Life Is On | Schneider Electric

The Impact of Energy Management on Process Automation Systems

by Peter Hogg

Executive summary

In 2012, 4% of large corporations surveyed by Accenture said they deselected suppliers who failed to meet environmental objectives. Another 39% projected that they will soon follow this lead. This increasing focus on sustainable production is not only driven by regulation but also by the ability of sustainably focused companies to outperform their peers.

Executive summary

In 2012, 4% of large corporations surveyed by Accenture[1] said they deselected suppliers who failed to meet environmental objectives. Another 39% projected that they will soon follow this lead. This increasing focus on sustainable production is not only driven by regulation but also by the ability of sustainably focused companies to outperform their peers.

Strategies for energy efficient production need to take a holistic approach in order to achieve the universal targets of reducing carbon emissions by 20-30%. The approach needs to focus on more efficient equipment, process changes, and operator engagement to make and maintain significant energy savings.

Many companies have started on this journey, often by simply adding some power metering and dashboards. Most of these systems, however, fail to link the consumption with specific production efforts and operational tasks. Consequently, their conversion to real energy savings is low.

In this paper, we will detail the key functions of an energy-aware process automation system (PAS) and how its links between production and energy result in increased production and energy efficiency.

Introduction

The industrial sector is by far the world's largest consumer of energy,[2] and for many industrial companies, energy is the single largest cost within their business. If we take the example of a wastewater treatment plant, energy represents 34% of operating costs, yet the focus has traditionally been on process efficiency and the use of chemicals, which only represent 16% of the total cost.

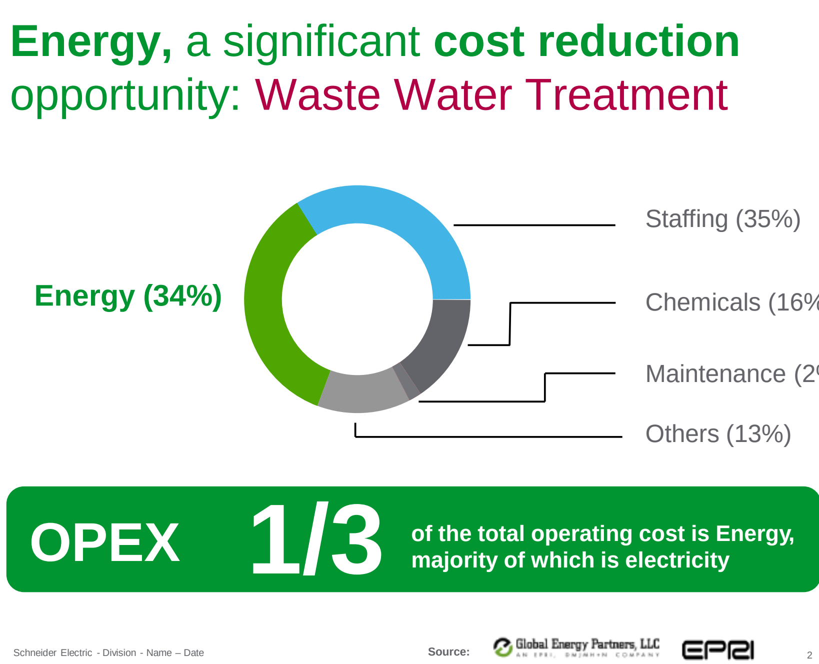


Figure 1

This is the figure description which should be centered vis-à-vis surrounding text

[1] Accenture CDP 2012

[2] US Energy Information Administration http://www.eia.gov/tools/faqs/faq.cfm?id=447&t=1

The reason we were happy to focus on production efficiency was based on two widely held assumptions. The first was that an efficient process uses the least amount of energy, and the second was that the cost of energy was so small that its consumption in any one location had minimal impact on the overall costs of operating a plant.

"Energy consumption is on the rise and set to almost double between 1990 and 2035. The majority of this rise will come from outside OECD nations and is driven by long term economic growth."

