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Process Control for Active Energy Management in Industry

Industries are changing their view of energy; from being a necessary overhead cost to a strategic resource to be managed effectively. Obvious approaches to making energy management improvements include focusing on specific physical assets (to make them more energy efficient) or implementing people-centric changes or installing stand-alone energy management systems. However, a true systems approach can be best achieved by leveraging tools that span the entire process and that operators are already familiar with – site-wide process control solutions. These tools can help operators measure, improve and analyze energy and process data in context and in real-time; so that business and environment goals are met without the need for significantly large capital expenditure.

Background

This white paper was written by analysts of the Industrial Automation Practice at Frost & Sullivan to elaborate on the potential to leverage process control solutions for active energy management in Industry.

Founded in 1961, Frost & Sullivan, the Growth Partnership Company, partners with clients to accelerate their growth. The company's TEAM (Technical, Econometric, Application & Market) Research, Growth Consulting and Growth Team Membership empower clients to create a growth focused culture that generates, evaluates and implements effective growth strategies. Frost & Sullivan employs close to 50 years of experience in partnering with Global 1000 companies, emerging businesses and the investment community from more than 40 offices on six continents. The Industrial Automation & Process Control Practice of Frost & Sullivan monitors and tracks markets and technologies in MES, PLC, DCS, SCADA, HMI, asset management and optimization, simulation, robotics, motors, drives, fluid power and other process and manufacturing systems.

For further information on Industrial automation markets and technologies, visit http://www.industrialautomation.frost.com

The Paper was completed in February 2012.

Hidden in Plain Sight

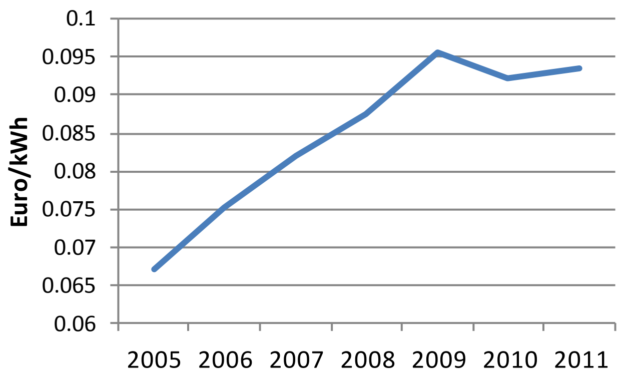
Process Control for Active Energy Management in Industry

Introduction

> *"The most important contribution to reaching energy security and climate goals comes from the energy that we do not consume."*
> \- ***World Energy Outlook 2011, International Energy Agency***

For industry today, energy management is no longer a distant after-thought. Obviously, stricter compliance requirements and national mandates are key drivers[1]. However, industrial organizations across regions and verticals realize that high energy consumption (and high emissions) have significant negative impacts on their financial, competitive and social performance metrics. More than viewing this as a threat, an increasing number of these organizations are seeing the energy challenge as a significant opportunity for growth.

Electricity Prices for Industrial Consumers (EU 27), 2005-2011



Source: Eurostat

As global energy demand increases by one-third over the period 2010 to 2035 and energy-related CO_2 emissions increase by 20%[2], as energy prices rise[3] and become more unpredictable, and as energy supply limitations become more acute in some regions, industrial organizations are actively looking at all viable options for managing energy more effectively.

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[1] For example, in the U.S., Section 106 of the Energy Policy Act of 2005 (EPAct 2005) mandates a 25% reduction in industrial energy intensity by 2017.

[2] World Energy Outlook 2011, International Energy Agency (IEA)

[3] As the price chart indicates, for Industrial consumers in the EU 27, electricity prices rose by close to 40% over the period 2005 to 2011 (Source: Eurostat).

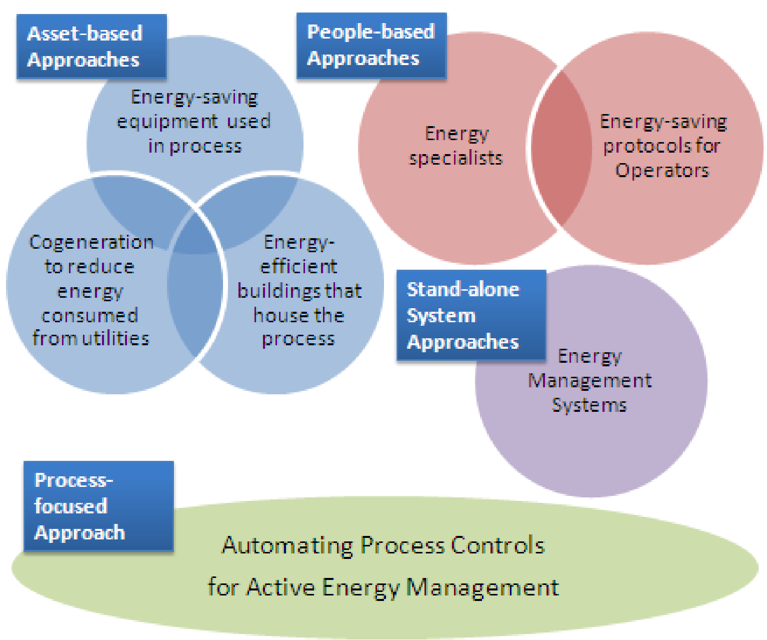
Also, as industrial organizations are asked to track their carbon footprint and become smart-grid-ready[4], they will need to understand the energy profiles of their various plants and of each part of every process in these plants. However, not many currently know this. Not many can confidently identify what are the low-priority loads that can be reduced or shut, and what are the critical loads that cannot be.

