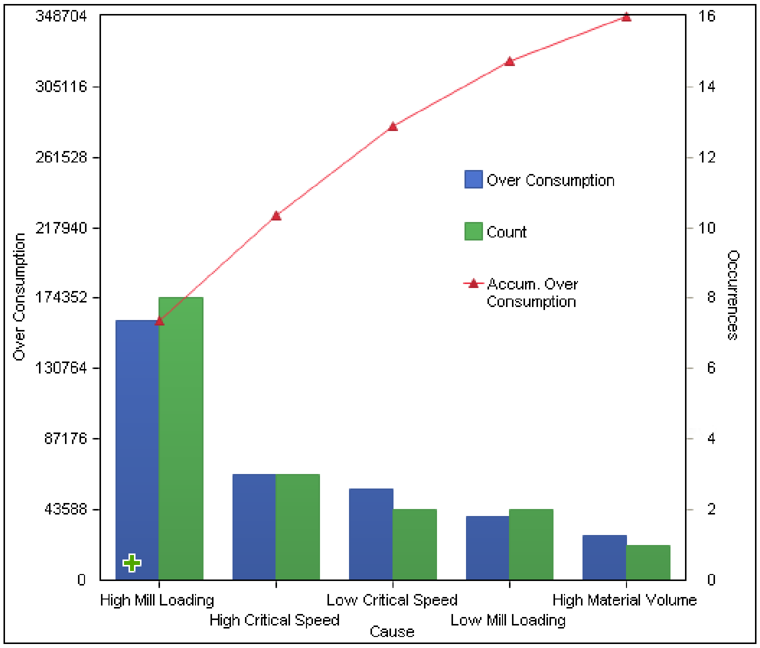
Another important characteristic for an operational level energy management dashboard system is its ability to model the consumption habits of a process as over time, production throughput can be compiled with energy use to automatically build an energy forecast dependent on future production schedule. Being able to accurately anticipate future energy consumption enables the prediction of the *peak demand*. Energy procurement contracts can then be adjusted to lower the peak demand threshold (represented by the solid horizontal line of Figure 9), potentially reducing the cost of every kWh consumed.

Figure 9. Control of Peak Demand Threshold Based on Energy Forecast



Once the predictive model is established, the operational energy management system would enable the detection and analysis of energy events. An *energy event* is a condition that causes the actual energy to exceed the forecasted energy, even for an instant. The energy management system captures not only the time and date of each event, but also all of the relevant process variables associated with it. Within a short time, enough energy events are captured to perform a meaningful analysis with tools such as a Pareto chart (Figure 10).

Figure 10. Pareto Analysis, Energy Events by Cause



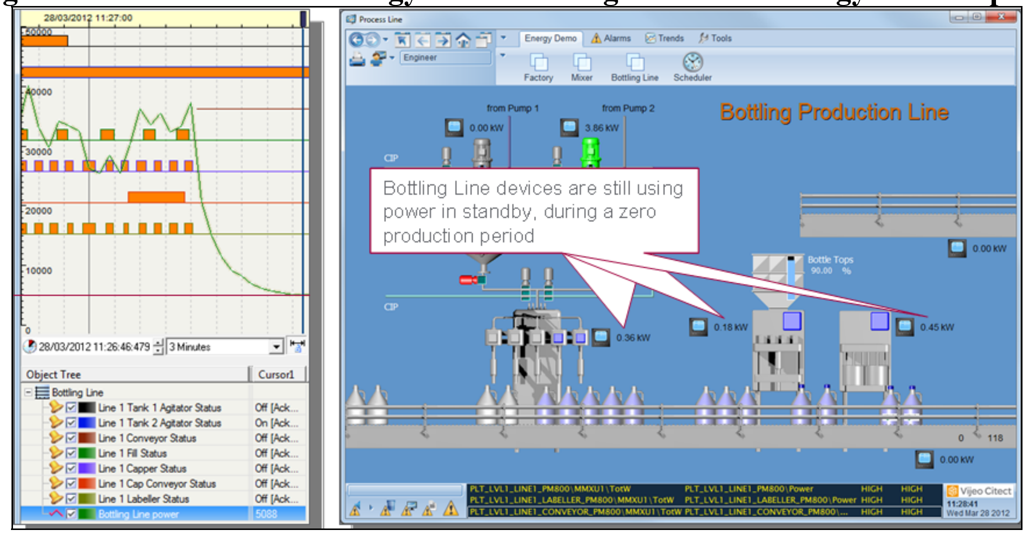
In the example provided, it becomes clear that energy events in this manufacturing process are most often correlated with a process condition known as “High Mill Loading”. Further analysis, using similar tools perhaps in combination with a manufacturing execution system (MES) system, may reveal that the mill is being loaded improperly by a specific work crew, which has adopted an unconventional work habit. Without analysis tools such as this, it would never be apparent that this practice is increasing real operating costs in the form of energy consumption.

The frequency of data updates to support operational level dashboard and associated decision making is generally per-shift or per-day at a level that requires automated data collection and storage. Fortunately, the data required to support these dashboards is often already available from the plant historian software, the MES, or from the meters and automation systems directly.

Control Level

At the control level, energy decisions are made on a per-minute or per-hour basis, generally by line managers, machine operators or maintenance staff. Through visibility, training, and metrics, plant floor personnel can be empowered to make real-time decisions to influence energy consumption in the same way that modern production interfaces allow for an impact on product quality and throughput.

