More muscle, less waste

ABB's workout program realizes sustainable energy savings and reduces costs in process plants

Jim McCabe

Maintaining the good health of a process plant is prime to securing its long-term profitability. With concerns over energy prices on the rise, operators are finding that it pays to invest in ways of slimming their consumption. But what is the best way to optimize efficiency?

Wasted energy can take many forms. These can include such widely different causes as inadequate scheduling and planning, suboptimal setpoints in control loops or inappropriate or incorrectly used equipment. It is often accentuated by leaks or the inadequate lagging of boilers and pipes.

ABB's Energy Improvement Program is designed to identify and deliver energy savings in process plants, achieving sustainable savings of up to 20 percent.

In the face of fluctuating fuel prices and tightening legislation on emissions, reducing energy consumption and greenhouse gas emissions are two of the biggest concerns affecting companies in the process industry today. Energy and utility systems provide manifold opportunities for savings – especially when it is the entire system rather than just some individual subsystems that are available for scrutiny. Considerable potential for savings is possible by reducing the consumption of process utilities (such as steam, chilled water and compressed air), minimizing distribution losses and improving generation efficiency. In fact, a successful implementation of these measures can yield up to 20 percent reduction in energy consumption.

But what is a successful implementation? The dangling carrot of potential benefits is only part of the equation. An informed decision on optimization must weigh such gains against the costs and possible risks.

Enter ABB

Energy is a fundamental ingredient in almost any manufacturing process. In a process plant, the principal means of delivering energy are electricity and the process utilities mentioned above. As energy represents an increasing proportion of the operating costs of many companies, the focus of optimization is increasingly shifting towards these utilities and where they are consumed in the production process.

Drawing on years of experience in process operations, ABB Engineering Services supports plant operators in their efforts by identifying improvement opportunities and implementing a program to make sure these benefits are delivered – and this as quickly as possible. More than 50 companies around the world have already benefited from this support. In such a program, ABB's experienced energy and utilities consultants apply a structured process to assess the overall potential of energy savings at a manufacturing site before developing and implementing energy conservation projects 1. As well as the huge energy savings that were attained in these projects, many companies have through this process acquired the skills and motivation necessary to develop their own sustainable improvements in energy efficiency.

The dangling carrot of potential benefits is only part of the equation. An informed decision on optimization must weigh such gains against the costs and possible risks.

Identifying opportunities

An efficiency improvement process begins with an overview of the site's energy balance and an assessment of the savings potential. All aspects of the energy chain are considered; from utility generation through distribution to consumption. Improvements can range from low- or no-cost "quick wins" to the implementation of energy efficient technologies. Quick wins may involve simple housekeeping activities such as maintaining insulation and repairing leaks or may require more fundamental challenges to "the way we've always done it"; eg, turning off main plant items instead of keeping them running, or challenging the set points of process control loops in utility distribution temperatures, pressures or flowrates.

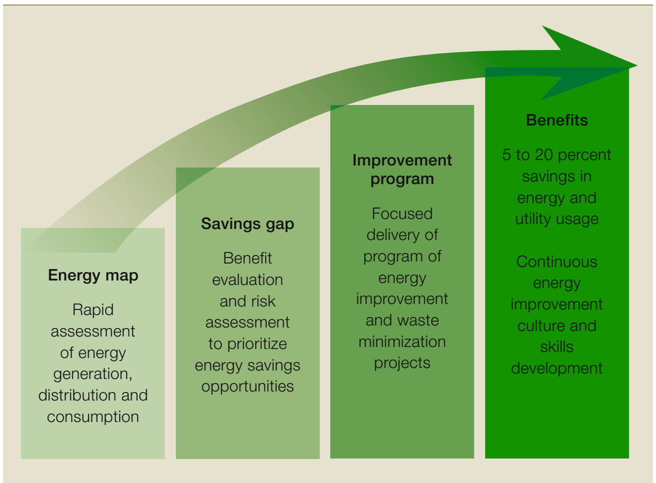
When it comes to efficiency-boosting technologies, numerous options are available: These range from variable speed drives to advanced process control. The larger challenge lies in identifying which of these are suitable for the situation in question – and this requires a careful analysis of benefits and risks. Benefits are usually related to the delivered energy savings but may include other non-energy related advantages such as improved reliability or increased capacity.

ABB frequently receives praise from its customers for the pragmatic nature of its analyses. In the words of the director of a UK ingredients company, "We've had no end to audits that either tell us to turn the lights off or invest millions of pounds. What I like about [ABB's] approach is that [they] concentrate on the practical."

