

solutions

From Shop Floor to Top Floor:

Best Business Practices

+

in **Energy Efficiency**

+

+

by

William R. Prindle
ICF INTERNATIONAL



PEW CENTER

ON

Global CLIMATE CHANGE

CASE STUDY

Dow Chemical Company Integrated Approaches

Headquarters:	Midland, MI
CEO:	Andrew Liveris
Revenues (2007):	\$54 billion
Energy Costs (2007):	\$27 billion
Energy Savings Target:	20 percent reduction in energy used per pound of product, 1996–2005. 25 percent further reduction in energy used per pound of product, 2006–2015.
Key Efficiency Strategy Successes:	<ul style="list-style-type: none">• Since 1994, Dow's energy efficiency strategy has saved 1,600 trillion British Thermal Units (BTUs) of energy—enough to power all the residential houses in California for one year. These energy savings also led to \$8.6 billion dollars in cost savings and prevented 86 million metric tons of carbon dioxide equivalents (CO₂e) from entering the atmosphere;• Sustaining savings over a ten-year period, and then strengthening the target for the next ten years;• Finding significant energy savings in an already efficiency-oriented, energy-intensive primary manufacturer;• Leveraging the company's energy business unit to provide a wide range of energy efficiency and related technology and operations services.

Energy Efficiency Strategy Overview

Energy is a small cost for most companies—the 48 respondents to the survey conducted for this project (see Appendix A in main report for details) reported energy costs averaging less than 5 percent of revenues. For Dow Chemical, nothing about energy has ever been small. About half of every dollar the company spends goes toward energy, mostly in the form of natural gas and natural gas liquids, which are the energy feedstock for the company. Not all of that energy is used to power Dow's operations; in fact, two-thirds of the energy molecules Dow buys are used as feedstock, transformed via chemical processes into myriad products. That still leaves 30 percent of Dow's costs as energy to run its plants, making it one of the world's most energy-intensive companies. Dow's energy intensive nature, coupled with its continuous-processing, 24-7 operating mode, makes its energy efficiency strategy somewhat different than some of the other companies studied in this report that use relatively moderate amounts of energy. While certain aspects of Dow's strategy are more applicable to other energy-intensive companies, many elements will hold relevance

for a broad range of companies. These include Dow's efforts to organize an effective program, set up a detailed reporting system, and gain cooperation across business units to meet ambitious energy savings goals.

Everything about Dow's energy operations is large in scale. The company's energy purchases (feedstock included) roughly equal Australia's entire energy bill, and are equivalent to 10 percent of all the oil the United States imports. Dow's Freeport Texas site is nothing if not large, taking up several square miles along the Gulf Coast and accounting for over one percent of all the energy consumed in the state.

Energy is so big it constitutes its own business unit at Dow. The energy business sells electricity, steam, and natural gas to other business units. It is also a major player in world, national, and state energy markets, selling as well as buying energy on a wholesale basis. At the Freeport Texas site, Dow operates some 1,000 Megawatts of electricity generation, as much as the largest utility powerplants. From its high-tech control center with its panorama of brightly-colored display screens and switch-studded control panels, Dow buys and sells power among its production units, and with the Texas power grid operator, The Electric Reliability Council of Texas (ERCOT). Dow's power generation is fully interconnected with ERCOT, allowing it to behave like other large generators on the system. Operators monitor market conditions and Dow operations minute to minute, making decisions on dispatching power flows. On relatively rare occasions, when ERCOT prices are high enough, Dow will elect to shut down one or more production units for short periods, and sell power into the grid, because it is more profitable to sell electricity than to make chemicals under those conditions.