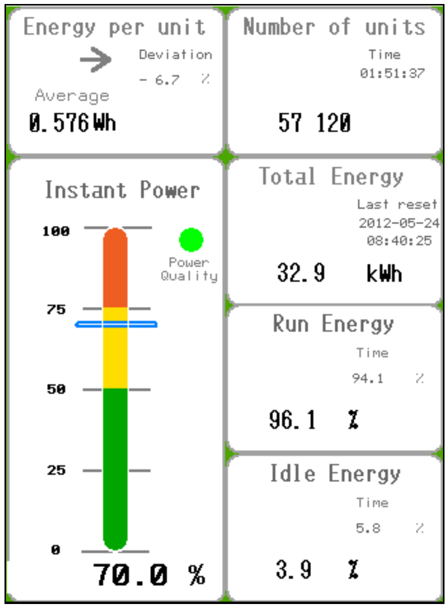
Figure 11. Machine-level Energy Data Showing Real-time Energy Consumption



The example, Figure 11 shows a bottling line with an energy meter based on every station. From this view, a line manager can observe that, although production is currently shut down to accommodate a line change; energy is still being consumed at each station. To eliminate this waste, an operator can take immediate action by shutting down equipment.

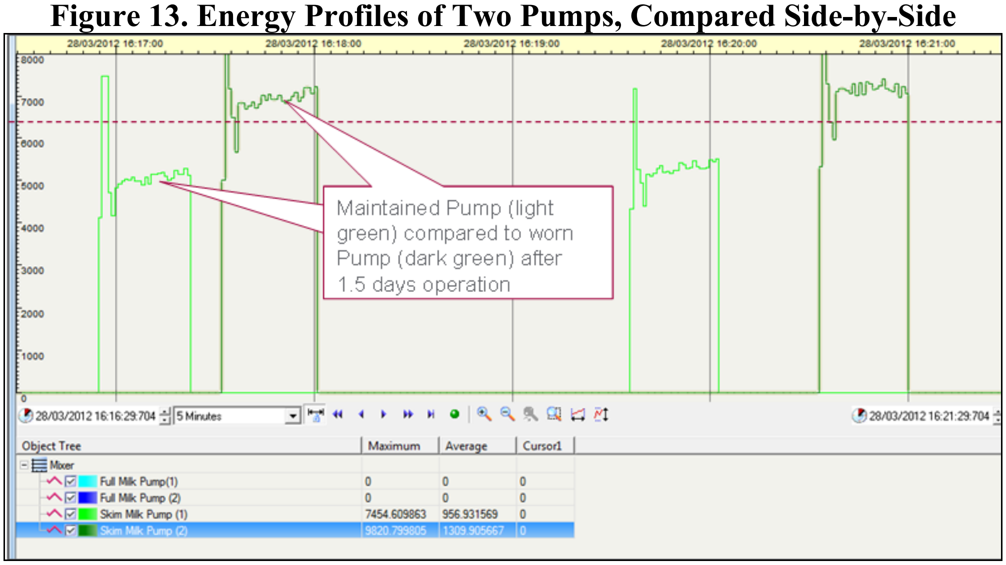
With simple interfaces, machine operators can be alerted to valuable energy statistics and adapt the use of equipment accordingly. The example in Figure 12 shows a machine-level dashboard from a plant that has established 0.617Wh per unit as a target maximum consumption and incentives have been created across manufacturing operations that align with this goal. A quick glance at the upper left-hand corner shows present consumption is 6.7 percent below this maximum.

Figure 12. Control Level: Machine-based Dashboard



Often, excessive energy use is a precursor to equipment failure. Recognizing this allows maintenance personnel to make preventative repairs on the off-shift, avoiding the expense of unscheduled downtime. For example, as a constant flow pump wears, it will use more power to pump the same volume of fluid. In the example (Figure 13), the energy profile of one pump is compared to another pump under similar load. In this case, a maintenance person can decide to configure a threshold of 6500W (represented by dotted line) to trigger a low-level alarm for a service order. This type of visibility allows plant floor personnel to ensure not only minimized energy waste, but also maximum productivity.

Figure 13. Energy Profiles of Two Pumps, Compared Side-by-Side



Conclusion

Industrial energy management initiatives have enormous potential to trim costs and reduce carbon emissions. With over a third of the world's energy demand coming from industrial facilities, the benefit of industrial energy mitigation efforts extends beyond the books of the manufacturers themselves. While working on facility energy consumption is a good start, such initiatives only represent the tip of the iceberg of energy saving potential.

Advancing the scope of an energy management program beyond the facility systems into the process not only provides a much larger playing field, but also the opportunity to improve production efficiency with the same investment dollar. Fortunately, advancements in the integration of information technology with production systems promote the ability to link production data with energy data, which provides a basis of correlation, trending and continuous improvement.

This benefit; however, tends to be lost in the rapidly expanding field of energy management visualization systems, which tend to be labelled with the over-applied term *energy management dashboards.* To identify the most useful tools for *process* efficiency, the industrial end user must look beyond this all-in-one "dashboard" label and consider how the information will be used to manage energy at the enterprise, operational and control levels of the organization. Only then can technology be properly leveraged to deliver the most significant results.

References

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