The practical approach

A preliminary audit carried out for a European chemicals manufacturer 2

1 The steps of an energy efficiency improvement program



2 A preliminary audit carried out for a European chemicals manufacturer predicted savings equivalent to ten percent of the total site utility costs

predicted savings equivalent to ten percent of the total site utility costs. The following section investigates in more detail how this figure was achieved.

To start, numerous opportunities for utility cost reduction were identified during a review of the site's energy consumption. A benefit and risk analysis narrowed these down to four priority areas: tariff management, steam distribution, heat recovery and the application of variable speed drives.

Tariff management

ABB engineers observed that during the winter months, the electricity supply tariff structure for the site included a very high rate for a period of three hours every day. The total cost of electricity consumed during these three hours was equivalent to that consumed during the rest of the day. Significant savings potential at no capital cost were identified by scheduling production to minimize the operation of processes with high electrical demand during this period.

A further interesting savings potential was obtained in the area of two 160 kW pumps for cooling water. These are backed up by diesel-driven pumps. The spare pumps were tested for two hours every week and this test occurred outside the high-cost electricity period. It was shown that rescheduling the test to coincide with this period had the potential to save £3,000 per annum. Increasing the operating hours of the diesel pumps to cover the high-rate period five days a week could deliver annual savings of £14,000.

Steam distribution

Steam leakage was reduced by improved maintenance of steam traps. Overall steam consumption was furthermore reduced through enhanced heat recovery. Heat exchangers using the hot effluent from a steam stripping column to preheat the feed to the column were found to be undersized with the result that not all of the available heat was being recovered.

A preliminary audit carried out for a European chemicals manufacturer predicted savings equivalent to ten percent of the total site utility costs.

Variable speed drives

Engineers found that slurry pumps and air fans around the drying plant were oversized: In many cases they were operating at less than half their nominal load. Such situations are an ideal application area for variable speed drives. These can reduce the energy consumed by the pump and fan motors by as much as 60 percent[1)].

A successful project

In another example, a specialized chemical manufacturer 3 required reliable low-temperature refrigeration capacity for the manufacturing of several key products. As the cooling capacity of the installed refrigeration system deteriorated, production volumes were limited and energy efficiency was reduced because it was necessary to run two compressors instead of one.

The original installation comprised two reciprocating compressors (one operating, one standby) with R22 as the primary refrigerant, an oil separator, a throttle valve and evaporator with an oil rectification system, and an additional oil separator. The system was designed to operate at temperatures down to –48°C.

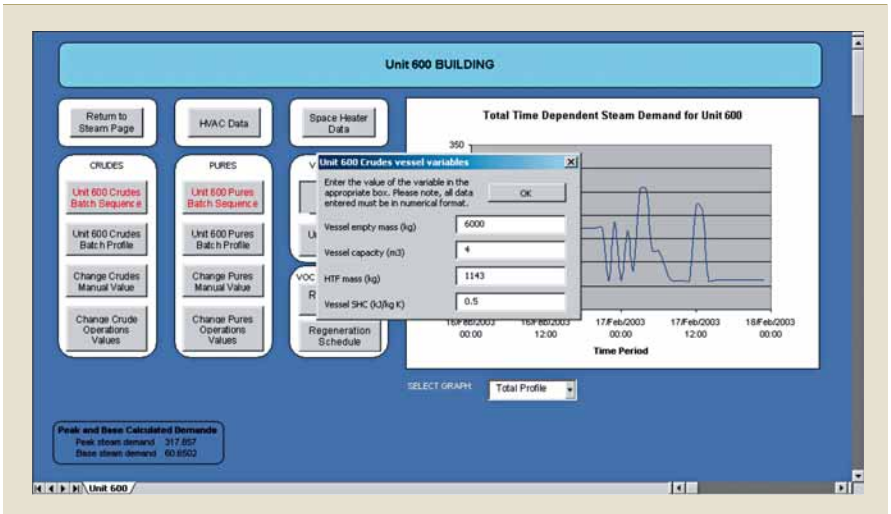
ABB carried out a detailed review of the process and mechanical performance issues. Following plant trials and data analysis, the problems were traced to mechanical faults and heat exchanger fouling. Cleaning these exchangers immediately increased plant capacity. ABB also specified mechanical modifications for phased implementation in order to prevent future fouling. In the final phase of the improvement program, an up-rated heat

Footnote

1) See also **Wikstroem, P., Tolvananen, J., Savolainen, A., Barbosa, P.**, Saving energy through drive efficiency, *ABB Review 2/2007*, 73–80.

