CELANESE CORPORATION: ENERGY DASHBOARDS

SOLUTION OVERVIEW

One of the key objectives of Celanese is to drive energy efficiency and cost reduction in its plants. One way to accomplish this is to engage the entire organization in energy reduction.

In Celanese, energy optimization was historically a management or engineering responsibility. However, Celanese management realized that although real time control of energy is in the hands of process equipment operators, energy consumption in many processes was not actively being optimized by the operators. Celanese discovered that if process equipment operators had access to real time information on energy consumption as well as dynamic energy targets for the key energy consumers, they could be more effective in optimizing energy use in the plants.

As a result, Celanese created Energy Dashboards to provide operators with access to real time energy consumption, and dynamic energy target information giving them effective knowledge and tools to reduce energy consumption.

The Energy Dashboard is intended to bring focus on energy efficiency to the unit and operator level. It is not intended to make energy a priority over safety and process safety, quality or productivity or promote constant “tweaking” of the process

The implementation of dashboards has been extremely successful. In the first plant where dashboards are fully implemented an annual energy cost savings of over $300,000 was realized just by operators having real time energy information and making process adjustments to improve efficiency. Also by using the statistical modeling and energy dashboards this plant has also identified more than $1.5 million in other energy costs savings. Many of the energy efficiency opportunities involve adjustments to process controls or to standard operating procedures and require little or no capital. Following this success, Celanese is currently implementing the dashboard concept in four other plants and will roll them out to three more sites in 2016. Any manufacturer with continuous or batch processes could benefit from the same methodology.

ORGANIZATION TYPE

Manufacturer of differentiated chemistry solutions and specialty materials

BARRIER

Lack of awareness of energy inefficiency – specifically by equipment / process operators due to inadequate information at the process control screen also called human-machine interface (HMI)

SOLUTION

Upgrade controls and HMIs adding "Energy Dashboards" that present relevant, real-time energy consumption and dynamic energy target information to operators enabling operators to take appropriate actions to reduce energy consumption when possible

OUTCOME

$300,000 in energy cost savings and identification of $1.5 million in low to no-cost energy-saving opportunities at one plant leading to greater roll out across the enterprise

POLICIES

A large chemical plant's energy consumption is complex and the optimum ranges of process energy consumption change often, based on production rate and many other factors such as equipment use or product mix. Because they continuously monitor the processes and process equipment, the process equipment operators are sometimes best positioned for making decisions and taking immediate action on energy usage and optimization in a manufacturing plant. Although the Celanese plant operating personnel understood the importance of energy management, the existing control screens (HMIs), did not give them the level of information required to optimize energy in real time.

PROCESS

To improve this situation, Celanese upgraded the process control HMIs so that the operators could visually understand process energy flows and optimum energy targets in real time and be empowered to take appropriate action to ensure that the processes maximize energy efficiency and reliability. This became the Energy Dashboards, which are a simple and continuous in-plant display of energy consumption and target ranges with the capability to also view the individual drivers that impact overall energy consumption.

The development of the energy dashboards included three main phases – Evaluate, Implement and Sustain.

During the Evaluate and Implement phases a cross-functional internal group of process engineers, operators, and Six Sigma Black Belts collaborated to map the energy users and key drivers, analyze energy data, develop the energy models, and implement the dashboards in the plant. The Six Sigma Black Belts leveraged their statistical expertise to do the statistical modeling that identified the process variables affecting energy consumption.

All of the needed equipment, SCADA, HMI and data historian systems, as well as the necessary statistical software packages were in place at the plants. All that was needed was to apply internal resources, including Celanese's Six Sigma and process experts. Some of the relationships between energy and the processes were not readily apparent, but the Six Sigma experts collected feedback from engineers and operators, which enabled them to accurately model the key energy consumption drivers, establish the data collection protocols, statistical models and develop the displays. Energy consumption target ranges were identified through statistical modeling and regression of the key process inputs.

Dashboard implementation typically took between 3 to 6 months requiring 300 to 600 man-hours for model development along with implementation and training.

In the Sustain phase, the operations teams developed a process to discuss energy-related issues at the shift handoff meetings and in routine production meetings so that energy discussion became part of the regular cadence of plant operations. This ensured sustainability of the energy review using existing meetings and systems. As well, an operations energy playbook was developed by the sites based on actions taken from the dashboard information to share energy best practices in the plant.

