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## Plants Strike Down Energy Inefficiencies

Large chemical manufacturers achieve improvements on many fronts

By Seán Ottewell, Editor at Large

**HIGHER ENERGY** efficiency ranks as a top priority in many chemical makers' efforts to enhance sustainability and competitiveness. As the ongoing experiences of companies such as DuPont, AkzoNobel and Eastman show, improvements can come in a hugely diverse number of ways, from process redesign to better lighting.

For example, DuPont, Wilmington, Del., made a significant process change in the Delrin Chemical Area (DCA) at its site in Dordrecht, the Netherlands (Figure 1), which is home to nine manufacturing plants where refrigerants, synthetic resins and powder coatings are produced. The DCA is the largest consumer of steam at the site. One of the main steam consumers in the DCA is a concentrator column that reworks a number of recycle formaldehyde/water steams to give a formalin solution for re-use in the Delrin (an acetal resin) process. The excess water goes to a waste treatment facility.

"To reduce the energy consumption of the concentrator column, a project was started to operate the concentrator column in a more-energy-efficient mode," explains Eelco de Visser, operations supervisor, Delrin compounding.

A simulation prompted a proposal for a process change — to split the recycle streams of aqueous

formaldehyde that were collected in a feed tank and then fed to the column. These recycle streams come from various sources and vary in formaldehyde concentration. The largest volume stream, the "extraction tails flow," has the lowest formaldehyde concentration (1.5–2%). The remaining recycle streams have much higher formaldehyde concentrations, ranging from 10 to 20%. The revision involved feeding the low-formaldehyde-content stream separately at a new, lower feed point in the concentrator column.

The modified process has been in continuous operation for over a year now with optimization still ongoing.

The upgrade has reduced steam consumption in the concentrator column by 16,7000 tons/yr with a saving of €418,000/yr (\$466,000/yr). Substantial savings also have come from the associated decrease in CO<sub>2</sub> emissions. "The total savings overall add up to €466,000/yr [\$520,000], all for an invested capital of €436,000 [\$487,000]," adds de Visser.

DuPont's Spruance plant in Richmond, Va., which has been in operation since the 1920s and today manufactures textile fibers, also has achieved substantial energy savings as part of its efforts to cut emissions. The site revitalized its energy conservation/efficiency program through participation in the



certified energy auditor training program,” notes John Kane Jr., principal consultant for DuPont Engineering Technology/Energy Engineering. Energy savings are estimated to have exceeded \$4 million over the last five years.

### GOING BEYOND THE FENCELINE

In Grindsted, Denmark, DuPont Nutrition & Health was screening possible energy saving projects for its site when it discovered a major potential win-win situation.

Surplus heat from production was being sent to cooling towers (Figure 2). The energy team decided to make better use of this surplus heat by selling it to the Grindsted electricity and heating plant (GEV), which delivers heat and electricity to private households and other buildings for water and space heating during winter.

“District heating is common in most cities in Denmark as they are densely populated, with little sprawl. This makes it possible to produce heat efficiently at combined heat and power plants and subsequently supply this to customers through a network of insulated pipes,” explains Martin Kirstein Madsen, Grindsted site manager.

The DuPont plant now supplies an estimated 12,627 MWh to GEV, enough to power 900 homes. It also saves GEV 1.2 million Nm<sup>3</sup>/yr in natural gas use. This translates to an annual reduction of 2,700 tons in CO<sub>2</sub> emissions at GEV and a decrease of 70 tons at the Grindsted site.

“This project shows that it is possible to find win-wins for both the economy and ecology. Fur-



Figure 1. The Dordrecht complex in the Netherlands includes nine manufacturing plants and is DuPont’s largest site in Europe. Source: DuPont.

thermore, it is an example of industrial symbiosis where a byproduct initially perceived as waste in one company can be turned into a valuable resource input for another company,” adds Madsen.

### DIVERSE EFFORTS

AkzoNobel, Amsterdam, the Netherlands, does not have a specific energy target but tracks energy use with a metric called the Eco Efficiency Footprint, which incorporates nine parameters, one of which is energy used per ton of product.

