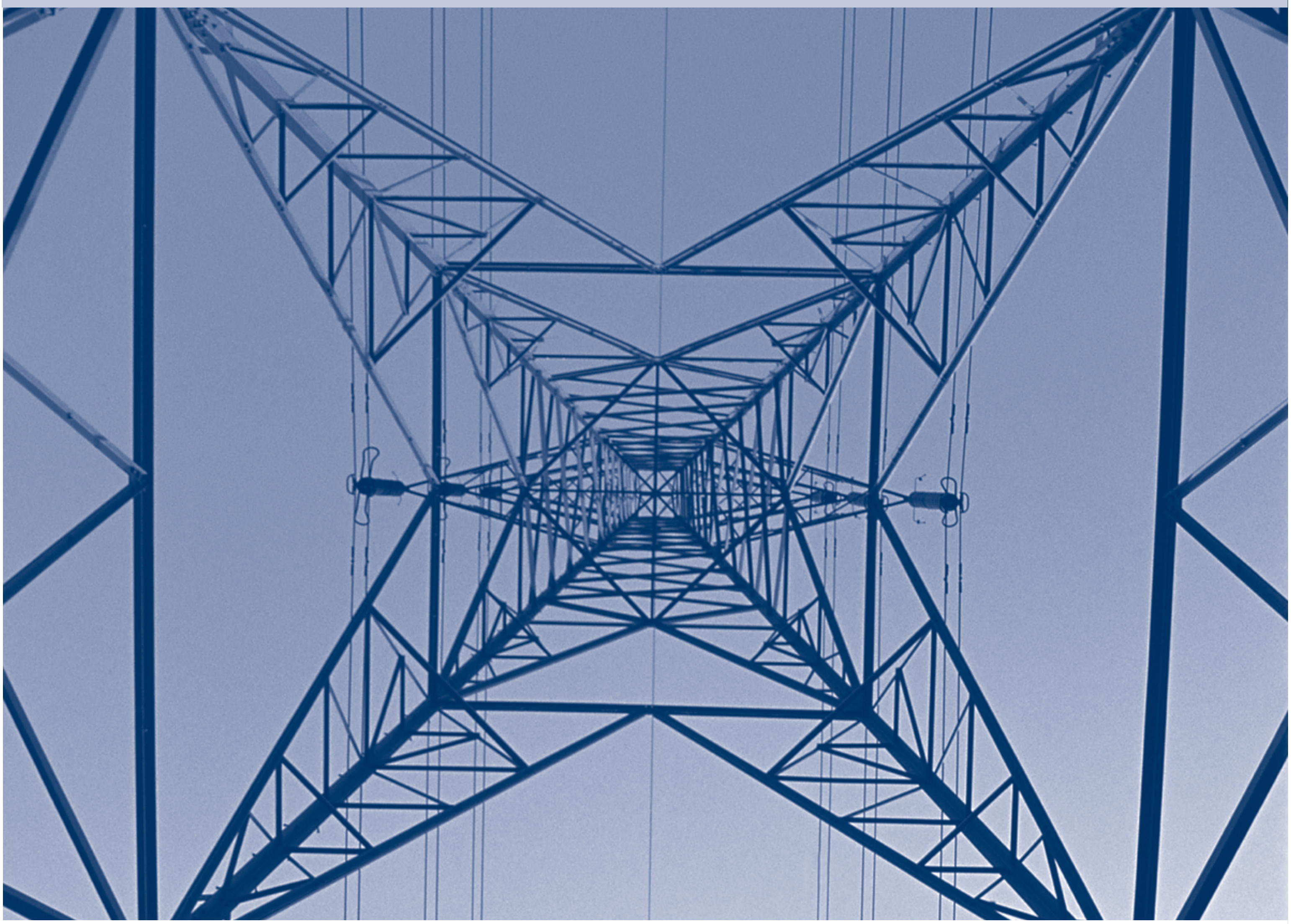
Efficiency and Innovation In U.S. Manufacturing Energy Use



NAM National Association of Manufacturers

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ACKNOWLEDGMENTS

The National Association of Manufacturers and The Manufacturing Institute, its research and education affiliate, have been advocates of energy efficiency for many years. This is the third publication on this topic that we have developed since natural gas prices started their escalation at the beginning of the decade.

This is the first time that we have partnered with the Alliance to Save Energy, however, and we turned to them at this time because of their expertise and three decades of knowledge about what works in spurring greater energy efficiency. We are grateful to Christopher Russell of the Alliance for authoring this publication and to Adam Hudson who assisted him in the writing and research.

We also thank the many companies that have provided the invaluable insights into their operations and innovations that are making this a more energy efficient economy. The sidebars about these companies that illustrate so many pages are true barometers of how extensive the interest is in energy efficiency today.

We want to thank John Engler, president of the NAM, and Jerry Jasinowski, president of the institute, for making this publication on energy efficiency an important objective this spring for use during both the Energy Efficiency Forum in Washington, D.C., and the World Expo in Nagoya, Japan.

Thanks also to Patrick Cleary, Bill Primosch and Laura Narvaiz for helping to shape the report. We are grateful to Marissa Gandelman for editing and her good suggestions on organization and clarity of the text, to Irina Stepanova for her cover design, to Kevin Sullivan and Ronni Hutchason for their production assistance, and to Jeanne Sano for arranging the translation, production and printing for the Japanese-language version released at the 2005 World Exposition in Nagoya, Japan. Thanks also to Bill Canis, executive director of the institute, who developed the concept for this booklet and shaped its evolution in conjunction with the Alliance. We are also grateful to Slade House, an intern with the institute, for assistance with research and writing about some of the companies profiled here.