The pressure of the world's expanding population and increasing standard of living[3] is driving up the demand for energy, with estimates expecting that energy usage will double by 2050 and electrical consumption by 2030.[4] This increase in demand can only be supported by new power generation and infrastructure, resulting in higher prices. This increase in demand coincides with a growing awareness in the community of the detrimental impact of carbon emissions on the environment, as seen in recent studies which show that most consumers are actually prepared to pay higher prices for goods produced in a sustainable way.[5] These standards define the processes and the auditing which are required – but rarely explained – to realize energy savings.

How much do we need to reduce?

Energy consumption is on the rise and set to almost double between 1990 and 2035.[6] The majority of this rise will come from outside OECD nations and is driven by long term economic growth. Increasing standards of living require more manufactured goods, but the increased energy levels required to produce them are not sustainable.

The graph below shows the anticipated increase in energy consumption (our reference scenario) but then also looks at the mediation methods which are required to deliver the energy reductions to restrict carbon emission growth. Energy demand in the New Policies Scenario still grows by 35% in the period between 2010 and 2035, but without implementing the assumed efficiency measures, the growth would be 43%. It indicates (in lavender) that the largest energy savings must come from end user energy efficiencies. Industry is not only the largest consumer of energy, but also the area with some of the most cost effective energy savings capabilities, and it is expected to make the largest contribution to energy reduction.

The graph below demonstrates the need to change the way energy is consumed in the manufacturing sector.

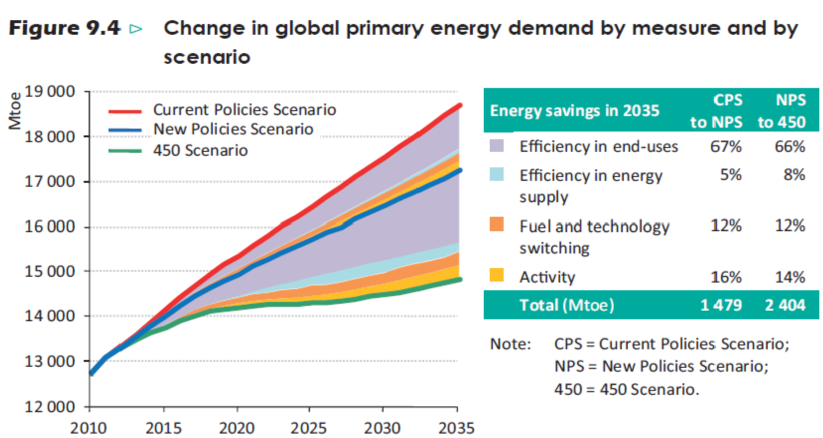


Figure 2

Change in global primary energy demand by measure and by scenario

[3] International Energy Agency - World Energy Outlook 2012

[4] US Energy Information Administration 2008

[5] Our green world survey 2008: 59% would pay more for green products; 52% would pay 5% more and a further 33% would pay 10% more.

[6] US Energy Information Administration http://www.eia.gov/forecasts/ieo/index.cf

Managing energy

In order to help customers meet this challenge and generate large energy savings, it is necessary to take a more holistic approach to energy management. The following energy management life cycle model illustrates an effective guide. It shows five distinct areas of focus for improving energy management. The strategy, supply, demand (our focus), analysis, and performance monitoring.

Figure 3

The energy management life cycle

The most common starting point for energy management is to measure performance. It's hard to develop a strategy without first understanding the current position, and most energy management processes will start with an audit or measurement. This stage of "Energy Awareness" often looks at benchmarking plants and production against target energy consumption levels. In Europe, this Energy Efficiency Audit, or Energy Management Information System, is required as part of the European Parliament's Energy Efficiency directive (published October 25, 2012).