Peter Nieuwenhuizen, AkzoNobel’s RD&I director specialty chemicals, Utrecht, the Netherlands, cites an operational eco-efficiency program carried out at the company’s surface chemistry plant in Stenungsund, Sweden. The ethylene oxide



manufactured there goes into a variety of products including detergents, asphalts and mining chemicals.

The program has focused on two of the main variable cost drivers at the plant: primary steam consumption and efficiency of raw material use.

Nieuwenhuizen explains: “We took an integrated approach involving many people across the business. Specifically, this included using simulation models and plant tests to investigate the lowest possible reflux and steam consumption on individual distillation towers at different production levels. It was essential to ensure that product quality would not be affected. We gave this new knowledge to distributed control system operators and engineers and then provided them with live — i.e., real time — numbers, which were displayed on screens showing savings per hour/year. We used visualized KPIs [key performance indicators] wherever possible in meetings to drive the transformation needed.”

The program has resulted in variable cost savings of €3.8 million (\$4.3 million) and reduced CO<sub>2</sub> emissions by 11,650 tons so far.

Meanwhile, the company’s Mons, Belgium, polymer chemistry plant is saving energy thanks to a new two-step incinerator with an extra unit to reduce NO<sub>x</sub> emissions to below the level achieved with standard units, and a wireless sensing system to monitor and control storage tank temperatures. The incinerator is expected to cut NO<sub>x</sub> emissions by 80% to 20 tons/yr while the improved control enabled by the sensors has significantly decreased steam consumption. “The accumulated energy savings from these two investments is expected to be €90,000/yr [\$101,000/yr],” notes Nieuwenhuizen.

#### EXPORTING HEAT



Figure 2. Grinsted plant in Denmark no longer rejects surplus heat but instead sends it to a district heating company. Source: DuPont.

#### ENERGY PROJECT



Figure 3. Wind turbines provide clean energy to AkzoNobel’s pulp and performance chemicals business in the Nordic region. Source: AkzoNobel.



AkzoNobel also heavily focuses on the use of renewable energy. According to Nieuwenhuizen, about 60% of the company's worldwide pulp and performance chemicals operations currently run on renewable power — a level that might rise to 80% by 2020.

In an effort to boost renewable energy use, the company has established three wind parks in Europe's Nordic region as part of its Vindin wind energy project (Figure 3). This aims to deliver clean energy to the pulp and performance chemicals business in the region.

In the Netherlands, AkzoNobel has custom-built a 2-km pipeline to provide steam from a waste-to-energy plant to its salt packing facility in Hengelo. In the Benelux region, it has signed a long-term power purchase agreement with the biggest and most-efficient biomass plant there.

"In Brazil, we're excited about our 'chemical island' concept, which enables us to run our Imperatriz plant on 100% renewable energy. By harvesting the local eucalyptus trees every seven years, the pulp producer uses waste material to generate electricity via biomass. It's a beautiful, cost-effective business concept, with no or limited transportation of chemicals required. But taking what works in Brazil and replicating it in Europe or the U.S. is not always feasible. Our goal is that by 2020, 45% of our total energy needs will be met by renewable energy, up from 34% currently. So, despite these successes, there's more to be done," Nieuwenhuizen concludes.

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#### AMBITIOUS PROGRAM

At Eastman Chemical, Kingsport, Tenn., the goal to reduce energy intensity by 20% by 2020 from a 2008 baseline involves staff at all levels within the company. "Through the Worldwide Energy Management program, we engage employees on a variety of levels, from major manufacturing and engineering projects to awareness campaigns," explains Sharon Nolen, program manager.

As part of the program, a dedicated worldwide energy-management team continually analyzes energy use at Eastman sites to look for new opportunities. "We have commitment and support from our executive team to drive continuous change and improvement to ensure focus on sustainable operations," she adds.



