Tools to Drive Energy Efficiency Improvements

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ABSTRACT

Within the chemical industry, The Dow Chemical Company is a leader in driving energy efficiency improvements. This paper will discuss how a large integrated chemical company improves energy efficiency through strong corporate commitment, the effective use of data collection software, Six Sigma methodology, internal communications and our particular organizational structure.

All of the aforementioned tools and resources already existed and were being used to drive improved performance in the organization. What was needed was an increased emphasis on using these tools to drive energy efficiency and conservation. This paper will also discuss how energy use awareness was elevated at the company and how the particular tools and resources were adapted to include an energy efficiency and conservation mindset.

In the area of data collection an existing Access database, used for asset utilization reporting (which included production volumes), was expanded to include energy reporting from all production plants. Enhancements included loading of metered energy data directly into the database.

The Six Sigma methodology has been a powerful tool for identifying and providing sustained solutions to energy efficiency opportunities. Examples of how Six Sigma projects have improved energy efficiency will be presented in this paper. An important aspect of the success of this program is how information is shared about these projects across the company so that others can learn about the projects and build upon the previous work.

The Dow intranet is used extensively to share information about energy efficiency resources, best practices and success stories. It is also used for internal and external communication on our progress toward our energy efficiency goals.

Our company is organized around business portfolios, technology centers and production sites. The paper will discuss how we use the organization to achieve optimal focus on energy efficiency.

Introduction: A Brief Description of The Dow Chemical Company

Dow is a leader in science and technology, providing innovative chemical, plastic and agricultural products and services to many essential consumer markets. Committed to the principles of sustainable development, Dow and its approximately 43,000 employees seek to balance economic, environmental and social responsibilities. Among these responsibilities is to make substantial improvements in energy efficiency. In 1994 the corporation established a comprehensive set of ten-year goals focused on generating a step change improvement in Environmental, Health and Safety performance. It was recognized that if Dow could make a significant reduction in energy, it could have a measurable and favorable impact on the environment and also improve resource productivity and cash generation. Therefore, a corporate goal was established to reduce energy intensity by 20% by the end of 2005. Since 1994 Dow has reduced the energy intensity (Btu per pound of product) required to make its products by over

21%, exceeding the 2005 goal of 20%. The energy intensity improvement (decrease) for 2004 alone was almost 6%. The amount of energy saved in 2004 is equivalent to that required to provide the electricity needs of over 330,000 single family homes for one year. The environmental impact can be measured by the decrease in direct CO_2 emissions by Dow. Between 1994 and 2003 direct CO_2 emissions have decreased by 27%[1].

Dow was an early innovator in cogeneration and today the company meets nearly 75% of its electricity needs from cogeneration. Eleven new cogeneration facilities were installed globally between 1994 and 2005. These new large-scale cogeneration power plants operate with the highest efficiency and the lowest emissions. In 2000, the Dow Freeport, TX site won the 1999 U.S. EPA Energy Star Combined Heat & Power Award[2].

Dow's success in improving energy use is based on utilizing standard work processes, Six Sigma methodology, comprehensive and transparent energy accounting tools, the utilization of focused energy conservation teams in both business units and geographic locations, and a strong commitment by senior management to improve energy use.

A Brief Description of the Overall Energy Conservation Program

Dow is a large consumer and generator of energy. Energy is primarily managed through the Energy Business Unit within Dow, which has the overall responsibility for not only managing fuel and energy purchases and the power and utility facilities within Dow, but driving energy efficiency as a mindset across all of Dow. The Energy Business is a global organization that utilizes vast operational experience along with separate technology and commercial expertise centers to manage energy supply. However, the drive to improve energy efficiency is part of the culture for each business unit that consumes energy within the corporation. Each business unit also assumes the responsibility to design, operate and maintain their facilities to constantly improve energy consumption. Business units are expected to adopt energy efficiency and conservation goals and plans within their business specific plans to align to the overall corporate energy improvement targets.

The company generally views energy management broadly – not only in the context of energy use and improving energy efficiency, but also in the context of energy supply as it pertains to the safe, cost effective and reliable operation of our power generation and other utility assets.