Unfortunately, a large number of organizations take a 'blunt instrument' to energy management. With production and throughput as the main priority, they swing from one extreme of excessive energy use to the other extreme of a production halt (in the case of process upsets). This 'all or nothing' approach to energy management hurts productivity and profitability.

Given the fact that industrial organizations are amongst the largest energy users[5], gains made in this sector have the potential to make a significant difference to overall energy consumption levels.

The difficulty remains in identifying and leveraging the right tools to achieve this.

The good news though, is that in a high proportion of cases, these tools are already available to organizations.



Options for Improved Energy Management

Typically, efforts to improve energy management require a combination of approaches. These include focusing on improving efficiencies of the physical assets themselves, changing energy usage patterns of operators and other staff, or

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[4] Revenues in the global smart grid market are projected to grow at a compound annual growth rate of 26.6% between 2010 and 2017 (Source: Frost & Sullivan, Global Smart Grid Market Report, Aug 2011)

[5] The industrial sector accounted for 52% of total delivered energy consumption globally in 2011 (Source: International Energy Outlook 2011)

the introduction of stand-alone systems.

What is often ignored in these efforts is a process-focused approach.

Physical Asset-based Approaches

The most obvious avenue to saving energy and improving energy efficiency is the use of energy-saving equipment and devices. For example, soft-start motors and variable speed drives in processes, or energy-saving lighting and efficient air-conditioning in facilities that house the processes. Alternatively, cogeneration (that can harness by-product gases and heat from existing processes for power generation) can help a site reduce its overall consumption of energy from utilities (thereby increasing overall energy efficiency by as much as 50%[6]). However, these are only part of the solution (and in capital-constrained conditions, large upfront investments on new equipment may need to be postponed on account of long or unclear payback periods).

People-based Approaches

Some organizations recruit energy specialists to design energy-saving protocols, and typically operators are asked to follow these protocols. However, these are usually paper-based documents which, more often than not, leave room for diverse interpretations by different operators and result in inconsistent actions or interventions. More importantly, plant operators, seeking to focus on core processes, are loathe to make their job more complex with the addition of energy management tasks. After all, their first priority is and should be the process itself. This is a justifiable concern, especially since distraction[7], confusion or response errors on the part of plant operators can lead to higher inefficiencies, lower quality of output or even process upsets.

Stand-alone System Approaches

Stand-alone energy management systems are also viewed by some as the easy quick-fix. However, the problem with stand-alone energy management systems is that they tend to track energy variables only and cannot relate these effectively to process conditions. In most process environments, diverse material, equipment, personnel, timeframes and process flows are involved. Unless energy consumption is viewed directly against these variables, context for actionable insight cannot be derived. Also, since the typical manufacturing site is a composite

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[6] U.S. National Energy Education Development (NEED) Project

[7] Distraction is often cited as one of the key Error Producing Conditions (EPCs) that impacts the probability of task failure in Human error assessment and reduction technique (HEART) studies.

of several interlinked sub-systems and processes, energy consumption is also interlinked between processes. Finally, in the case of most stand-alone energy management systems, operator confidence in these systems is not high (considering the relative novelty of these solutions).

The Solution – Hidden in plain sight

Active energy management (or energy measurement, monitoring and control that effects permanent change) is now possible by leveraging what plant operators are most familiar with – site-wide process control solutions.

Process control solutions have traditionally been used to optimize people, processes, equipment and raw material. This they have done this extremely well over a long period of time, to ensure organizational goals are met in relation to throughput, safety, quality and profitability. However, it is only recently that they are being viewed as a means to achieve active energy management.

A 2010 UNIDO survey of industrial firms investing in energy efficiency projects (119 firms globally) found that the internal rates of return were higher for projects which "commonly require small investments, involve process reorganization and housekeeping measures, (and) use existing infrastructure better...". The survey also found that "projects that involve larger investments and require changing machinery and equipment (mainly in process sectors) are less profitable and require longer periods to mature.."