This kind of sophistication in its energy business, driven by the essential role of energy at Dow, flows to the end-use level as well. When energy is such a huge part of production costs, reducing the energy needed to make a pound of product is a matter of competitive survival. It's not surprising then that Dow was among the first companies to set quantitative, measured energy savings goals. In 1995, the company set a goal of cutting energy use per pound of product 20 percent by 2005. Dow beat that goal, realizing 22 percent savings as of 2005. But from 2002 to 2007, Dow's energy bill rose from \$8 billion to \$27 billion as natural gas prices skyrocketed. While these price effects offset the energy intensity improvement, Dow saved almost \$8 billion compared to the energy bills it would have paid without the efficiency strategy.

Against the backdrop of sustained high energy prices, in 2006 CEO Andrew Liveris raised the bar, increasing the goal by pledging to slice another 25 percent off the energy needed to make a pound of product. Dow's energy efficiency goal is represented in British Thermal Units (BTUs) per pound of product produced, so natural gas used as feedstock (which does not emit greenhouse gases in the production process) is not included



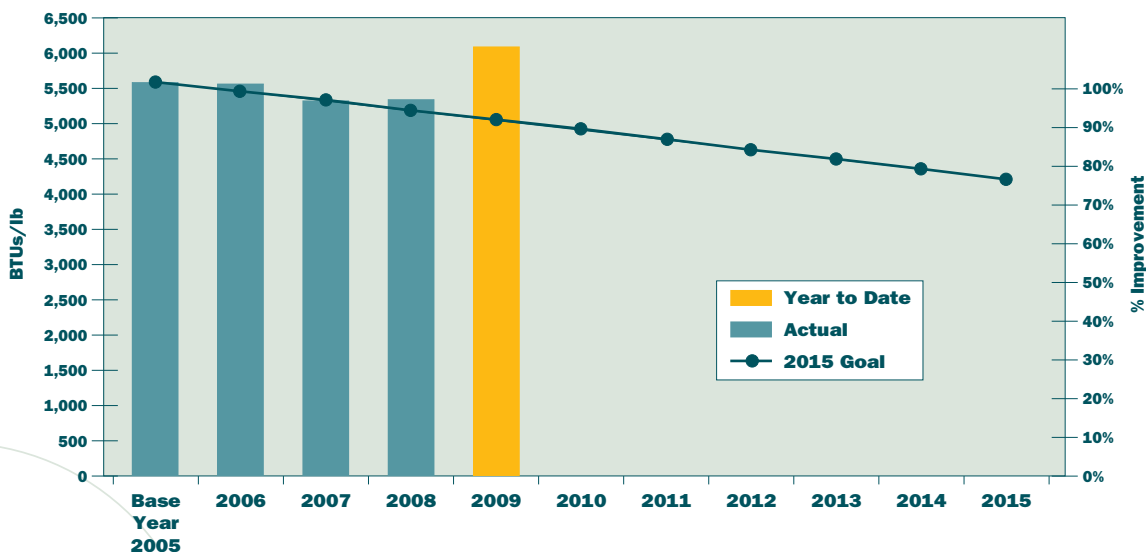
as part of the goal. However, Dow is exploring ways of becoming more efficient in its use of feedstock primarily due to cost concerns. **Figure 1** illustrates the company's goal and progress to date. 2009 usage shows an increase in energy per pound, largely because the economic slowdown has cut production, and energy use cannot be reduced in proportion, but as the economy recovers Dow expects energy intensity to go down again.

The way in which the 2015 energy goal was announced illustrates Dow's commitment to energy efficiency. Rather than simply issuing a press release from headquarters in Midland, MI, Liveris spoke at a special event in Washington, DC, delivering a speech, largely unscripted, that showed a detailed understanding of the numbers and the technologies involved. Dow's extra effort and the CEO's personal and visible involvement indicate that this is a high priority for the company. And the energy savings commitment, with the company's other sustainability goals, are measured and reported on the Dow website on an ongoing basis. The Dow home page includes "Sustainability" as a top-level menu title so visitors are able to easily track the company's progress toward meeting its goals.