Dow's corporate commitment to energy management is reflected in the goals set by the corporation as well as in the communication, both external and internal, on energy management. Energy intensity is listed as one of the key metrics on the overall corporate scorecard.

The following excerpt is from the Energy Business Strategic Summary document:

> Dow's commitment to Sustainable Development will include managing and coordinating efforts in greenhouse gas strategy development and trading, placing a high priority on energy efficiency and conservation, alternative and renewable energy procurement…

The energy management process in Dow is based on the premise that business and site organizations both have roles in improving energy efficiency as part of their overall efforts and organizational structure to operate facilities and improve operations. Therefore, roles were created within the business (technology center) and site organizations to ensure the energy

improvement is incorporated into the management plans and processes. More about the roles established within the technology centers and the sites will be discussed in the Organization section of this paper.

The energy conservation effort was given renewed emphasis in 2001 with the creation of a new position, the Global Energy Conservation Leader. The Global Energy Conservation Leader leads the energy conservation effort at Dow. In summary the Energy Conservation Leader "will have full responsibility and accountability for the implementation and management of an aggressive global energy conservation plan. Success in this role will be measured through the achievement of Dow's 2005 Energy Reduction Goal, which he will lead and facilitate. Helping to create an Energy Conservation mindset throughout Dow by networking with all Businesses and Technology Groups will be critical to this success. He will play a leadership role in the development of the Energy Envelopes across Dow's large integrated sites and be an active participant on the Global Climate Change Team".

With this new role and an increased emphasis, an updated energy reporting system was implemented, energy focal points were identified and a more formalized and comprehensive communication plan was established. The corporate goal was translated into individual business and site goals. These goals drive behavior and tie in with the use of tools to improve energy performance.

Dow has established work processes for managing and implementing improvements, driving operational and maintenance excellence, and improving environmental health and safety. The focus of the energy efficiency program is to utilize these processes with a greater emphasis on energy efficiency.

As with many industrial energy efficiency improvement programs, there were, and continue to be, some barriers to full implementation. One barrier is the ability to cost-effectively modify or replace existing, older facilities that do not incorporate the best available technology for using energy. Large chemical plants are built to run for thirty years or more and there is a practical economic limit to how quickly this capital stock can be replaced. A second barrier is that energy efficiency has to compete with other important priorities competing for time and resources. The key to addressing these barriers is to make a strong business case for energy efficiency and show how it ties to the overall corporate objectives so that it is appropriately incorporated into the allocation of resources.

Energy Reporting

An important element of any successful energy efficiency program is the ability to monitor energy consumption in a timely and comprehensive manner. The data needs to be made available to all the users as well as management. It needs to be in a form that allows for easy classification of information and has the ability to provide graphs and tables for ease of evaluation. It should be a requirement for all significant energy consuming facilities to submit data. The ability to automatically or easily input data is also important. The Dow energy reporting data system does all the above and more.

Dow uses a common, easy to use system to monitor energy and production across the entire company. The remainder of this section will describe how Dow uses this system to track energy consumption, how this information is used in the overall energy management strategy and the value derived from benchmarking.

Most Dow manufacturing facilities meter their utility consumption and these metered quantities are reported into the Dow accounting system. This information is also downloaded into a database program on a quarterly basis. Those few facilities that do not have meters provide quarterly estimates based on plant design information. Contacts from the various business technology centers are required to validate the data before the data is finalized. A data validation program is in place to help the contacts easily identify data that is incomplete or out of range.

The database for energy consumption is part of a larger database that also tracks asset utilization and production output for the corporation. Typically the same persons that enter and validate energy data also enter and validate the production data. The production data is used to normalize energy consumption for goal setting purposes and for process evaluations.

The metered or estimated energy data is further tagged by production unit, technology center, site, and business unit. This allows different roll-ups of the data by the various organizations in Dow that have a need for the data to meet their respective objectives for cost control, future planning and improved environmental performance. The data is presented in a standard Excel PivotTable format. There are separate tables for data organized by business, site or technology. The tables allow one to drill down from the highest level of the organization structure down to the individual plant. Separate tables are available to view data by the actual metered units for each utility consumed at the plant level.