#### SUBSTANTIAL SAVINGS

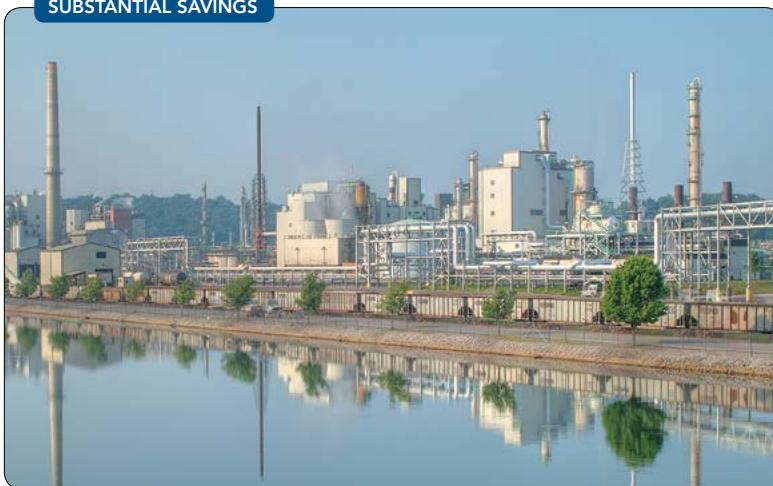


Figure 4. Ongoing energy efficiency improvements at Kingsport complex have saved over \$30 million in energy costs since 2008. Source: Eastman Chemical.

One of the most dramatic savings was a 4% improvement achieved between 2013 and 2014 in the two most-energy-intensive processes at Kingsport; the company will not reveal details, however. This is only one of many recent projects that together since 2008 have helped save over \$30 million in energy costs at the site (Figure 4).

Another involves the installation of a flash system that uses 600-psig condensate from columns — eliminating the need to drop steam pressure to 300 psig steam as originally required. Then there's the azeo energy optimization project, which involves developing a process control strategy for low- and medium-pressure steam use on distillation columns to reduce energy consumption. Another initiative is the replacement of steam jets with more-efficient

liquid ring vacuum pumps to eliminate the loss of steam condensate and decrease energy use.

The company's Indian Orchard operation in Springfield, Mass., has implemented two successful projects. The first focuses on hot water recycle — cooling water previously sent to a sewer now serves as feed in a washing process. In addition, the plant has reduced dryer steam consumption by installing

a new heat recovery system designed to re-use waste condensate also previously sent to the sewer.

At its Chestertown, Md., site, Eastman has replaced burners and installed a new burner management system on the primary steam boiler, improving its efficiency. This enabled the plant to retire two of its older, less-efficient thermal oil furnaces and replace them with a more-efficient unit.

In addition, Eastman has upgraded to more-efficient lighting at a Kingsport warehouse. LED lights and occupancy sensors have replaced fluorescent lamps, resulting in not only lower energy use but also improved visibility for warehouse staff. Together with a similar project in office buildings at the same site, the company has reduced this sort of energy use by 26% in the last year. ●



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## Break Energy Audits into Phases, Part I

A four-phase approach that cyclically repeats can yield improved energy savings

by Ven V. Venkatesan, Energy Columnist

**A SYSTEMATIC** energy audit can be broken into four phases: planning, investigating, implementing and sustaining. Proactive facilities strive to continually improve energy efficiency by repeating these phases at regular intervals. This two-part column will highlight each of the four phases.

**Planning phase:** Once plant management commits to energy conservation, the following preplanning activities should be initiated: 1) determining the scope of the audit; 2) picking members of the audit team; and 3) developing audit tasks with a targeted timeline and assigning responsibility to members. These activities could take anywhere from a few weeks to a couple of months depending on the facility size and the scope of the audit.

A relatively small audit team — between three to five experienced employees — should be tasked with the bulk of the audit work. At least one process and one maintenance person should be part of the team. A high-level manager should head this team or should be closely involved so necessary decisions can be made quickly.

The audit team must decide which systems to investigate in the initial scope of the audit and the depth of the investigations. Audit scope always can be expanded later. However, it's helpful to establish early criteria for expanding the scope along with how other phases of the audit will be influenced.