INTRODUCTION

Industry uses more than one-third of the energy consumed in the United States—and even more when product transportation is factored in. The escalating costs for natural gas and oil clearly have a major impact for manufacturers in America that, left unaddressed, could hurt their competitiveness in world markets. Moreover, energy experts predict that global market pressures on oil and gas markets will ensure that high prices will be with us for some time.

The NAM has partnered with the Alliance to Save Energy to develop this booklet for manufacturers who want to achieve more strategic control over rising energy costs. Being better energy managers is important not only for each company, but is also an essential component in achieving a low-inflation, high-growth economy. We hope that the opportunities outlined in this booklet will encourage manufacturers to make energy efficiency a part of standard operating procedure.

Such investments in today's economy are well worth the effort. According to U.S. Department of Energy figures included in this report, industry can achieve practical energy reductions of about 20 percent. These savings are worth almost $19 billion at 2004 energy prices. About 30 percent of the savings can be achieved without capital investment, using only procedural and behavioral changes.

One of the major findings of this report is that the rising costs for energy also offer opportunities for manufacturers. By strategically building energy efficiency decision-making into production, manufacturers will identify new ways to—

- cut costs, raise productivity, and improve shareholder value;
- improve managerial performance;
- meet environmental standards;
- create energy efficient products and market opportunities;
- improve their competitive position; and
- ensure better community relations.

We are releasing this publication in two places: at the Energy Efficiency Forum in Washington, D.C., and also at the first world's fair of the 21st century, Expo 2005 in Aichi, Japan, because the expo's high-visibility theme is progress and the importance of man's relationship to the natural world. This publication shows how manufacturers such as Caterpillar, Procter & Gamble, The Timken Company and Riverdale Mills are changing their processes to be more energy efficient and using innovation to bring forth a range of less energy-consuming products. They are contributing to progress, while also reducing the environmental and energy impact of product manufacturing.

We commend this booklet to all manufacturers who seek to be world-class competitors in a tough global market.

John Engler
President and CEO
National Association of Manufacturers

Jerry Jasinowski
President
The Manufacturing Institute

EXECUTIVE SUMMARY

Responding to rising energy costs and the need to protect the environment, U.S. manufacturers have introduced a variety of innovative technologies, new business processes and enlightened management techniques to encourage greater efficiency in the industrial use of energy. This report, which was prepared through a partnership of the U.S. National Association of Manufacturers (NAM) and Alliance to Save Energy (Alliance) highlights current challenges in U.S. industrial energy use, examples of innovative practices by manufacturers and business strategies that are critical for the success of energy-saving programs in today's competitive manufacturing environment. Our research shows that effective strategies focus on the following key elements:

Enhancing Financial Performance

The recovery of wasted industrial energy is an opportunity for U.S. manufacturers to improve financial performance in a globally competitive marketplace. Lack of energy awareness, misinformation and conflicting priorities often result in manufacturers' earnings literally going up in smoke. More than one-third of all energy in the United States is used by industry; more than 40 percent if transport of manufactured goods is included. Manufacturing facilities of all types, sizes and locations have the potential for energy-driven productivity gains. Reduced energy bills are only a start. Strategic deployment of energy efficiency is an indispensable component of any effort to improve productivity.

Identifying Valuable Secondary Benefits

Energy efficient practices are aligned with the principles of lean manufacturing and continuous improvement. Industry's near-term energy-saving opportunities come from energy-smart procedures applied to current assets. In addition, there are a range of secondary benefits that come with a comprehensive energy efficiency strategy, including:

- energy training and skills helps reduce the investment risk associated with new technologies;
- combustion volumes reduce proportionately with fossil fuel consumption, contributing to emissions compliance while also reducing energy costs; and
- emerging business development opportunities related to environmentally superior products and production processes.

Evaluating Factors That Influence Energy Decisions

In addition to how manufacturers implement energy efficiency in their facilities, other factors affect energy use, such as government policies and programs, environmental regulations and technological and managerial innovations. The report evaluates these factors and their impact. Within most companies, there are also barriers to energy efficiency, ranging from lack of awareness to outmoded budgeting and accounting to lack of staff resources and skills. Similarly, the report's section titled "Lessons Learned" describes the attributes within a company that most often lead to success, such as a "champion" in the company to press for change, adoption of standards such as ISO 9000 and establishment of new criteria for fiscal and engineering decisions.

Applying Innovative Technology
Improving staff training, businesses practices and management techniques can bring big increases in energy efficiency. But many U.S. manufacturers have also found that investment in innovative technologies can achieve substantial additional benefits not only to the financial bottom line but also to corporate image and community relations. The cost-and-benefit analysis for investment in technology, however, needs to take into account all of the potential benefits for a company and not just the immediate financial results. Advances in information technology, materials sciences, process control technology, alternative energy research, nanotechnology and other fields have created many new opportunities to increase energy efficiency through technical innovation.

Getting Started
All manufacturers should start with energy audits of their facilities. Industry surveys indicate that the average facility can reduce its energy consumption by 10 to 20 percent. At least 30 percent of industry's overall energy savings potential can be obtained without capital expense, by simply making changes to procedures and behavior. Obtaining these results by making energy management standard operating procedure—and not just a one-time project—is a process that bears a striking resemblance to financial planning:

- Establish goals and a strategy for goal attainment;
- Learn about available solutions and select the ones needed to reach the goals;
- Start early, and maintain regular contributions over time;
- Keep track of earnings; and
- Grow wealth and defeat risk through reinvestment and diversification of earnings.

Presenting Real-World Successes
As a number of case studies in this report show, companies enhance their competitiveness by applying the power of energy innovation to their processes and their products. Frito-Lay's resource conservation efforts consistently earn 30 percent return on investment. Riverdale Mills grabbed the opportunity to cut its $800,000 electricity bill in half by operating a water-powered generator that paid for itself in 1.3 years. DuPont applied Six Sigma™ to more than 75 procedure-based energy improvement projects—each required no capital investment and on average saved $250,000 per year.