Some of the challenges included getting sufficiently accurate data to develop the correlations between energy consumption and key process variables due to infrequent lab testing, inaccurate instrumentation, and some instrumentation that was not in place. Another challenge was getting buy-in from the operating personnel that the models were accurate and could be acted on routinely and effectively. A significant element for obtaining operator buy-in was to involve the operators in each step of the dashboard development process. By being involved at each step the operators understood and had input into how the dashboards were developed. Celanese also conducted training with the operators as it rolled the dashboards out to sites.

Celanese also performed rigorous testing for each dashboard before full implementation. In these test runs the plant sites would typically apply the dashboard in one of the units in the plant (typically the most energy intensive) and validate the models in real time operation. When the dashboard was tested, tuned and working well the systems would be fully implemented and then rolled out.

Plant engineers follow-up daily on the energy information and operator feedback to determine potential energy cost or usage reduction projects. These improvement project are often no or low-capital projects such as improved control, improving or repairing instrumentation, operator training and awareness projects.

On a plant unit basis Celanese looks at the total energy consumption of that unit. An energy curve to model the energy consumption is developed and target ranges are identified through statistical modeling and regression of the individual drivers that impact overall energy usage. Ranges are dynamic, varying with rate, product mix or other parameters. Red, Yellow and Green zones and action trigger points are developed based on the models. Green indicates, within optimal range, Yellow indicates within process boundaries but not in energy optimum and Red indicates outside process boundaries and energy optimum

Figure 1: Energy Curve

With the dashboards operators can see if the real time energy consumption is in the most efficient range – “In the Green”. Overall unit level energy performance can be monitored, as well as the specific key energy drivers’ performance against their dynamic energy optimum targets at the sub-unit (consumer) level and equipment or process (x-variable) level such as a heat exchanger performance or reflux ratios. Operators can drill down into the key process variables to see the cause of deviations and can diagnose problems and initiate actions to improve energy efficiency.

Figure 2: Energy Performance Dashboards at Various Levels

When an energy exception - “Out of the Green”- occurs, operators fill in an exception log indicating the energy gap that occurred and the action taken. The exception log is reviewed by engineers and operators and feedback given on the effectiveness of the action and sharing of best practices. An example of an exception log is provided below:

One project example is displayed below and was discovered utilizing the dashboard system (see figure 3). This is a process requiring cooling that varies with the feed rate. A wide variation of excess cooling was being used in the feed system, wasting energy. The diamond marks represent the cooling flow and the blue line is the target set point, where the process should have been operating. Because most of the diamond marks are above the blue line, the feed system was using excess cooling most of the time. By adjusting the controls to reduce the flow of chilled water and raising awareness, the operators were able to reduce the process cooling energy consumption without any product loss or adverse impacts. This project improved the process control and the energy intensity which yielded annual energy cost savings of more than $300,000 with no capital spending.

Use of the dashboards has improved the plants' energy situational awareness and is enabling the operators and engineers to find opportunities like this. The dashboards enable operators to understand the effect of control issues and different practices in between the shifts and how they impact energy consumption.

Figure 3: Process Cooling Example

TOOLS AND RESOURCES

The tools used to develop and implement the system include:

- A strong statistical package to conduct multiple regression and correlation. Celanese used commercially available third party packages - Minitab© and SIMCA©.
- An IT application for display of the dashboards on the operator screens. Celanese utilized its data historian software and process control systems to develop the operator interface.
- An exception log – an Excel tool for operators to log when a gap was identified using the dashboards and action was taken. This exception log is used for best practice and energy playbook development.

MEASURING SUCCESS

The key measure of the success of the project is energy cost and energy intensity reduction. This is measured through energy metrics and an energy productivity log.

A second measure is operator engagement in energy reduction. This is measured by operator involvement and feedback.

OUTCOMES

In the first plant to implement the dashboards an annual energy savings of over $300,000 was realized just by operators having real time energy information and making process adjustments to improve efficiency.

Another benefit was the development of over $1.5MM of new energy reduction projects through visibility to the energy usage, the statistical modeling effort, operator engagement and new ideas. These projects are being implemented currently at the site.

The same dashboard concept is being rolled out to seven other Celanese plants globally using the same methodology.