Gathering the baseline data is an essential preplanning step; it serves as the reference point to compare, set target and track the progress. Utility bills are the most common source for the baseline data. Other sources include equipment specifications, manufacturers' recommendations and maintenance records. Baseline data also include the plant profile — covering size and area, energy expenditure, major energy users and loads, and other basic facts.

**Investigation phase:** This involves inspecting each system within the scope of the audit. It traces from the source of primary energy purchased to the point of final energy use. As much as possible, all energy-loss-related parameters should be measured or taken from the appropriate plant instrument panels. Standard engineering practices should be followed for all energy-savings calculations. Several well-established standard software programs are available for evaluating energy-savings values. The U.S. Department of Energy developed several such programs for optimizing energy systems and these are available free at <https://ecenter.ee.doe.gov/Pages/default.aspx>.

The audit investigation should assess the efficiency, operating conditions of the equipment, including the duty cycle, load changes and controls. The length of this phase may extend several days or



weeks depending on the plant's size and the scope of the audit.

The second part of this phase involves preparing the audit report, which should summarize the audit's findings and recommendations in an organized and prioritized format. It should spell out, based on the audit measurements, the financial impact or potential cost improvement of each instance of controllable energy waste. The conceptual level details of each recommended action for reducing or eliminating the energy waste should be included in the report.

If multiple remedial actions could eliminate or reduce the energy waste, they should be evaluated for the best-possible cost/benefit ratios. The appropriate action could vary between plants for reasons such as differences in the cost of fuel the plant uses or local labor costs. For example, in one fine-chemicals plant the use of steam jet ejectors was recommended to replace the barometric condenser, while in a petrochemical plant a mechanical water-ring vacuum pump was recommended. Both recommendations improve the vacuum required for the process but the appropriate means were different because one plant was using bio-mass fuel to generate steam.

Occasionally, an energy-savings action could

create a safety risk. For example, electric tracing may consume less energy than steam tracing but may pose more of a safety risk when handling highly inflammable chemicals — so it's better to opt for steam tracing. [For more on electric tracing, see "Make the Most of Electric Tracing," <http://goo.gl/fE1Hpq>.] Hence, any safety concerns should be addressed first before making an energy-savings recommendation.

Budget restraints or plant shutdown limitations could prevent implementing all the recommended projects at once. Also, if excess air reduction is done first, then it would reduce the savings due to economizer installation. If steam demand reduction is implemented first, then it would reduce savings due to condensate recovery. So, double-check savings calculations after prioritizing the recommended projects. This will help management in planning their investment budget.

More on the remaining phases of an energy audit cycle will be highlighted in Part II of this column. ●

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## Break Energy Audits into Phases, Part II

After approval of projects, implementation can begin

by Ven V. Venkatesan, Energy Columnist

**ONCE AN** energy audit team presents its findings, along with a prioritized list of actions, decision makers must decide which — if not all — recommendations should be implemented. (Keep in mind, unless the cost benefits of the recommendations are attractive, decision makers will focus on other compelling budget priorities.) Then, for those projects getting the go-ahead, the third phase of the energy audit cycle can begin.

*Implementing phase:* The first step in the third phase of the energy audit cycle (Phases 1 and 2 were highlighted in the previous column, “Break Energy Audits into Phases, Part I) is to develop an implementation plan. Each team should include members from relevant disciplines. Some recommendations, such as fixing steam leaks and reducing excess air levels at the fuel-fired boilers and heaters, are straightforward and require obvious actions. These projects can be started quickly, typically yield quick results, and require zero or little capital investment.

For instance, in a graphite plant that molds and bakes calcined petroleum coke powder into large-sized electrodes, an energy expert attempted to control excess air at one of several baking furnaces to record the best-achievable

operational settings. Because the baking cycle undergoes several stages of heating over a 72-hr period, a portable flue gas analyzer, along with the recordings of the existing on-line flue-gas oxygen analyzer, monitored and adjusted hourly the excess air level. Due to its capability of measuring the CO and combustible gas contents in flue gas, the portable flue gas analyzer trimmed the oxygen levels. A fuel-oil flow totalizer also recorded hourly readings from the baking furnace. This oxygen-trimming exercise resulted in developing a chart of operational settings for the baking furnace that established just 5% excess air achieved complete combustion at some stages of the baking cycle. The exercise also reduced fuel oil consumption 12% compared to the average fuel oil use per cycle recorded earlier in that same furnace.