Energy-smart innovations also contribute to corporate goals for business growth. Advanced cooling technologies by Emerson can cut consumers' energy consumption by as much as 40 percent. Caterpillar developed a new technology to reduce emissions while boosting fuel economy by nearly 25 percent. And Procter & Gamble's research team created Tide Coldwater to satisfy consumer demand for products that perform well but are also more economical to use.

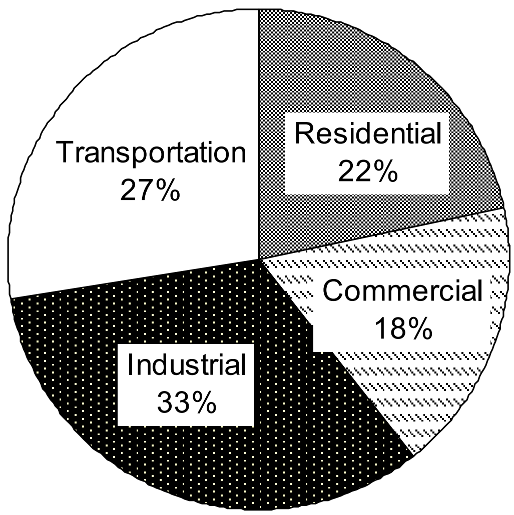
Today's forward-thinking corporations improve their business performance through better stewardship of energy and other resources. This strategy allows companies to improve their income performance, reduce operating risk and build new markets. Energy innovation can boost the competitiveness of manufacturers seeking to develop tomorrow's market opportunities.

INDUSTRIAL ENERGY INTENSITY: CHALLENGE AND OPPORTUNITY

Energy is the lifeblood of manufacturing. Industry converts fuels to thermal, electric or motive energy to manufacture all the products of daily life. Food, paper, metals, plastics, glass, electronics, automobiles, aerospace products, rubber, fertilizer, paints, asphalt, cell phones, refrigerators, cosmetics—and the intermediates from which those products are made—all require some amount of energy to be fabricated. American industry's energy demand is one-third of total U.S. energy consumption (*see Fig. 1*). In addition, a large proportion of energy consumed for transportation represents the shipment of manufactured goods, by land, sea and air.

Fig. 1: Energy Consumption by Sector (Total Energy) 2003

Total Consumption: 98,156 Trillion Btu

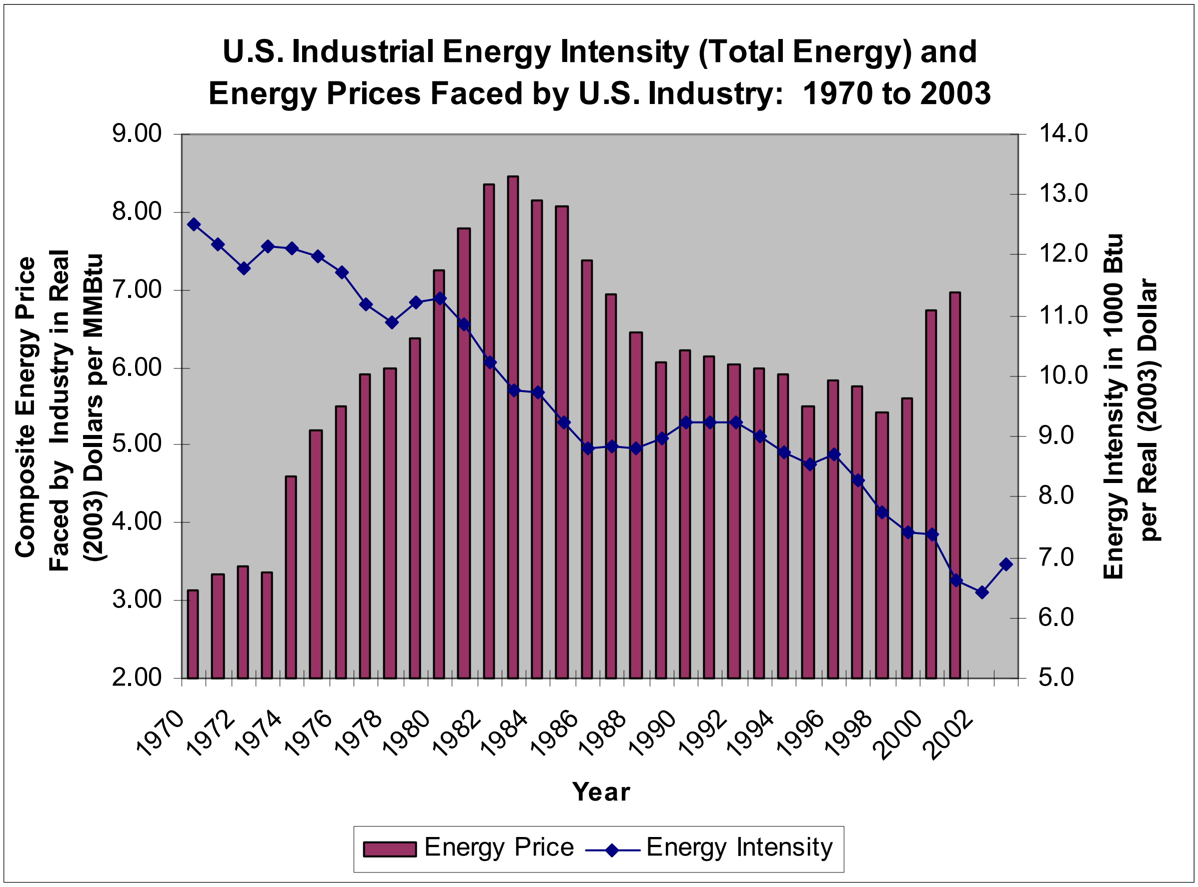


SOURCE: U.S. Department of Energy, Energy Information Administration. (DOE-EIA, 2004) See References section.