Andrew Liveris continues a hands-on tradition of Dow leadership driving energy innovation dating back to Herbert H. Dow's 1897 launch of his bleach business. Even in those early days, energy was critical to Dow's business. As Herbert Dow envisioned today's bulk-chemical production process and business model in the early 20th century, he realized that the energy technologies of the day would not allow him to produce chemicals at

Figure 1

Dow's **Energy Intensity** Performance 2005-2015



Recreated based on image provided courtesy of Dow (2009).

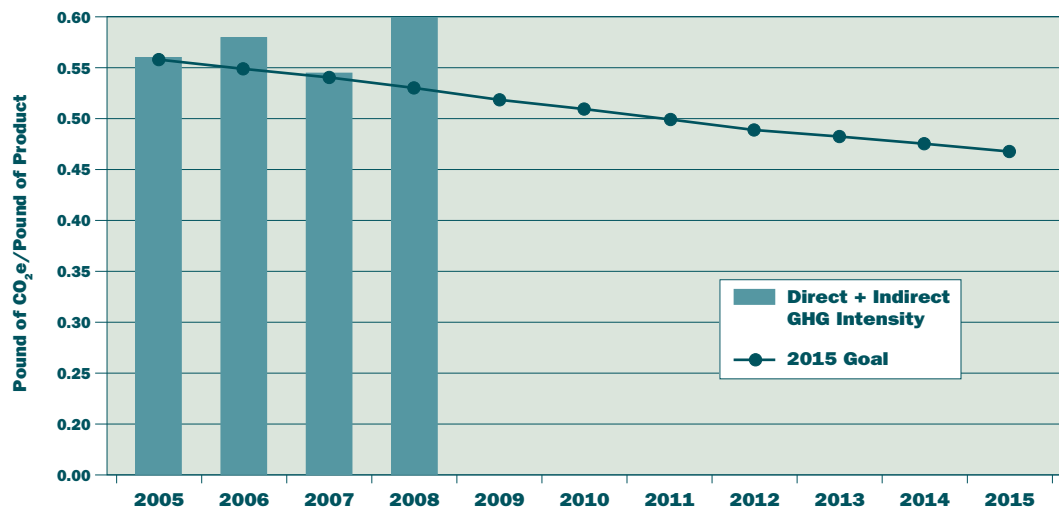
the scale he needed. George Westinghouse, pioneer of the gas power generation turbine among other energy technologies, worked in partnership with Dow to create the specialized electricity and steam technologies that enabled the Dow business model to advance. The fact that Dow leadership and employees remember and tell this story a century later reflects a deep appreciation for the role that energy innovation plays at Dow.

Energy Efficiency and Dow's Climate Strategy

Because energy use is such a major factor in Dow's operations, energy efficiency and GHG reductions are closely linked. Accordingly, the company's 2015 sustainability goals include a 2.5 percent per year reduction in GHG intensity per pound of product. This closely tracks the ten-year, 25 percent energy savings goal. **Figure 2** illustrates the GHG intensity goal. As with energy, recent data show an uptick in GHG intensity caused by the economic slowdown in production.

Figure 2

Dow's **GHG Intensity** Performance 2005-2015



Recreated based on image provided courtesy of Dow (2009).

Internal Operations

Dow's business units are broken out by product type, even as their operations are highly interconnected: Olefins, Chlorine, etc. Energy is such a large part of Dow's operations that it is structured as its own business unit. The energy business owns and operates about 10 percent of all of Dow's assets, making it the second-largest business unit behind the Olefins business, followed closely by the Chlorine business. The Energy Efficiency and Conservation (EE&C)

program leadership team operates from the energy business, engaging some 40 roles overall, about 26 leads in the various business units, plus 14 site leaders, and some individuals at larger individual plants. Like many companies, Dow does not have many people with a full-time energy efficiency job title—that distinction goes to corporate energy manager Joe Almaguer. As Almaguer explains it, the matrixed nature of the EE&C team makes estimating total labor effort involved in the company's energy efficiency efforts an “all and none” paradox. Most EE&C members work on a number of issues including energy; energy might take up all their time some days and little or none on others. The amount of time spent on energy is driven partly by the EE&C team's regular meeting and reporting cycles, and partly by specific actions undertaken at given plants or sites in response to operational changes or project investments.