3 Fine chemical plant: Energy optimization methods permit significant cost savings

4 Time-dependent steam demand profiles for different production buildings in a multi-product batch (fine chemical or pharmaceutical) plant



exchanger was installed to increase the capacity of the refrigeration system.

The improvements to the refrigeration capacity have allowed shorter batch cycle times and increased production rates and reaction yields. Refrigeration system reliability has also improved and the use of a single compressor has delivered energy savings to the tune of £48,000 per annum.

Targets and improvements

As with any improvement program, it is important to be able to set performance targets and verify progress against those targets. As the program is developed, the scope, budget, timescale and expected returns for each energy conservation project are agreed upon with the client and a means of performance verification is put in place. When possible, an energy management system is installed including metering, data collection and analysis.

Setting the right improvement targets is a key element of most energy efficiency programs. If goals are unachievable, the motivation for improvement is quickly lost. On the other hand, unambitious targets compromise cost and emissions reduction. The problem is particularly acute for operators of plants in which utility demands are strongly time-variant; for example, batch production of fine chemicals or pharmaceuticals. In such facilities, the load profile of the utility infrastructure will vary from hour to hour and from day to day, depending on the mix of products and the specific cycle time, and the utility requirements of each batch. There is no straightforward answer to the question "how much utility?" in multi-product plants. This makes setting effective targets a tough challenge.

Targets are often based on historical energy and utility consumption, an approach referred to as Monitoring and Targeting (M&T). One weakness of this approach is that it is highly dependent upon the quality of the input data, and in particular the conditions when the historical data was collected. A steam trap may have been passing or there may have been a significant leak from a compressed air line during the data collection period. Because these inefficiencies are not apparent from the data, this inefficient performance becomes the baseline for future comparison. In addition, M&T does not take the capacity of the current utility infrastructure into account and cannot identify bottlenecks in the utility distribution network.

Minimum Practical Energy is a robust method used by ABB to determine benchmarks for energy and utility consumption and to set improvement targets based both on sound theory and real production schedules. Areas where actual energy use is significantly different from the minimum practical requirement – eg, where a process is consuming more steam than expected – are identified quickly. This allows improvement targets to be pinpointed and provides a basis for tracking performance against the target. The demand profile for a particular production slate is compared to the capacity of the utilities infrastructure, highlighting bottlenecks and allowing the utility plant to be operated for maximum efficiency. Careful scheduling can reduce peaks in utility demand and eliminate the need for capital expenditure.

Setting the right improvement targets is a key element of most energy efficiency programs.

ABB has used this concept to identify annual savings of around £100,000 for the operator of an active pharmaceutical ingredient (API) plant. A simulation model of the utility infrastructure calculates the minimum practical energy requirement. Mass flows and pressure drops are rigorously modeled throughout the site distribution networks for each fluid utility (eg, steam, compressed gases and water). The dynamic utility system model predicts flows, pressures and velocities based on the time-dependent demand profile 4 arising from the daily activities in each unit. Production and non-production areas such as reservoirs, effluent plants and electricity for offices and canteens are included in the analysis.

The utility demand can be entered manually for each unit operation – heating or cooling, mixing or adding reactant – or calculated from the sequenced activities in the batch recipe. Individual batches can be combined to simulate a complete production schedule, and the demand profile calculated over a time period lasting from one day to five years. Climatic data are also incorporated to account for the demand from space heating or air conditioning.

This model of expected utility demand is compared with the known capacity of the utility systems, facilitating the identification of instantaneous or sustained capacity constraints. Process-control schemes for the utility systems can be incorporated, allowing different utility sources to be brought online to meet demand fluctuation. The simulation allows the operator to predict the level of utility required to meet the production schedule – for instance, how many boilers need to be fired at any one time. Future production schedules can be optimized to minimize excessive fluctuation in utility loads and to prevent them from creating peak demands that exceed utility system capacity. The model also allows the user to identify areas where the actual energy and utility consumption exceeds the minimum practical energy value and hence identify opportunities and targets for future energy conservation efforts.

The ABB Energy Improvement Program is a structured process with well-developed tools that identify and deliver energy savings to operators of process plants while they concentrate on core activities. Participating companies can realize savings of up to 20 percent of energy costs and develop their own capability to make sustainable improvements in energy efficiency.

Jim McCabe
ABB Engineering Services
Daresbury Park, UK
jim.mccabe@gb.abb.com