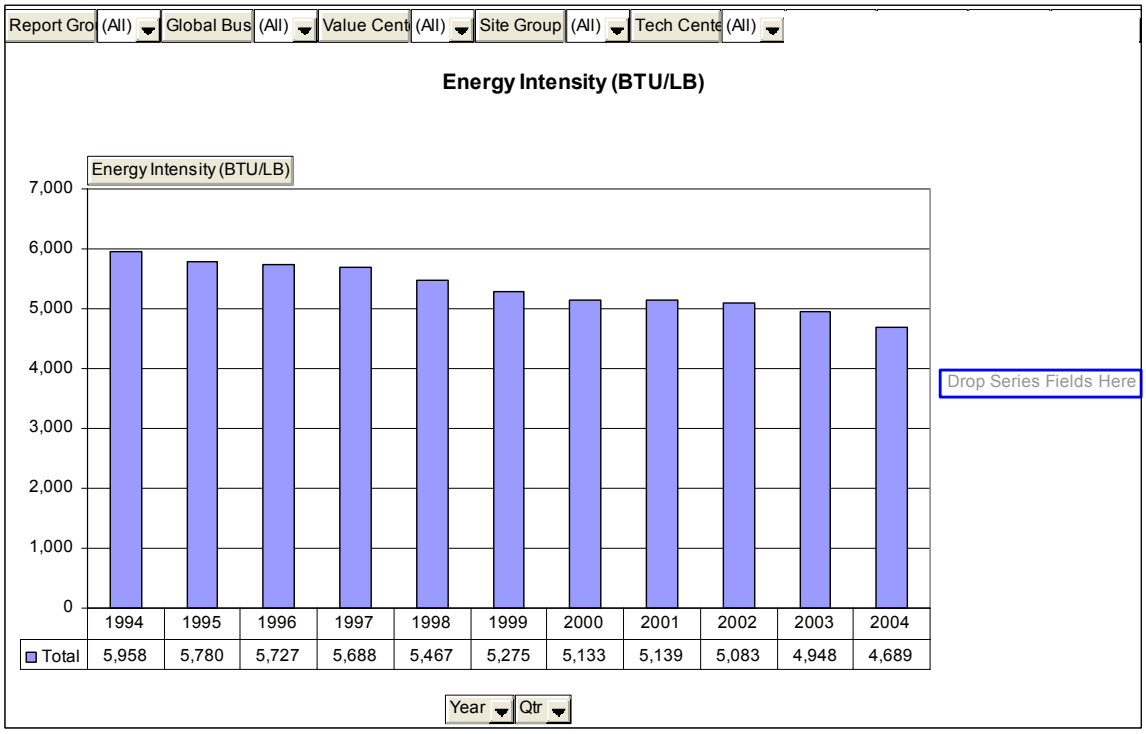
As mentioned earlier, utility information is collected mostly from meter readings and in a few cases the utility quantities are estimated. The different utility streams are converted to a common unit (Btu) to allow for aggregation. Each utility stream is assigned an activity code that identifies the inherent energy characteristics of the utility. For example, activity code S23 describes 475 psig with approximately 280 degrees F superheat. This particular code is then assigned a Btu value per unit quantity to allow conversion of different utilities to the same energy units. The Btu value is determined based on the amount of natural gas required to generate that utility from a combined cycle cogeneration plant with a heat rate of 10,000 Btu per kWh. The 10,000 Btu/kWh heat rate may seem high by today's standards, but at the time it was established, it was intended to reflect the mix of both Dow power plants and energy supplied by other sources such as the utility grid. Adjustment for reporting purposes is made to the overall energy consumption based on actual heat rates of Dow and third party supplied power and steam.

As previously mentioned, the heat rate on which the energy value is determined remains constant over time for all facilities. This allows plants, sites and businesses to compare their energy consumption over time, as either total energy or energy normalized for production, apart from changes in the efficiency of the utility that is supplying the facilities. It also allows comparison of facilities on a common basis. Many facilities at Dow use this information, separately or in conjunction with external benchmarking, to identify areas of opportunity to improve their performance. They can compare not only total energy consumption but energy consumption by utility type. Normalization for other factors such as weather, product mix or operating rates are not attempted at a corporate level due to the wide variety of facilities and locations. Many facilities do take the energy data and normalize it for the factors that significantly influence energy consumption so as to be able to better identify trends and opportunities for improvement.