How the EE&C Program Operates

A note on Dow's terminology for its operating units helps in understanding the EE&C operation. Because of the large scale of Dow's manufacturing, and the many different chemical products involved, its manufacturing centers are termed “sites,” within which it operates several individual “plants.” A plant is typically defined by its product; so a site might hold an olefin plant, a chlorine plant, a power plant, and others. The Texas site, for example, contains some 75 individual plants of the 328 total U.S. plants Dow operates.

+ Since 95 percent of Dow's energy use flows through its 14 largest sites, the 14 site leaders play an important role, especially when it comes to energy efficiency opportunities that cut across different plants. For example, all the major sites have extensive steam systems with miles of piping; at the Texas site, one pipe moves steam four miles from the powerplant to a remote production plant. Steam systems need regular maintenance, especially for steam traps, the valvelike devices that remove condensed steam from the line while keeping the live steam flowing. A site EE&C lead will typically develop a site-wide steam trap maintenance contract; plants can opt out, but typically don't because of the cost-efficiency of the larger contract and the operating efficiency benefits. Site leaders also play an important role in the company culture, building relationships with plant operators, providing them help and information, and leaning on them as needed to achieve energy goals.

+ As in most of the successful energy efficiency programs examined in this report, energy efficiency team members faced challenges in gaining the active cooperation of production plant operators and other site-based staff. Getting participation in the company's data reporting system was not as big a challenge, in that Dow already possessed in most cases the metering and billing information, based on the way the energy business is structured. The company had long used a centralized reporting system, and was able to build the new energy reporting elements

into it. More detailed monitoring systems and data reporting occur within each business unit and each operating plant. The energy metrics thus act as a high-level indicator with centralized information; finer-grained information is kept decentralized at individual business units and sites. Since the energy business is a functional unit like others in Dow, it has had the core data it needs to track performance at a high level; setting aggressive energy performance targets motivated business unit and plant site staff to look harder at their finer-grained operating data to look for ways to meet the targets. Other companies with more numerous and disparate operations, such as IBM and UTC, had to go through a longer and more complex process to establish and achieve compliance with the data reporting system. Each company seeks the right balance of centralized and decentralized data.