U.S. Industrial Energy Trends

Over the past 30 years, the energy efficiency of U.S. industry has improved remarkably. Energy intensity, the amount of energy it takes to produce one dollar of goods, has been cut in half, from 9.13 thousand Btu in 1970 to 4.32 thousand in 2003 (*see Fig. 2*). Roughly half of the reduction in energy intensity can be attributed to energy efficiency improvements—using less energy to do the same amount of work. The rest is the result of structural changes in the economy, such as changes in the product mix (*i.e.,* consumers buying less energy intensive products) and shifting of energy intensive product manufacture to off-shore locations. [1]

[1] Estimates of the relative contributions of structural change to reductions in energy intensity have varied widely, ranging from 10 percent to 60 percent. The Alliance to Save Energy conservatively assumes that 50 percent is structural change, thus at least 50 percent is due to energy efficiency improvements.



SOURCES: U.S. Department of Energy, Energy Information Administration; U.S. Bureau of the Census; U.S. Bureau of Labor Statistics. See References Section: DOE-EIA, 2004; BOC, 2005.1; BOC, 2005.2; BLS, 2005).

The manufacture of a large and growing proportion of consumer products, and their intermediate components, are increasingly imported from countries where energy efficiency lags far behind prevailing practices in the United States. While many industries on U.S. soil make steady gains in energy efficiency, the products bought by Americans increasingly reflect energy intensities that are worse than the global average.[1]

The Total Energy Profile of Manufactured Products

A product's *energy lifecycle* describes its total energy impact, including all stages of its manufacture through the end of its operating life and includes its eventual disposal. Historically, if industry had any interest in energy consumption, it ended when products were finished and shipped. Today, however, because consumers are increasingly concerned with the energy consumed by their appliances, cars and homes, manufacturers should be, too. And at the end of a product's useful life, its disposal must respond to growing concerns about environmental impacts.

The lifecycle energy concept outlines the opportunities to create superior product value—beginning with the elimination of energy waste in manufacturing, and continuing through energy efficiency benefits conveyed to the consumer. Innovative technologies tie together all the stages of the energy lifecycle. Industry's opportunity is to harness the same innovation that goes into its products and apply it to their energy use. Emerson's compressor applications are a good

[1] (Bremner, et. al., 2005; Pottinger, et. al., 2004). See References section.

illustration of an innovative technology that benefits the customer through combined savings in energy, maintenance and production space (*see the following case study*).

Case Study: Emerson

Emerson is a leading manufacturer of compressors used in air conditioning and refrigeration applications. Its Copeland Scroll™ compressor is more efficient, reliable, lighter, quieter and has fewer parts than traditional compressor designs. The Copeland Scroll™ design eliminates the need for pistons and valves to compress gas which leads to greater efficiency during operation. Re-expansion and valve losses are eliminated, and the scroll compressors achieve 100 percent volumetric efficiency which provides reduced energy costs in the scroll's many applications. The absence of valves also results in reduced vibration and up to three times quieter operation than reciprocating models. Its simple and efficient design allows the Copeland Scroll™ to use 80 percent fewer parts on average than a traditional compressor of the same capacity. The Copeland Scroll™ is 240 pounds lighter and occupies three fewer cubic feet of space. Weight and space savings add value in addition to energy costs savings.

Recently, Emerson unveiled their new Copeland Digital Scroll™. Traditional modulation technologies consume close to full-load energy no matter what the required capacity. Copeland Digital Scroll™ technology reduces power consumption by modulating compressor capacity. The result is more precise capacity control, which can lower energy consumption in some applications by as much as 40 percent.

SOURCE: National Association of Manufacturers

Manufacturers can partner with their suppliers to map their energy intensity to strategically squeeze out avoidable costs. Technology research and development (R&D) is crucial, but so is parallel development of human skills to manage energy use by large organizations. Companies are always partnering to achieve economies in distribution and inventory, so why not in energy management? The information technology exists, and it can be done. Toyota provides an excellent example of how a manufacturer can develop superior value by partnering with suppliers to reduce their cumulative process waste (*see the following case study*).

Case Study: Toyota

In Toyota's view, environmental stewardship is not only the practice of a good corporate citizen, it is good for business. To that end, the Environmental Action Plan implemented by Toyota Motor Manufacturing North America demands that the company achieve the highest level of environmental performance in the auto industry.

Recognizing the environmental impacts beyond its own facilities, Toyota encourages and supports its parts and materials suppliers' efforts to protect the environment as part of the action plan. For example, following Toyota's issuance of Green Supplier Guidelines in 2000, 98 percent of its North American suppliers became ISO 14001 certified/registered. Toyota, which set an example by reducing water and energy consumption 15 percent per unit of production since 2000, also shares best practices and ideas with its suppliers.

Toyota's Green Supplier Guidelines also require the elimination of chemicals included on Toyota's global chemical ban list and that suppliers create their own compliance systems for the handling and transportation of hazardous materials.