- ***Industrial Development Report 2011, United Nations Industrial Development Organization (UNIDO)***

The advantage of leveraging process control solutions is their ability to relate energy flows across the whole system. This way, the focus is not on one piece of equipment or one shift or one operator. Opportunities (for energy savings or efficiency improvements) can be identified across the process (after all, energy at a manufacturing site is not only consumed in core production-related activity. In fact, in a mass-production environment, around 85% of energy is used in non-machining operations which are not directly related to production of parts[8]).

In keeping with this new 'systems thinking', energy management and operations management solutions provider, Schneider Electric has released new features for their control solutions offerings that can deliver significant value to plant operators.

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[8] Gutowski, T., C. Murphy, D. Allen, D. Bauer, B. Bras, T. Piwonka, P. Sheng, J. Sutherland, D. Thurston, E. Wolff, 2005, "Environmentally Benign Manufacturing: Observations from Japan, Europe and the United States," Journal of Cleaner Production, 13, pp. 1-17.

Measuring

As with any attempt to improve performance, the critical first step is to accurately capture current performance. In the context of energy consumption, this is done through the vast array of power meters hardwired around the plant that record energy use across devices and processes. However, meter data is not typically drawn and viewed on the same screen as process data for plant operators.

With Schneider Electric's **Vijeo Citect +PowerConnect**, this is now possible. This pack allows operators to view how much energy is being used alongside process metrics; an effective way of inducing operator actions to reduce energy use where possible. Better still, it allows for the addition of alarm conditions and alerts to notify operators on defined events such as unusually high input surge current. Given the fact that power meters are extremely complex to configure and customize, the availability of ready-to-use templates simplifies the process of bringing meter data to the operator's view.

With this tool, organizations move beyond metering for energy accounting to metering for process-induced energy savings. And with an increasing trend toward sub-metering (which allows organizations to identify and allocate energy costs to each production line, process area, department or individual piece of equipment), increased operator visibility of energy-production data helps them play a more active role in reducing costs to their department or site.

Taking this principle beyond the process itself, Schneider Electric's **Vijeo Citect +Facilities** pack helps organizations to draw energy use data from the buildings in which the process is situated, to help throw up additional avenues for reducing energy consumption of the whole site.

Improving

Once energy use data is made visible through +Power Connect, intelligent load shedding or load shifting is made possible through Schneider Electric's **Energy Scheduler** in Vijeo Citect.

This enables operators to move processes from one state[9] to another based on equipment hierarchy, to help with:

- Peak demand management: This ensures that the process never hits peaks. In fact, operators can change the sequence of various equipment start-ups, to ensure that not all start at the same time; thus preventing the most common cause for peaks[10].

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9 A state refers to a type of operation i.e. low capacity running, maintenance mode, standby mode, etc.

- Time demand management: This enables operators to use power when it is most cost-effective (from a time-of-day utility billing perspective). This not only enables large users to take advantage of better tariffs at certain times of the day, but, in special circumstances, helps them avoid potentially large penalties[11]. The Scheduler can be used to make state changes across the year; controlled by timers. Recurring events, special days and interval-based events can be set.
- Process demand management: Based on the nature of different product runs, types of shifts or process flows or even portion of a process, the operator can request state changes to optimize energy use. For example, if there is a downstream process upset, the operator can change the state of the upstream process to lower capacity runs so that unusual buffers of throughput or bottlenecks are avoided till the downstream process upset is resolved. Given the fact that in most real-world process environments, disruptions (that impact energy use) are bound to occur, the ability of the operator to reactive quickly and appropriately, by revising pre-established schedules, is critical. Energy Scheduler enables this type of dynamic scheduling.
- Demand response management: This enables operators to take appropriate action when requested by utilities to reduce energy consumption by a certain amount (on account of extended hot weather and consequent high demand or extreme weather events or network faults/capacity constraints resulting in a higher risk of system

> *"In reality, due to unforeseen disturbances on the shop floor during the execution of a schedule, an originally optimal schedule may become sub-optimal or even unacceptable; thus, a new schedule will often have to be found in a relatively short time frame."*
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> - ***Ouelhadj, D., Petrovic, S., (2009): A Survey of Dynamic Scheduling in Manufacturing Systems, in: J. of Scheduling, Vol.12, No.3, pp 417-431***