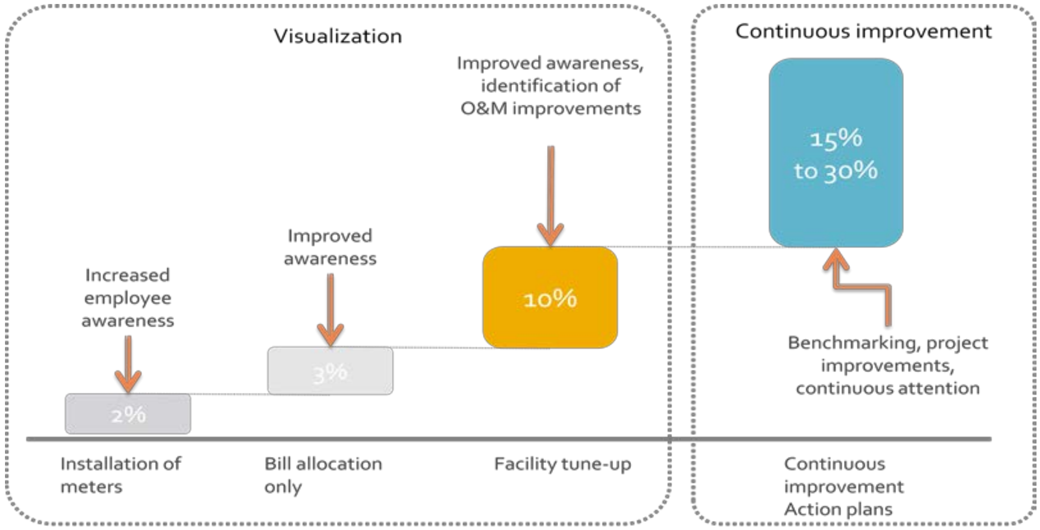
The information from the performance phase is typically displayed on a dashboard. The data can be shown on large screens so it is visible across an enterprise. In industries where there are lots of repetitive systems or existing benchmarks, this information provides businesses with a clear picture of their performance.

When measuring building efficiencies, there are clear benchmarks for energy consumption based on the building's floor area and the external temperature. Based on these values, energy consumption models can be used for generic buildings. This approach can also be applied to the industrial sector where there are benchmarks for some processes, but where it is rare that we get a clear benchmark on energy consumption.

The issue with benchmarking for industrial companies is twofold. First is the complexity of the process. Take, for example, a simple process such as a water pumping station. Its energy consumption will change on a daily basis; it will also be impacted by the distance and height pumped, as well as local rainfall. All these factors increase the complexity of our model. The second is that while a benchmark offers a point of comparison, it does not provide guidance on what to change within the system.

Figure 4

The potential energy savings difference between visualization and continuous improvement.



Source: Schneider best practices, US Department of Energy Metering Guide, Feb 2006

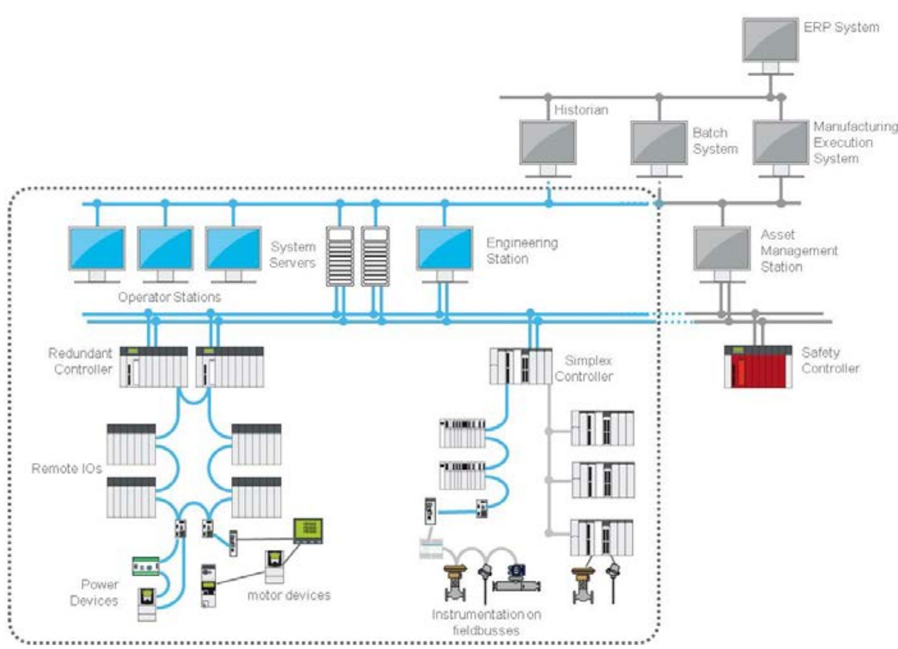
Key to delivering energy savings in a manufacturing process is the ability to convert the information into an action or a change within the plant. To create actionable change in our plant, we must stop focusing on energy consumption against time and instead focus on what the energy is actually doing (i.e. the production).