SOURCE: National Association of Manufacturers

Turning Challenges Into Opportunities

A major energy challenge is to identify manufacturers' *embedded energy costs*. Managers at each stage of manufacture may overlook energy waste because "energy is only two, three or five percent" of production costs. But the prices of final products must absorb these layers of energy inputs. For example, the direct energy cost for assembling an appliance might be only a few dollars—and a very small fraction of its retail cost. But in the big picture, there was energy consumed in mining the appliance's iron ore, copper, and bauxite; in metal treating; in rubber and glass manufacture; in powerhouse fuels for the facilities that make plastics, paints and dyes; and in energy feedstocks, which are energy commodities consumed directly as product ingredients. Any waste of energy in the manufacture of these intermediates, disguised in the cost of inputs, eats up profit margins at every step. In effect, consumers are "taxed" for any waste committed at all stages of the manufacturing process. This is true for appliances, consumer electronics, toys, processed food and many more goods.

Manufacturers are also beginning to think about the energy burden that their products place on their customers. Innovation leads to the development of new products that provide the same service with reduced energy requirements. Procter & Gamble, a leading U.S. manufacturer of household cleansers and related goods, noted how the use of their product affected their customers' energy costs and responded to the market opportunity with an innovative promotional campaign (*see the following case study*).

Case Study: Procter & Gamble

P&G research indicated that consumers were concerned about high energy prices but believed that laundry would not get as clean in cold water as in hot or warm water. The company's response was to develop a new Tide Coldwater laundry detergent formulated to provide deep cleaning in cold water, which causes less wear and tear on colors and fabrics. To demonstrate its commitment to energy efficiency, P&G partnered with the Alliance to Save Energy on a campaign to educate consumers about the energy and money savings they could realize by washing laundry in cold water. The company's research, verified by the Alliance, found that households could save up to $63 a year on home energy bills by switching to cold water.

The joint campaign includes the interactive, Web-based "ColdWater Challenge," where consumers pledge to switch to cold water washing to save up to $63 a year in return for a free sample of the Tide Coldwater detergent. In addition, the company contributed $100,000 to the National Fuel Funds Network, an organization that assists state and local groups that help low-income families pay their energy bills.

As part of the campaign's consumer education component, the Alliance provides numerous no-cost/low-cost energy-saving tips on materials in retail stores, decals for consumer refrigerators and washing machines, and the money- and energy-saving areas of both the www.coldwaterchallenge.com and www.TideColdwater.com Web sites. The ColdWater Challenge was launched Jan. 18, 2005, resulting in 340,111 challenges in 10 days. By mid-April, the ColdWater Challenge passed the 1 million mark.

SOURCE: Alliance to Save Energy

THE ROLE OF ENERGY IN MANUFACTURING

Energy allows manufacturers to transform raw materials into final consumer goods. Raw materials pass through a number of intermediate stages, with these intermediates representing the bulk of industrial energy consumption. In an economic sense, energy performs work that adds value to intermediate products as they are progressively transformed into final consumer goods. The opportunities to improve energy efficiency occur at each step of the manufacturing process.

Manufacturing processes vary by industry and are too numerous to list here. In general, industry's fuel inputs become energy that performs work. Manufacturers' energy inputs typically follow this sequence:

- **primary energy input,** which is the total volume of energy assembled to serve industrial needs;
- **central generation**, which mainly occurs in powerhouses where fuel is converted to heat and power by a steam plant, power generator or cogenerator;
- **distribution**, which pipes heat and sends power from central generation to process units;
- **energy conversion**, consisting of motors, fans, pumps and heat exchangers that transforms heat and power to useable work; and
- **processes**, in which converted energy transforms raw materials and intermediates into final products.

A summary of manufacturing's total energy inputs and losses is presented in Table 1.

Table 1:
U.S. MANUFACTURING SECTOR IN 2001
Summary Allocation of Primary Energy Consumption

Stage of manufacturing energy use	*Volume of energy (trillion Btu)*	*Percent of original energy input available at this stage*	*Characterization of losses*
Primary energy input	**24,658**	**100%**	
Offsite losses	-6,884		Energy is lost by power utilities in the generation of electricity. Also, electricity and fuel is lost in transit to industrial facilities.
Central energy plant	**17,774**	**72%**	
Steam generation loss	-1,233		Powerhouse combustion efficiency determines the proportion of fuel that is converted to heat and power.
Power loss	-166		
Energy distribution	**16,375**	**66%**	
Distribution loss	-1,330		Distribution pipes and vessels sustain a variety of leaks and radiation losses.
Energy exported offsite	-79		In some states, manufacturers can sell surplus electricity that they generate onsite.
Energy for facility heating & cooling	-1,405		Not a "loss," but a reduction of energy available to process. These applications can also be inefficient.
Energy conversion	**13,561**	**55%**	A combination of inefficiencies, some avoidable and some not, are encountered as energy is converted to motive energy used by motor drives, pumps, heat exchangers, etc.
Energy conversion inefficiencies	-2,862		
Energy applied as process work	**10,699**	**43%**	An indeterminate volume of residual energy after process work is either reapplied to central generation or is lost without reclamation.

SOURCE: U.S. Department of Energy, Industrial Technologies Program. See References section (DOE-ITP, 2004).

Energy is lost at each stage of handling as described in Table 1. The fundamental laws of physics and thermodynamics make some losses unavoidable, but some of these overlooked losses are opportunities to embrace efficient technologies and practices.

Despite the overall improvement in U.S. industrial energy intensity since 1970, the best analysis (Table 1) still concludes that only 43 percent of all manufacturing energy inputs are applied to process work. But industry pays for all energy consumed, whether it is used or wasted. The recovery of lost industrial energy—to the greatest practical extent—is an opportunity for U.S. manufacturers to improve financial performance in a globally competitive marketplace.