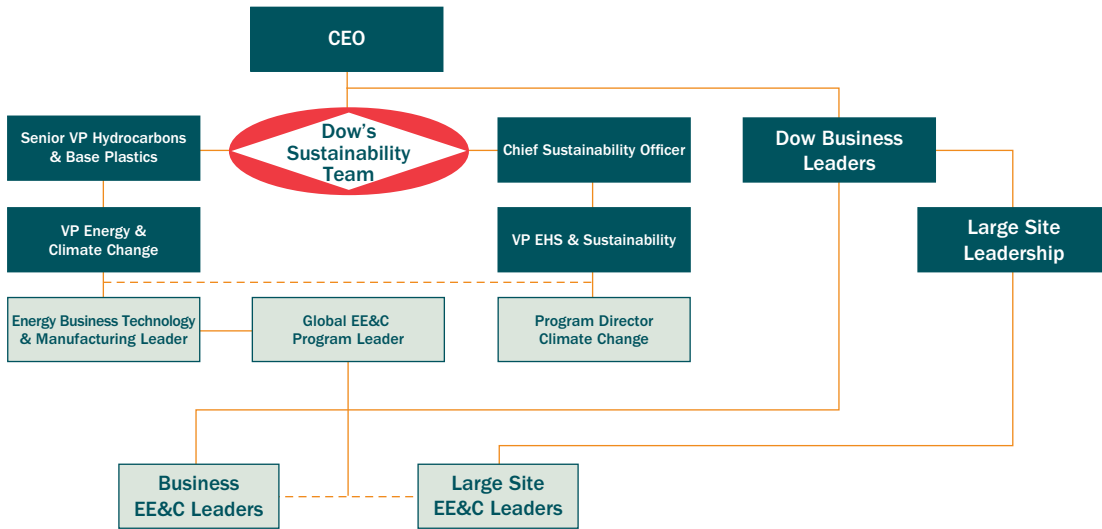
But Dow shares with other companies the challenge of persuading production managers to consider changes in operating practices and technologies. Production staff are focused on product quality, production volume, and reliability of equipment and systems. Energy improvements, be they changes in operating or maintenance procedures or new technologies, pose potential risks to these ironclad principles. Dow addresses the potential conflicting interests of the energy team and the production plants partly through its Tech Centers. Each business unit has a Tech Center, with experts on its particular production technology, and with one or more EE&C experts. These Tech Centers each have a director reporting to the business leadership. As a result, the Tech Centers create focused teams that not only develop technology and operating solutions, they also build trust relationships that help the EE&C team gain the cooperation of product staff. The involvement of Tech Center staff in developing, testing, verifying, and then instituting new practices and technologies is key in this respect, as is the highly interactive nature of the EE&C team. Regular conference calls, webinars, email exchanges, and site visits build trust and help spread technical information.

Dow's EE&C team is part of the larger Dow Sustainability Team, as illustrated in **Figure 3**. EE&C includes team members from each business unit, and each large site. Having an EE&C team member at each large site allows for coordinated and collaborative efforts among the many plants operated by different business units within a given site.

Drilling deeper into the EE&C structure, **Figure 4** shows how EE&C works within a given business unit. Each business's EE&C team leader is sponsored by the respective business Tech Center Leader. The team leader works with people at the individual plants in the business. For example, each olefin plant has a person assigned to work with the olefin plant's EE&C team leader. The Tech Center's role is to provide engineering and technology support for the business, developing new specifications for production equipment and ancillary equipment, and working with plant operators to advance and sustain operating practices.

Figure 3

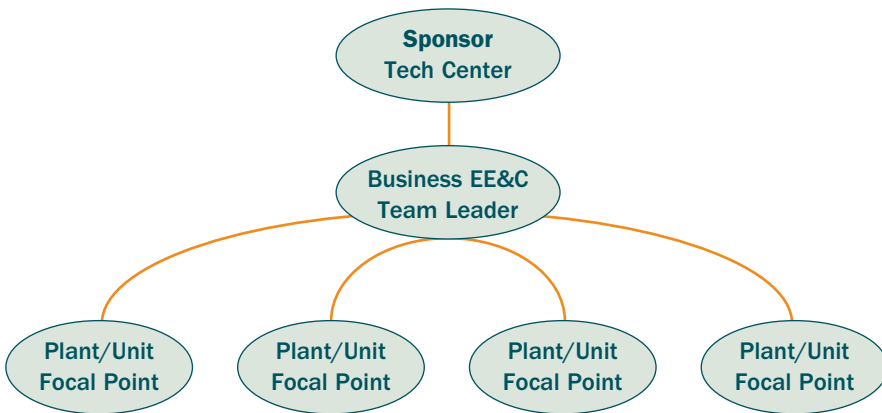
Dow's **Energy Team**



Recreated based on image provided courtesy of Dow (2009).

Figure 4

Business EE&C **Team Structure**



Recreated based on image provided courtesy of Dow (2009).