To get an accurate link between production and the energy consumed, we need to collect energy information in alignment with process data. The cleaner the relationship is between the action and the data collected, the more accurate we can be in our analysis and the better our results.

A typical control system includes a large number of energy consuming elements. Each of these elements contains one or more of our energy sources (water, air, gas, electricity, and steam). Some pieces of process equipment may actually change energy source based on the customer's strategy for managing their energy supply.

Figure 5

A typical PAS architecture



The first step to using energy management to enhance the performance of your process automation system is to collect data from the energy data sources and energy consuming devices across the control system. If power metering exists, it is often already connected to alternative systems which communicate data via power system protocols such as IEC 61850. The PAS needs the capacity to communicate with these power meters in parallel to their existing systems, or to communicate with the energy systems, themselves, to collect the energy data.

Energy data is also available (at lower resolutions) within many types of energy-consuming process equipment. In some cases, it must be calculated or approximated through the use of process values which are known to correlate to the energy usage (virtual metering). In the past, the process of collecting data from a production system has been difficult due to multiple vendors and standards. The Open Device Vendors Association (ODVA) has created standards for the measurement and transfer of energy data within control systems. Support for standards like these enables energy management to be rapidly implemented on sites with systems from a variety of automation vendors.

Energy in the context of production

While the display of energy and production data over a period of time on the same graph helps to identify energy waste, it nonetheless hides the complexity of the process which creates the demand. To relate energy to production, we must be able to allocate a specific energy consumption level to a specific process within the system (possibly aggregating data from multiple energy sources) and also divide the energy consumption into intervals of common production (process segments) so that targets can be set and comparisons made.

To aggregate the energy data within a single process, we often need to combine electrical and non-electrical data for a large number of sources across a network. This link is available in an energy-aware PAS. It links the energy consumption and the process, ensuring that changes in the process are reflected within the energy management system.

"To relate energy to production, we must be able to allocate a specific energy consumption level to a specific process within the system."

While the aggregation of components is required in some systems, it is also necessary to measure the energy consumed in "unmetered" systems. This concept of a "virtual meter" – to create a meter for data which is unmeasured – can either measure "what is left" from a parent meter or the theoretical energy consumption of simpler devices. The implementation of the exact aggregation/virtual meter topology will need to be customized based on the available energy data.

Connecting our process energy to process actions requires a measurable unit of production. Sometimes, this will simply be a time period of production; sometimes, it will be the production of a certain number of units of output, and sometimes it will be a cycle. The choice of measurement is impacted by the process, but the automation system should be able to work with any of these intervals and capture production information and energy data for further analysis.

Energy-aware automation systems provide objects to easily collect the data recorded by these intervals and pass this information on for analysis.