Some energy audit recommendations, such as those requiring partial or total plant shutdowns, need well-defined individual project plans and more-detailed engineering before implementation. Typically, these recommendations should be evaluated carefully with more supportive operating data as well as detailed cost estimations that should include budget quotes from equipment vendors and contractors.



These projects typically take longer to implement.

For example, in a medium-sized oil-field chemicals manufacturing plant in Oklahoma, an energy audit produced seven recommendations. Management approved all seven and initiated detailed engineering development for each one. The results confirmed the savings levels for each recommendation, but the detailed project cost estimates for implementing them was much higher on two of them. So, management decided to implement the five projects that were still attractive.

This stage also can help fine-tune the initial energy audit recommendations. For instance, in one of the projects (installing an economizer for a boiler), after a detailed review, engineers changed the heat recovery source from boiler feed water to soft water heated by steam. In another condensate recovery project, the group changed the initial suggested location of the condensate pump to facilitate future maintenance needs. Hence, detailed engineering is essential to make better investment decisions.

*Sustaining phase:* As projects are implemented, the next phase focuses on measuring and quantifying results to determine whether the project achieved the initial envisioned goals. Measurements should verify the actual attained operational settings compared to the expected or set

target levels. Deviations from the initial savings estimates commonly remain within 60–110% range. In most cases, the lower values in this range stem from inaccurate assumptions due to lack of flow measuring devices in the processes. Changes in the plant's production levels also can cause deviations. Energy audits typically recommend installing permanent monitoring instruments to sustain the achieved results. Simple monitoring devices such as on-line flue-gas oxygen indicators contribute significantly to preserving optimum combustion conditions at fuel-fired boilers and furnaces.

Adjusting maintenance programs and practices is another important requirement to sustaining energy audit results. This involves providing necessary preventive and predictive maintenance activities to the process equipment, and cleaning and calibrating monitoring devices. Timely troubleshooting support and prompt repairs during failures are essential to sustain the achieved energy savings. Periodically, a follow-up energy audit may be required to verify and sustain the results and to systematically repeat the cyclic process. ●

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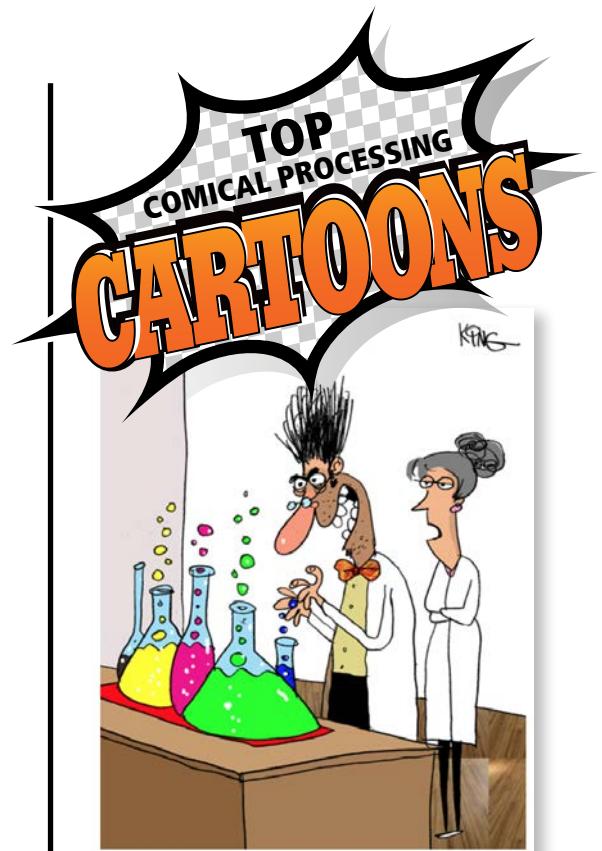
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