Data Collection and Reporting: The Global Asset Utilization Reporting System

A key element of Dow's EE&C program is the energy data collecting, reporting, and accountability system built around the company's Global Asset Utilization Reporting (GAUR) system. GAUR collects energy data from the numerous metering and submetering points at each plant, aggregates them up to a total BTU number, and reports the BTU total along with pounds of product per plant. A typical GAUR report consists of rows for each reporting facility, and includes its energy use, production, and energy use per pound of product. The columns show this information by quarter and year, allowing quick visual comparison of performance over time. Plant operators, business unit leaders, EE&C staff, and corporate staff all have access to this information.

GAUR reports look deceptively simple. Developing the calculations needed to produce the BTU totals in GAUR was not simple. A longtime Dow engineer painstakingly developed methods to convert the various flows of energy commodities, and intermediate energy flows in Dow's complicated operations, to a standardized set of BTU equivalents (calculating GHG equivalents added another layer of computational complexity). Dow uses lots of primary (raw) energy, but also converts it into intermediate forms like steam and electricity. Accounting for the conversion and distribution losses, and the energy content of various energy streams as they are delivered to each plant, involves complex calculations, which led Dow to institute a formal, documented procedure to ensure consistency and quality of information across the company.

Because natural gas is the dominant source in Dow's energy purchases, all energy forms consumed are translated to equivalent BTUs of natural gas and adjusted to reflect real-world efficiencies and losses associated with energy conversion. This method allows staff across the company to use a common currency, in terms of how much natural gas has been or would have to be used to produce the energy consumed at a given plant. This methodology also reflects the ability of each energy form to do real work and not just theoretical work. It therefore estimates how many BTUs of natural gas equivalent would be saved from a given energy saving opportunity. This gives the EE&C team a consistent way to make realistic calculations of primary energy impacts and thus derive better estimates of expected energy cost savings. The company knows the price of natural gas, so turning everything into equivalent natural gas units makes it possible to compare energy performance and energy savings across plants, sites, and energy markets.



GAUR reports roll up to business unit and corporate levels, and form the basis of the energy and production numbers in quarterly sustainability reports, which are posted on the Dow website. But GAUR numbers are also used to produce internal reports with much more detail. In addition to the basic energy and production numbers, the internal reports assess actual vs. target performance, discuss issues that explain performance numbers, and suggest action items to correct any sub-par performance levels. These reports go to business unit leadership as well as to plant operators and site leaders, and often become the focus of extended discussions and followup actions.

How Dow Achieves Energy Savings

Dow achieves its energy savings goals somewhat differently than other companies. While all of the case study companies focus on low-cost operating improvements, Dow is much more capital-intensive, and less labor-intensive, than most. One can drive around a Dow site for some time without seeing a human being, whereas in a Toyota or IBM facility, as in most companies, people are everywhere. Dow also typically operates in a continuous processing mode—the chemical plants normally run 24-7. This reduces the opportunities to apply downtime shutdown strategies that companies like IBM and Toyota have used to great advantage to gain “free” energy savings.

+ Dow plant operators rely on the continuous flow of data they get on energy and other performance indicators to determine whether their operations are on track. This may occasionally include operating adjustments or maintenance actions, but most big efficiency improvements come from process technology changes. For example, Dow's Light Hydrocarbon (LHC)-7 plant at the Freeport Texas site won a 2008 American Chemistry Council (ACC) Responsible Care® Energy Efficiency Award in 2009 for replacement and upgrade of its ethylene furnace capacity. Dow replaced the existing 10 furnaces with five new, larger state-of-the-art furnaces with significantly higher energy efficiency. Interestingly, this investment was initiated for compliance with NO_x emissions regulations, but the additional benefits in energy savings, yield improvements, corporate sustainability, and extended lifetime of the facility made the business case very strong. This investment has improved LHC-7 plant energy efficiency by more than 10 percent, producing energy savings of over 2,000,000 MMBTU/yr, equivalent to the annual electricity use of more than 17,000 homes, and cutting CO₂ emissions by 105,000 metric tons annually.