Although the corporate reporting is done on a quarterly basis, most of the larger energy consumers track their energy consumption on a monthly basis in order to more quickly respond to trends. Of course, those with significant and variable energy consumption can also monitor energy consumption continuously from their control and data acquisition systems in order to optimize energy use on a continuous basis.

Below is a standard PivotTable graph from the reporting database. Note that you can drill down by different reporting groups from the drop down menus.

Figure 1. Energy Intensity Graph



Six Sigma

A significant initiative at Dow has been the implementation of Six Sigma -- a methodology that Dow has undertaken to improve performance and to better meet customer needs. Since its implementation in 1999, when Dow launched a company-wide program to incorporate the Six Sigma methodology into all of its business functions, Six Sigma has proven that it is the breakthrough process that can take Dow to the next level of performance for all our key stakeholders.

In the Company's 1999 annual report, it was stated that by year-end 2003, Dow expected its Six Sigma implementation to deliver $1.5 billion in Earnings Before Interest and Taxes (EBIT) from the combined impact of revenue growth, cost reductions, and asset utilization. At the close of 2002, Dow achieved its $1.5 billion cumulative financial goal…a full year early[3].

The term "six sigma" is used as a measurement standard in defining a normal curve of statistical data. Motorola engineers expanded on the term in the 1980s when they decided that the traditional quality levels (measuring defects in thousands of opportunities) were inadequate. Instead, they wanted to measure the defects per million opportunities. By using statistical

analysis to minimize variation, Six Sigma enables data-based process improvements. Operating at Six Sigma quality levels produces 99.9997% accuracy, with only 3.4 defects per million opportunities.

Six Sigma is a methodology, tool set, and mindset that accelerates the implementation of business strategies. Six Sigma is designed to dramatically upgrade a company's performance, improving quality and productivity. Using existing products, processes, and service standards, Dow employs Six Sigma MAIC methodology to upgrade performance[4]. **MAIC** is defined as follows:

Measure – Gather the right data to accurately assess a problem.
Analyze – Use statistical tools to correctly identify the root causes of a problem.
Improve – Correct the problem (not the symptom).
Control – Put a plan in place to make sure problems stay fixed and sustain the gains.

Since 1999 more than 725 Six Sigma projects have been implemented to improve energy use and reduce costs. The total impact has been over $275 Million. In just 2004 alone, over 250 new projects have been chartered. Some of the types of energy savings projects are listed below.

- Fired heater and boiler projects reduced fuel consumption by optimizing combustion controls and improved burner design
- Projects reduced venting or flaring of byproduct fuels and developed ways to off-set natural gas purchases by fully utilizing by-product hydrogen.
- Projects improved yields and reduced off-grade product and in the process saved energy
- Projects optimized the use of compressed air and other industrial gases in both manufacturing plants and in one case over an entire site
- Use of electricity during peak periods was reduced
- Projects reduced water use and thereby reduced the energy used to pump and treat the water
- Steam optimization projects included better distillation control, reduction in flow from steam pressure reduction stations and recovery of low pressure steam for process heating.
- A number of projects reduced the consumption of motor power by optimizing process systems and shutting down excess equipment

In addition to individual projects, the Six Sigma methodology has been successfully used to evaluate large systems, or envelopes, in order to identify opportunities for improvement. These systems could include everything from large, complex production units, to an entire product chain or to a large integrated manufacturing site's utility use and infrastructure system.