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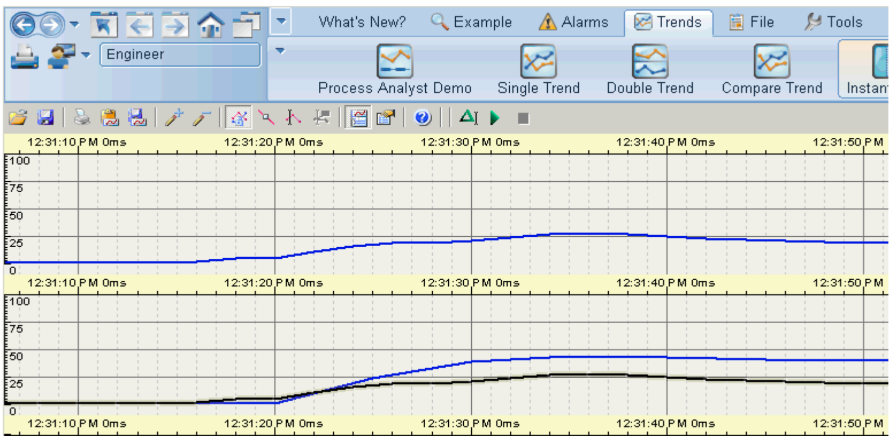
[10] Such approaches will eventually help create the scenario where all large end users benefit from reduced peak load prices.

[11] In 2011, for example, the Japanese government required the industrial sector consuming over 500 kW to cut electricity consumption by 15% compared with the same period the previous year - between 9:00 and 20:00 - or face penalties of up to JPY 1 million (approximately USD12,500) for each hour in which the target was not met.

failure[12]). Demand response is increasingly used by utilities to balance supply and demand during system emergencies[13]. With Energy Scheduler, user-defined levels can be set, so that response to requests from utilities is fast and easy.

Energy Scheduler helps operators avoid an "all or nothing" approach and instead change states rather than execute a complete electrical switch off.

Lowered peak for power consumption after offsetting of Product Line Startups



- Near-real time intelligence on energy consumption in the production context
- Presented visually
- With the ability to customize displays
- To the right level of detail.

Source: Schneider Electric

As the screenshot of Schneider Electric's Process Analyst shows, a clear and intuitive view of energy consumption in relation to the process can help reduce consumption and achieve savings.

Analyzing

Beyond tangible improvements, the next level up above the control layer, **Ampla Express: Energy Insight**, built on Schneider Electric's leading operation management software, allows organizations to analyze energy use to answer key questions such as: What is the average cost of energy per output of production[14], when was energy waste highest, or what energy was consumed in downtime or on which shift, during which process upset or on which product run?

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12 Given the fact that critical event prices could be 3-10 times the annual average, it is clearly in the interests of industrial organizations to be able to respond to emergency events when they arise.

13 For example, the potential resource contribution by demand response in Regional Transmission Organization (RTO) and Independent System Operator (ISO) markets operated in the U.S. increased by more than 16% from 2009 to 2010.

14 For example, in the steel industry, gigajoules per tonne of steel manufactured.

This is done through near real-time key performance indicators (KPIs), graphically displayed on an easy-to-read dashboard.

This means that organizations can create the OEE+E view (overall equipment effectiveness plus energy) that gives them the ability to see the 'big picture' of production energy across different time periods and so tie all energy and production data in context.

Conclusion

The day may come when industrial facilities are designed and built based on energy flows (rather than material flows). However, in the current and medium-term, by automating energy management directly to the process, smart organizations can improve their bottom line, competitiveness and compliance.

However, ultimately, the value of solutions such as those delivered by Schneider Electric is in avoiding the disconnect between energy and production that normally occurs in process environments. By enabling operators to view process and energy data on the same screen, such solutions can truly make operators energy efficiency champions who take energy saving decisions in real time rather than retrospectively.

Case Study: Process Optimization and Energy Management at Biological Wastewater Treatment Plant, Tyrol, Austria

Objective

- Optimizing energy usage at the Fritzens wastewater treatment plant (WWTP) in Tyrol, Austria, which processes approximately 6.1M cubic metres of sewage per year (80% municipal and 20% industrial wastewater).

Solution

- Improved on-site power generation
- The "Energy Efficiency Loop" to measure, analyse, improve and control energy flows; supported by SCADA, PLC, VSDs, LV distribution as well as process optimization and energy management applications from Schneider Electric

Benefits

- Availability of energy data on the dashboard aided behavioural change amongst operators - encouraging continuous improvement
- Schneider Electric's controller libraries reduced engineering and commissioning time
- The plant moved from being a net consumer to a net generator of energy (through on-site produced heat and electricity meeting all of its demand, as well as feeding back green power to the grid)

"Schneider Electric convinced us with their automation solutions that met our water treatment needs. The solutions are based on their reliable products and make the whole system highly available. It was extremely important for us to work with a partner who is familiar with the water segment and knows the water basics in order to engineer and commission such a plant."
Christian Callegari, Managing Director, Fritzens WWTP

Source: Schneider Electric & Fritzens WWTP