+ Across the Atlantic in Antwerp, Belgium, Dow and its partner BASF in 2009 opened the world's first commercial-scale propylene oxide (PO) plant based on the innovative hydrogen peroxide to propylene oxide (HPPO) technology the two companies jointly developed. Producing up to 300,000 metric tons of PO per year for the polyurethane industry, the new Antwerp plant reduces energy use by 35 percent and wastewater by up to 80 percent.

Finding the Funding for Energy Projects

While these projects represent major efficiency gains and provide several streams of business benefits, the capital for such projects is hard to come by, even for a large company like Dow, and especially in the current economic downturn. According to its corporate financial report, Dow spent approximately \$2.28 billion in total capital investment in 2008, up from about \$1.78 billion in 2006. However, in 2009 capital expenditures will be drastically lower due to the current economic conditions. While even \$1 billion is nothing to sneeze at, it gets competition from all the company's investment needs. For context, \$1 billion is less than two percent of Dow's total revenue, and less than four percent of total energy costs.

Dow's capital budget must serve many priorities, and meeting energy goals is just one of them. Dow applies various financial criteria to project investment opportunities; including discounted cash flow, net present value, and internal rate of return. Business units use their own analysis and prioritization methods, driven by competitive forces and the norms of their businesses. In many cases, investments that are seen as critical to maintaining or improving competitiveness are moved to the fore; this forces the EE&C team to make a broader business case for energy-related investments, documenting the co-benefits in competitiveness terms. For example, a given efficiency investment might not meet a simple payback criterion; but if it keeps the company competitive in a specific market and avoids the loss of a specific customer or a certain share of the market, such considerations can help justify the investment.

In one sense, energy has long been a key issue for Dow, so energy efficiency competes relatively well when the numbers are compelling. Dow expects to ultimately factor in carbon price expectations in assessing energy projects. But because it does not expect carbon prices to appear in energy markets for several years, except in Europe, carbon prices only have a material effect on larger capital projects, and these tend to be major process changes that involve more than energy as driving forces. Dow does have facilities that are regulated under the European Union's Emissions Trading System. The carbon price created by the trading system is an added cost that Dow incorporates into the evaluation of energy efficiency projects.

Dow has looked at trying to leverage outside capital through performance contracting, but like other case study companies it has found the performance contracting business model hard to match to its own operating models. Energy service companies typically require long-term agreements to make their financing structures work, and most corporations are not inclined to enter such long-term contracts. Performance contracts also tend to require



long repayment terms to enable energy savings to exceed payments, because they must roll all of the development costs, interest costs, and other “overhead” factors into debt service payments on top of direct capital costs.

Moreover, in a complex industrial operation like Dow’s, establishing the critical baseline energy use calculations on which savings are based can be too difficult and uncertain to build into long-term agreements. Dow uses companies like Johnson Controls, which has a large performance contracting business, but tends to use them for more specific technology and service contracts on a traditional sales or fee basis.

Pursuing Operational Improvements vs. Capital Investments

The challenge of raising capital for efficiency investments turns the focus back to operating improvements. Dow works hard at this on an ongoing basis, but EE&C team members also know that the sheer scale of energy and product flows in a continuous processing environment limits the relative impact of operating changes. Using the engineering talent in the Tech Centers and other EE&C team members, Dow sometimes uses Pinch analysis, a methodology evolved in industrial circles in the last three decades. The Pinch method is designed to minimize energy consumption in chemical processes by calculating technically feasible energy targets, and then achieving them by optimizing heat recovery systems, energy supply methods and process operating conditions. In a Pinch analysis, process data is typically represented as a set of energy flows as a function of heat load against temperature. These data are combined for all the energy flows in the plant to give composite curves, one for hot flow and one for cold flow. The point of closest approach between the hot and cold composite curves is called the pinch temperature or pinch point. By finding this point, various heat recovery or transfer solutions can be developed.