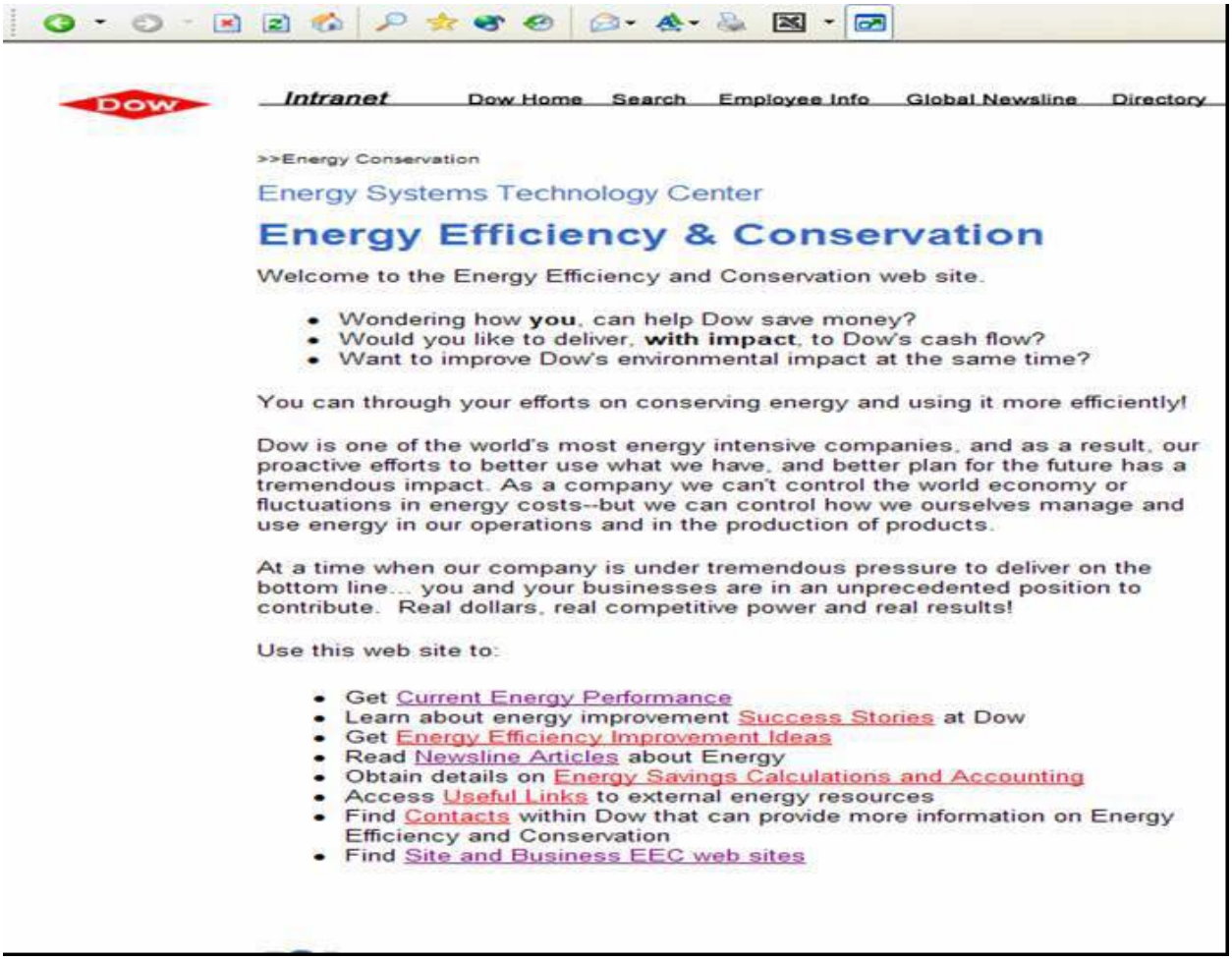
One example of a Six Sigma envelope study was done at the Freeport, Texas site and involved a study of the hydrogen collection and distribution system across the site. This study led to a number of specific Six Sigma project charters to improve the cost effectiveness of the collection and use of hydrogen at the site.

To provide a platform for leveraging the information learned from energy efficiency projects, a web site has been developed that allows Dow employees to easily sort through Six Sigma energy projects by the type of type of utility saved.

Employee Communications

Dow continues to encourage an energy efficiency mindset among employees by reinforcing the critical importance of reducing our energy intensity and recognizing successful teams via ongoing employee communications. Dow regularly publishes internal articles on the company's intranet related to regional and global energy challenges and the role of energy conservation in helping to resolve them. Dow has a web site dedicated to energy efficiency and conservation. Below is an excerpt from the web site listing of the general topics.