Analyzing energy

The analysis of energy consumption and production data can be done at many levels within the control system. At the lower levels, the operations team is able to use the energy data to detect processes which are not operating at their rated efficiency and, in so doing, detect restrictions in the process' capability which were previously going undetected. At higher levels, energy managers can compare the plant's overall energy efficiency in order to create energy management programs and drive down the manufacturing costs.

Key to analyzing the root cause of energy consumption is, naturally, to investigate the process which is consuming the energy. The energy-aware PAS will bring together these production and energy consumption data sets. Doing this at lower levels within the process generates a large set of production and energy data for an operator to monitor. Rather than adding additional displays for the operator to review, it is better where possible to analyze the energy consumption with the controllers, and either take direct action or flag only abnormal energy consumption to the operator via the alarm system.

The data in the example below shows the strong relationship between production (tons) and the energy (Kwh) used to convey ore through the system. It also reveals that there are numerous periods in which no production has occurred but energy was still being consumed.

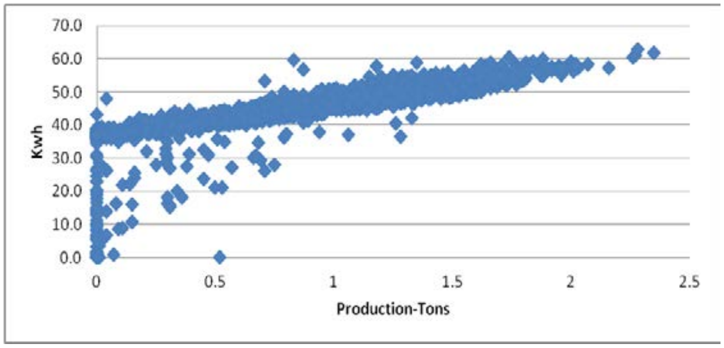


Figure 6

Production and energy data for operating periods of a conveying system

The control system's ability to detect this unnecessary or wasted energy also allows it to take action to remove the waste (almost 7%). The control logic used in this system was similar to that used in many control systems, but because it wasn't energy aware, frequent starting and stopping resulted in energy wastage. In this case, an energy aware control system could detect the absence of feed on the belts and more rapidly start or stop the sequence (using power consumption as a process sensor). Energy aware control systems are speeding up production while reducing the operational cost of the control system.

While many processes are continuous (resulting in a strong relationship between production and energy consumption within a time interval), other process are batch oriented. Batch oriented process are often analyzed only at the completion of each batch, with the batch size and amount of energy consumed following the same relationship as in a continuous system. Some longer batch processes can also be analyzed within the batch.

The data in the example below shows the relationship between energy production (as waste heat) and the operation time of a longer process. As expected, the longer the process continues, the less energy is generated. The significant periods are highlighted in different colors.

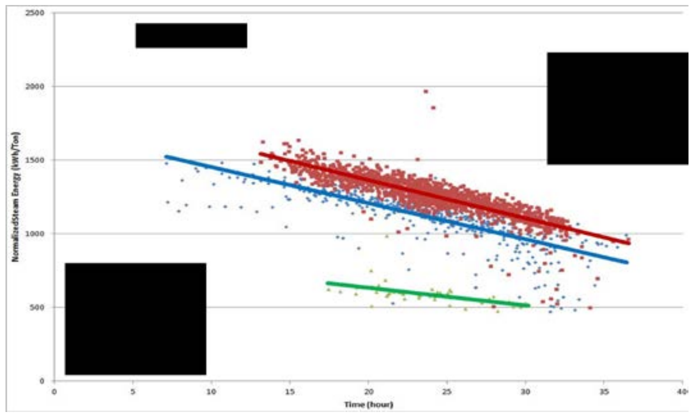


Figure 7

Production and energy generated data from a slow process

The operation of a waste heat recovery system is much more complex than a simple conveyor. The energy-aware control system has detected the lower performance of the system but is not able to attribute this to a specific cause so it alerts the operator. System alarms can be caused by manual operations, changes in setpoints or other factors which are not specifically monitored so some analysis is still required. Triggering alarms as close to real time as possible allows the operator to minimize the likely cause of the underperformance.