FACTORS THAT INFLUENCE INDUSTRIAL ENERGY DECISIONS

The Impact of Technology, Regulation and Market Forces

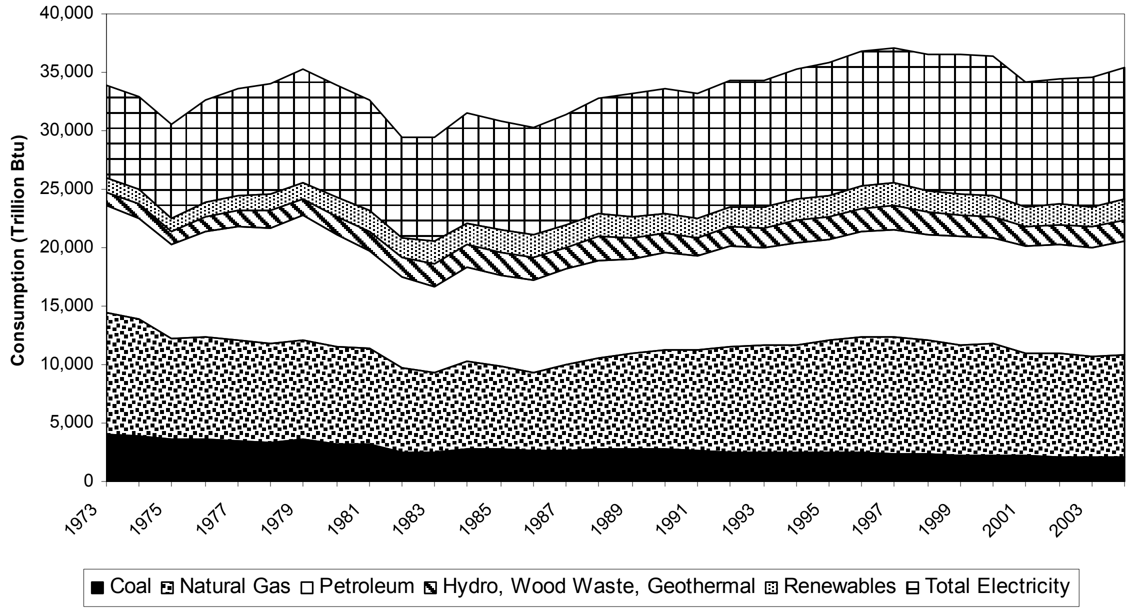
Production decisions are paramount in industry, and all other decisions are usually subordinate to production goals. Given the complexity of manufacturing operations, managers typically seek to ensure that production decisions become as routine as possible. Decisions on energy use are no exception, and may be best understood in a sequence working backward from production goals:

- A facility's production targets drive its total energy consumption.
- The amount of energy consumed *per unit of production* is largely dictated by the plant assets themselves. Work procedures and the integrity of equipment also affect per-unit energy requirements.
- A facility's fuel choices primarily reflect fuel availability and the nature of the facility's process, as well the capabilities of the facility's powerhouse.
- Fuel procurement activities represent the front end of industrial energy decision-making. Fuel procurement choices are determined in part by the needs of powerhouse and process combustion technologies. Fuel selection is also influenced by regulations pertaining to combustion emissions and their impact on air quality. Finally, today's industrial energy procurement activities are shaped by deregulation of U.S. utility industries that supply energy to industry. Since the 1980s, deregulation has dramatically altered the way energy is bought and sold. This is reflected in the variety of purchasing arrangement options available to industry.

In 1970, industrial energy decision-making in the United States was simpler than it is today. Production targets and prevailing facility technologies largely dictated energy consumption. Natural gas and power utilities distributed their commodities at regulated prices. For most of industry, energy consumption was perceived as a fixed, uncontrollable cost of doing business. Energy management entailed little more than paying utility bills on time to avoid late charges.

A combination of forces emerging since 1970 has complicated industry's energy decision-making. The advent of air quality regulation generally reduced the demand for certain fossil fuels for combustion purposes, while stimulating the demand for energy sources that could be consumed with minimal environmental impact. The development of domestic fuel sources was accelerated by the occasional disruption of global energy markets. Figure 3 illustrates trends in industrial energy consumption by type of fuel. The volume of various fuels used to generate electricity, such as coal, nuclear, hydro and natural gas are included in the "electricity" portion of the data.

Fig. 3: INDUSTRIAL ENERGY CONSUMPTION
By Type of Fuel, 1973-2004



SOURCE: U.S. Department of Energy, Energy Information Administration. See References section (DOE-EIA 2005).

Today's industrial energy decisions must accommodate changes in technology, increasingly stringent emissions regulation and volatile energy markets. High energy prices obviously challenge manufacturers' profitability. Volatility in energy prices upsets a manufacturer's whole financial picture, and it forces ongoing adjustments to deal with it. A facility manager may respond to a spike in energy prices by making cuts elsewhere, like maintenance. Then if a decline in energy prices provides an unexpected boost to earnings, the facility's guard goes down and it becomes vulnerable to the next energy price spike. To offset the turbulence wrought by today's energy markets, regulatory demands and rapid technology evolution, manufacturers today must manage both their procurement and consumption of energy on a continual basis.

The Role of Energy Efficiency

If industrial facilities do not optimize their energy consumption, opportunities to create value are lost with energy waste. The forfeiture of additional revenues plus energy waste has a doubly negative effect on earnings. "Energy efficiency" refers to technologies and standard operating procedures that reduce the volume of energy per unit of industrial production. Manufacturers selectively implement energy efficiency initiatives for their potential to reduce expenses, build revenue capacity and contain operating risk.

Facility managers need to understand how energy efficiency supports overall corporate goals. The very activities that provide energy efficiency also provide better control over plant assets and inputs. For example, energy efficient practices ensure that thermal resources are applied at the right temperature, for the right duration and in correct proportion to raw materials. This control reduces a facility's scrap rates as well as energy consumed per unit of production. Control provides reliability. Greater reliability means less down time. Less downtime means orders are filled faster, which allows the facility to complete more orders over the course of a year—thus making more revenue. Energy efficiency is not just about reducing utility bills. It's also about boosting revenue through greater productivity.