Figure 2. Energy Efficiency and Conservation Web Site



Two methods of internal communication that are frequently used include the corporate *Newsline* and the quarterly *Around Dow* newsletter. Articles on energy costs and energy use have been included in each of the last four *Around Dow* newsletters. Over the past 16 months, 16 articles about energy, including references to the importance of energy efficiency and conservation, have been broadcast on the Dow intranet. In addition, an "Energy Efficiency Awareness Bulletin" is circulated on a monthly basis to a cross-section of influential Dow

leaders, emphasizing the need for continued focus on energy efficiency and conservation and recognizing those who have achieved significant results.

The 1Q05 issue of *Around Dow*, which was distributed to all Dow employees and later posted on our corporate Internet site for external audiences, reiterated the business case for a continued worldwide focus on energy efficiency and conservation – and provided 10 simple tips to help Dow employees and their families conserve energy at work and at home. An earlier *Newsline* article also provided a list of some of the different employee groups that then linked them to ideas that they could use:

> All employees can impact energy conservation – whatever their role. Take a look. You're bound to find something – large or small – that you can do to make a difference.
> All employees – particularly office/administrative teams
> Production Units
> Plant Operators/Technicians
> Plant Engineers
> Technology Centers
> Process & Design Engineers
> Plant & Business Leaders

For example, by clicking on the link for plant engineers you would see just a select few of the many suggestions for engineers:

> **Plant Engineering**
>
> How plant engineering staff can help:
>
> 1. Have you performed a gap analysis on current energy consumption versus design or optimum performance?
> 2. Has this been done for the range of operating conditions?
> 3. Have you developed Six Sigma Charters, improvement projects or Operating Discipline changes to close the gaps?
>
> *Drive continuous improvement with Plan – Do - Check - Act*

Recognition and rewards are also done using the Dow intranet. In 2003, for one of our first energy awareness activities, we conducted the "Electrical Energy Challenge". It was a contest across the company to see which businesses and sites could reduce the most electrical energy. We had large site, small site, large energy consuming businesses, and small energy consuming businesses categories. The contest generated over 1 Million dollars of savings for the company.

Related to communications is recognition and reward. One of our long-standing recognition programs is the Waste Reduction Always Pays (WRAP) program[5]. Projects that meet certain rigorous criteria qualify for these special awards. In 2004, 86 projects were recognized, many of which had energy savings related savings. The total energy savings from these projects was over 2.3 Trillion Btu.

Each quarter the company delivers a closed circuit broadcast where the Dow president addresses the company about current performance, strategy and other items of current interest. This has been a forum where the cost and impact of energy has frequently been addressed and on two recent occasions energy efficiency projects have been highlighted.

Last, but not least, presentations to different employee and management groups around Dow helps reinforce the importance of energy efficiency. In one presentation we use an interactive slide show called the Energy Game. Modeled loosely after the Jeopardy TV game show, the game uses a question and answer format to engage employees in a more active way, while introducing some good-natured competitiveness into the learning process.

Organization

There are two primary energy efficiency and conservation networks at Dow led by the Energy Conservation Leader. One network consists of Energy Focal Points for each Technology Center.

The primary functions of the Technology Centers are to drive process safety improvements as well as general technology improvement. The tech centers also identify the most appropriate technology for future implementation. The technology centers have the primary responsibility for the accuracy and completeness of the asset utilization and energy data. By tracking energy intensity the technology centers along with the production plants can identify and implement performance improvements. The Energy Focal Points for each technology center are responsible for driving energy efficiency within their respective technologies and typically have leadership roles within these technology centers. Most of the larger energy consuming businesses, in turn, have efficiency teams with contacts at the manufacturing facilities to ensure energy efficiency is leveraged between plants and across the business unit.

The other network consists of Energy Conservation Focal Points at our 12 largest energy consuming sites, which account for over 80% of Dow's energy usage. At these large, integrated sites there are numerous opportunities to improve energy flow and use between the plants as well as inside the plants. The Site Energy Conservation Focal Point and his/her team are responsible for identifying and implementing projects around these opportunities. These teams are also responsible for driving the cultural and mindset changes necessary to drive higher levels of improved energy efficiency. See Figure 3 for a simplified organization chart showing the relationship between the energy focal point networks.