The PAS is able to detect real-time variations in energy consumption from defined targets. This enables real-time action to be taken to adjust the energy overconsumption but it does not provide management with the data they need for a higher level of analysis. To access that data, industrial sites need an energy management information system (EMIS).

The EMIS spans both the supply and demand side analyses. For supply side analysis, the EMIS must link to tariff schedules and analyze energy consumption against the tariffs available. For the demand side, the EMIS must link the same energy data in the context of the production. The EMIS allows users to see longer term trends for each system against industry benchmarks and other systems on the site. For industrial customers, an EMIS must work with the data from an integrated power and process system.

Figure 8

Typical EMIS system

From opportunity to action

Energy analysis based on data from an energy-aware PAS will provide real insight into the energy consumption of each process, and will identify the major changes which are possible in order to reduce the energy consumption of a control system. To achieve this reduction in energy consumption, we need to turn to the control system, its equipment, processes, and operation.

Integrate efficient devices

More efficient devices are constantly being developed for the market. Sometimes, the efficiency is based on a more effective process, but sometimes it is about trying to save energy during non-operational times. Efficiency during operation is inherent in the device and its configuration. Integration of these devices and setups in the configuration of the PAS helps to better configure and maintain this efficiency.

While efficiency in production is important, there is an increasing focus on reducing the energy used during non-operational periods as this is waste (not used for production). For non-operational energy savings, companies should look for open standards. ODVA provides standards to enable a PAS to engage its energy saving modes. While energy saving modes are part of the ODVA standards, to be very effective in their implementation, they need to be integrated back into the PAS libraries so that energy can be saved both when the plant is stopped and during partial process downtimes.

Implement and monitor optimized processes

More efficient processes are developed based on years of process experience. Traditionally, vendors produce PAS libraries with a focus on achieving their process goals. An energy-aware PAS will have libraries designed to achieve optimum energy efficiency. The libraries are also typically pre-designed to support energy and production data collection to ensure easy benchmarking and comparison.

The great advantage of having energy information available within the PAS is its ability to constantly track its energy consumption relative to the targets identified for analysis. The effort required to execute a process (represented by the energy consumption level) is a valuable indicator of the progressive reduction in the process' efficiency. The energy-aware process control system can constantly track deviations between consumed energy and the target, and provide early indications of equipment wear or an obstruction in the process. While we can try to save energy in many locations, the largest energy wastage occurs during downtime. The failure of one component or system within the plant makes production by the rest of the system impossible, yet the energy consumption continues at production levels. By reducing downtime, the energy-aware PAS not only saves energy from being unnecessarily consumed, but also uses energy information to keep the process optimized and effective.

More effective people

Frequently, many of the opportunities to improve processes lie in improving the knowledge and behavior of the people operating the system. In the short term, these behaviors and knowledge can be enhanced with training, but as employees turn over, the most effective way to ensure energy efficient production is to build these effective behaviors back into the process control system.