The potential for greater asset productivity is underscored by the data in Table 1. Fifty-seven percent of industry's primary energy inputs are lost or diverted before reaching the intended process activities. Some manufacturers, like Riverdale Mills Corporation (*see the following case study*), have found ways to recapture wasted energy to do useful work. Their reward is to generate more revenue from existing facilities. A combination of new technologies and the optimization of current assets and practices are required to reduce energy consumption. Estimates provided in several industry studies indicate that on average, 10-20 percent of industry's energy consumption can be economically avoided.[2] Remember that 10-20 percent describes "average" savings. Some plants will experience greater savings, some less.

Case Study: Riverdale Mills Corporation

Riverdale Mills Corporation, a Massachusetts-based manufacturer with 105 employees, makes steel welded wire mesh for use in security fences, lobster traps, crab traps, erosion-control gabions, aquaculture, poultry farms and many other applications. Its product, AquaMesh®, revolutionized the lobster and crab industry. The company is dedicated to harnessing energy efficiency throughout all of its operations to enhance its competitiveness.

Among the many innovative applications adopted by President & CEO James Knott, Sr., are natural-gas-powered generators that make electricity for one-half the cost the public utility charges. A combination of natural-gas-fired generators and a hydropower turbine allows for Riverdale Mills to make their electricity for about $400,000 a year, compared to the cost of buying it at approximately $800,000 a year. These internal combustion generators also provide space heating that Riverdale uses for the building and in their manufacturing processes. The process for capturing heat from the generator involves sending the engine exhaust through a boiler to make steam and delivering hot water from water jackets to space heaters and process heat plates. Without this generator heat, Riverdale would have to run costly boilers for the manufacturing processes and space heating.

Located on the Blackstone River, Riverdale Mills restored a 1901 hydropower turbine and its civil works at a cost of $130,000. The turbine saves Riverdale $100,000 a year in electricity costs, which resulted in a payback period of only 1.3 years. A new turbine would have produced similar electricity and cost savings but cost $300,000 with a three-year payback period.

Knott acknowledges the importance of Riverdale Mill's energy-efficiency features. "The lower my energy costs, the lower my selling prices; and that's why we're able to compete with other foreign and domestic manufacturers."

SOURCE: National Association of Manufacturers

Good energy decisions can reduce certain non-energy expenses as well. A summary of 77 case studies gives some indication of the value of non-energy benefits attributable to energy efficiency in a manufacturing setting.[3] Of the total number of cases, 52 included a monetized estimate of both energy and non-energy savings. Based on energy savings alone, project paybacks in aggregate were 4.2 years. With non-energy benefits included, the aggregate payback was 1.9 years. It is also interesting to note that 41 of the 77 cases involved "state-of-the-art" technology installations, while 35 involved everyday (conventional) technologies. As a subset,

[2] (DOE-OIT, 2002; Griffin, 2004). See References section.
[3] (Finman & Laitner, 2002). See References section.

the conventional technology case studies displayed a 2.3 year payback on energy savings alone, while the inclusion of non-energy benefits dropped the payback to only 1.4 years.

Companies like Ford Motor Company recognize energy efficiency's potential to provide non-energy benefits such as reduced raw material waste, reduced water consumption, reduced maintenance and repair, improved process cycle times and other equipment performance enhancements. Ford's River Rouge plant in Michigan is a showcase for sustainable manufacturing principles (*see the following case study*).

Case Study: Ford Motor Company

Ford Motor Company has revitalized its historic 750,000-square-foot River Rouge Plant in Dearborn, Mich., so that it now handles three different vehicle platforms and nine different models. Chairman Bill Ford, Jr., wanted to "transform a 20th century industrial icon into a model of 21st century sustainable manufacturing." The new facility includes a wide range of features that mitigate its environmental impacts.

Ford's use of vegetation in its natural storm-water management system helps protect the nearby Rouge River while saving the company money on operating costs. The centerpiece of this system is the world's largest living roof. The 10.4-acre roof can absorb up to 4 million gallons of water per year while filtering out pollutants that normally run off into the Rouge River. In addition to filtering and retaining rainwater, the maintenance-free roof will last twice as long as a traditional roof and provides natural insulation.

Energy efficiency is another prominent feature of the Rouge plant. Innovative lighting, heating and cooling in the assembly workspaces reduce utility expenses. Indoor air quality initiatives, materials recycling/reuse programs, reduced consumption of potable water, porous parking areas and the creation of a wildlife habitat are some of the other features of the Rouge facility.

Ford highlights the facility to communicate its commitment to social responsibility and environmental leadership. As part of a tour program that showcases its innovative manufacturing facility, Ford invites visitors to view its green roof from the 80-foot-high Observatory Deck. Interactive exhibits, touch-screen kiosks and hands-on displays explaining the facility's environmental features are also located on the Observation Deck.

SOURCE: National Association of Manufacturers

Unchecked energy expenditures are like a tax burden imposed cumulatively on each stage of production. Plants of all types, sizes and locations use energy, so the potential for energy-driven productivity gains is everywhere. The benefits only begin with reduced energy bills. Energy efficiency is an indispensable component of any effort to improve productivity. Ultimately, energy efficiency contributes to wealth.

Frito-Lay, a U.S. snack food producer, uses resource efficiency to support the financial performance of its products (*see the following case study*).

Case Study: Frito-Lay

Frito-Lay spends about $110 million a year for its energy needs. This includes natural gas (everything we operate is natural-gas fueled), electricity, water and waste water. While this is well under 5 percent of our manufacturing cost, it is a substantial outlay. Saving any fraction of that cost is worthwhile, and energy-cost improvement projects turn out to be fairly reliable investments compared to other investments.