Dow engineers constantly use their creativity combined with the variety of energy and material streams in their plants to find new efficiency ideas. For example, at the Texas site, hydrogen occurs as a byproduct in one process. EE&C staff have experimented with blending this available hydrogen with natural gas fuel in their power turbines, taking the mix up to the limits that the turbines will tolerate.

For its efforts, the EE&C team also seeks outside input to find new ways to save energy. It maintains a panel of outside energy and environmental experts to provide technical and strategic input. Dow also participates in national programs: it won a 2008 ENERGY STAR Partner of the Year award from the U.S. EPA, and invited energy auditors from the U.S. Department of Energy’s (DOE) Save Energy Now¹ program to review its large US-based facilities. The

¹ For more information on DOE’s Save Energy Now program, go to: <http://www1.eere.energy.gov/industry/saveenergynow/>.

Save Energy Now team found several productive ideas, including innovative ways to load pumping systems that enabled Dow to shut down one pump station. In one instance, the potential savings the DOE review identified totaled about 11 percent of plant energy use. Dow in turn supports DOE by participating in several of its sponsored programs and initiatives, such as the development of the ISO 50001, international standard for industrial energy management.

Supply Chain

Dow sits near the top of the energy supply chain; it purchases raw materials and transforms them into bulk materials, and in some business units produces products for business or consumer markets. In this context, there is little energy efficiency opportunity for Dow to exert with its suppliers; its efficiency strategy focuses primarily on internal operations, where most of its footprint occurs. Dow has not conducted a formal analysis of its suppliers' energy or carbon footprint. In the energy arena, with 60 percent of the company's costs incurred as energy and most of that as natural gas, the supply footprint is relatively small compared to the footprint created by the conversion of that energy in Dow's processes.

Dow does, however, focus on supply chain issues in its broader sustainability commitments. In its Sustainable Chemistry commitment, for example, the company works to reduce its impact on water resources, and seeks renewable sources of natural gas, such as landfill gas or sugarcane. The Antwerp HPPO plant described earlier, for example, saves even more water than energy on a percentage basis. The company is using landfill gas at its Dalton, GA facility.

Products and Services

Dow estimates that its products and services have a smaller overall energy and carbon footprint than its internal operations. Nonetheless, it continues to innovate efficient products and other solutions for its customers. Dow's insulation products, mostly sold under the STYROFOAM™ brand, are used to reduce energy use in homes and businesses. One square foot of one-inch thick Dow STYROFOAM™ insulation will save one ton of CO₂ emissions over the average life of a house. Dow building insulation material saves hundreds of millions of metric tons of CO₂ each year. Dow actively supports programs and policies that encourage energy efficiency, in buildings, industry, transportation, and utilities.

Conclusions

Dow is one of the few companies that has not only set and met a 10-year efficiency target, but has gone on to set another, more aggressive 10-year target. This “in it for the long haul” demonstration of commitment is one of the hallmarks of a successful sustainability program. Dow has also set and met its goals in a manufacturing environment where energy has long been a critical factor of production, so the company had been paying attention to energy issues since Herbert Dow pioneered bulk chemical manufacturing a century ago. This means energy savings were not as easily found as they might be in companies where energy has only recently become an issue. Dow has made effective use of its energy efficiency team from its energy business unit, reaching across business units and functional lines to create teams of experts and local site leaders to keep the efficiency program moving forward.

Key lessons learned from Dow’s energy efficiency successes, include the importance of:

- Corporate leadership commitment. In Dow’s case, the CEO has made a very clear and public commitment to achieving the company’s energy savings goals.
- Building the appropriate organizational structure to institutionalize and lead the program. This includes cross-functional teams with clear lines of accountability.
- Robust measurement, tracking, and reporting systems so that management can monitor progress and identify potential problems.
- Establishing clear goals and objectives, and then revising them over time as the initial targets are met.
- Communicating the importance of energy efficiency as a core company value to both internal and external stakeholders.
- Recognizing success by rewarding employees and business units for energy saving innovations.