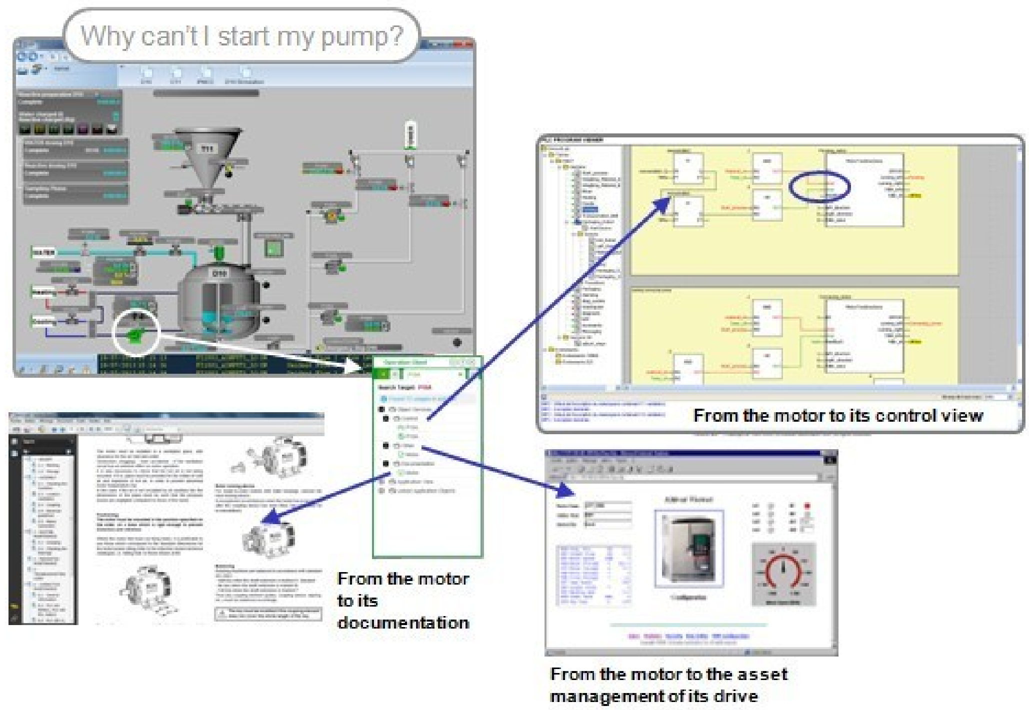
As identified above, the energy-aware PAS focuses on reducing or removing downtime by using energy as an indicator of the system's health. It also helps operators to rapidly resolve downtime issues by bringing meaningful information and tools from across the control system during runtime. This next generation of process automation systems allows operators to use navigation runtime services to access a full array of information (previously spread across different systems) at whatever point they need it.

The energy-aware PAS also improves operator effectiveness when the plant is operating. Because energy waste can also be caused by operator actions, the benchmark errors for energy consumption provide a way to ensure operators get rapid feedback on the way they run the process, reinforcing the training messages and expectations. It is also a useful asset for the transfer of knowledge from senior engineers to more junior colleagues upon retirement.

As well as capturing post energy event information, an energy-aware PAS can also be used to alert operators before excess energy costs occur, thus better connecting operator actions with the energy peak and, more importantly, endeavoring (whenever possible) to avoid energy peaks within the plant.

Figure 9

Context sensitive runtime services allow the user to rapidly navigate to multiple systems to resolve a fault.



Conclusion

In the age-old dilemma of how to increase production and decrease downtime, controllers have been refined and improved to ensure maximum efficiency. In fact, there now seems to be little room for improvement in this sphere. The way forward to greater production efficiency and less downtime appears to lie in the ability of a PAS to collect and aggregate energy data to match a process, and for this data to ultimately enable the system to communicate when a piece of equipment is not performing to its usual standard.

This approach not only delivers the benefit of optimal energy usage and, therefore, energy cost, but also the ability to diagnose, predict, and plan for equipment failure and malfunction – a solution that is surely a plant manager's dream come true…

About the author

Peter Hogg is the Global Offer Director of Libraries & Energy Management at Schneider Electric. In his 30-year career, he has designed, built, and consulted on control systems in the Mining, Pharma, Water, Food & Beverage, Automotive, and Infrastructure markets in Australia and Europe.

He first integrated power and process over 20 years ago to bring power factor data into the automation system. He continues to build on this experience to bring value to energy data within the PAS.

Glossary of acronyms

PAS	Process Automation System
EMIS	Energy Management Information System
IEC	International Electro Mechanical Commission
OECD	Organization of Economic Cooperation and Development
ODVA	Open Device Vendors Association