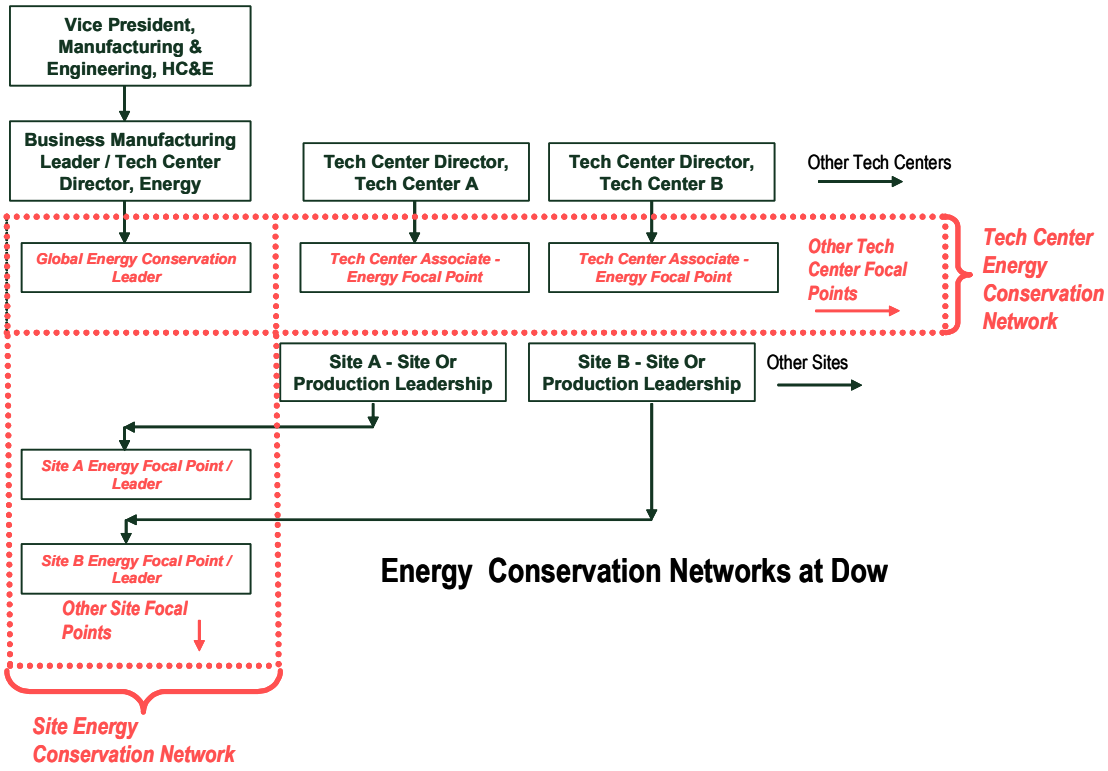
The reason for developing the two roles of Site Energy Efficiency Focal Point and Business Energy Efficiency Focal Point is the need to increase both energy awareness and energy intensity improvement throughout Dow. We need people "on the ground" in both the businesses and the sites to improve the collection of data and facilitate the energy improvement effort. It is intended for the businesses to drive the overall energy efficiency effort. However, it is expected that there are energy efficiency activities that are best driven across a site, such as energy envelope studies, that will require both site and business support.

Conclusion

This paper described how the Dow Chemical Company instituted tools and resources that helped lead to a significant improvement in energy efficiency of over 20% since 1994 through 2004. Strong corporate commitment was indicated by frequent messages and support of a multi-year corporate energy intensity goal. A key to successful improvement is the ability to measure improvement and this is done at Dow through a comprehensive database with data accessible across the entire company. The Six Sigma methodology has been an effective tool in improving efficiency as measured in both the large number of projects and the EBIT obtained. Frequent

internal communications and an organizational structure reaching across the corporation are important in order to engage employees at every level. Although all these factors were important to achieving success, the success of any initiative ultimately comes down to leadership throughout the entire organization in embracing change and being aligned to improving performance.

Figure 3. Energy Conservation Networks



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