For example, we spend a lot of money developing new products and concepts. Some products do very well while others don't do well at all. Product investments are unreliable in the sense that we can't be sure what return we will get—or if we will get any return at all. But our resource conservation portfolio consistently returns 30 percent on investment. For example, if we spend $100,000 on improving, say, a steam system, and we expect to get $30,000 in savings per year out of it, we can rely on getting those $30,000 savings year in and year out.

There is a community-relations aspect as well. In the communities where we operate, we are one of the larger energy consumers. When a curtailment happens, such as fuel shortages in cold winters or electricity curtailments in hot summers, it is critical for us to be able to show that we are making significant strides to reduce our consumption. We need to be seen as doing our best to alleviate the situation rather than exacerbating it.

SOURCE: Alliance to Save Energy

The Role of Government Policies and Programs

In the United States, the national government plays an important role in promoting energy efficiency in the private sector. For example, the U.S. Department of Energy, (DOE) with substantial help from federally chartered national laboratories, has been active and effective in advancing R&D for energy efficient technologies. Recently, DOE's Industrial Technologies Program (and earlier programs) published "BestPractices," technical reference materials to help plant managers develop their own strategies for improving energy efficiency. State governments often follow DOE's lead on energy priorities and draw on DOE grants to implement programs at the state level.

The U.S. Environmental Protection Agency (EPA) also has program activities that seek to promote energy efficiency. The activities address financial, marketing and community relations issues.[4] The EPA's services include a clearinghouse of information to help businesses select, evaluate and get recognition for energy efficient improvements.

Utility deregulation is another policy variable affecting industrial energy use. Reliable, plentiful energy has long been taken for granted as a key feature of U.S. economic infrastructure. That advantage is at risk today. Since the 1980s, the progressive deregulation of U.S. utility markets has permitted more large energy consumers to shop for fuel and electrical power in competitive markets. However, deregulation also dismantles the mechanisms for planning investment in utility infrastructure. These investment decisions are increasingly left to the free market. As a result, underinvestment progressively compromises utility services in some regions of the country where assets reflect age and capacity limitations. Energy efficiency practiced by large industrial consumers, therefore, not only lowers their energy consumption costs, but also helps reduce stress on overburdened utility distribution systems in their communities.

[4] http://www.energystar.gov/index.cfm?c=business.bus_index

Recognizing high energy costs, limited utility distribution capacities and the value of new energy sources, vehicle manufacturer General Motors is tapping landfill gas for a significant volume of its fuel needs (*see the following case study*).

Case Study: General Motors

General Motors' Oklahoma City Assembly plant has become the company's seventh to use landfill gas as energy and is helping fulfill the company's goal to increase the use of renewable energy in its energy supply portfolio.

Four other GM facilities—Toledo, Ohio (powertrain); Orion, Mich.; Fort Wayne, Ind., and Shreveport, La., vehicle assembly plants—also use landfill gas to power plant boilers. In addition, GM's Service Parts Operations in Grand Blanc and Flint, Mich., use landfill gas by purchasing 13 million kilowatt-hours of electricity annually, generated from the Granger Energy landfill gas-to-electricity project.

"GM is helping reduce coal and natural gas consumption at its plants and emissions by capturing methane that would have been released to the atmosphere from the landfill, and using it as a source of energy," said Thomas W. Neelands, director of GM's Energy and Utility Services. "Additionally, GM's landfill gas projects have proven not only to be good for the environment, but to reduce spending costs, generating annual savings greater than $500,000 at each plant."

By driving energy conservation initiatives and by using various renewable energy sources such as methane gas, GM has reduced its natural gas consumption by 21 percent since 1995 and is well on its way to achieving its 25 percent energy-reduction goal for 2005.

Last year, GM received the 2003 Partner of The Year Award through the EPA's Landfill Methane Outreach Program for achieving outstanding success in using landfill gas. GM also received the EPA'S ENERGY STAR "Energy Partner of the Year" Award in 2002 and the EPA's 2004 ENERGY STAR Sustained Excellence Award. According to the World Resources Institute and the Green Power Market Development Group in a 2003 study, GM is the largest non-utility direct user of landfill gas in the United States.

SOURCE: National Association of Manufacturers

The Role of Environmental Regulations

Fossil fuel combustion is the focus of air quality and the regulation of airborne pollutants. Beginning with the Clean Air Act of 1970, which was amended in 1977 and again in 1990, U.S. air quality has been managed by the U.S. Environmental Protection Agency, related state agencies and industry-based voluntary programs.[5] Air quality regulations focus on power plant and industrial emissions that contribute to smog, acid rain and global warming. Title V of the Clean Air Act empowers the EPA to regulate the combustion emissions from a targeted population, which includes many industrial sites. Similar regulations pertain to the environmental impact of industry's water and solid waste byproducts.

DENSO is a manufacturer that developed new products in direct response to public concern with environmental change (*see the following case study*).

[5] The American Chemistry Council's Responsible Care program is an excellent example of a voluntary industry initiative: http://www.responsiblecare-us.com/.

Case Study: DENSO

Currently, hydrofluorocarbon 134a (HFC-134a) is widely used as refrigerant for air conditioners. Although this substance does not harm the ozone layer, it does have a high global warming potential (GWP). Converting HFC-134a to a substance having no or very low GWP is essential to prevent global warming.
As a leader in the field of air conditioners, DENSO has been at the forefront of environmental technology. In 2002, DENSO introduced the world's first carbon dioxide (CO_2) air conditioning system for Toyota's fuel cell hybrid vehicle (FCHV-4).

Features of CO_2 refrigerant

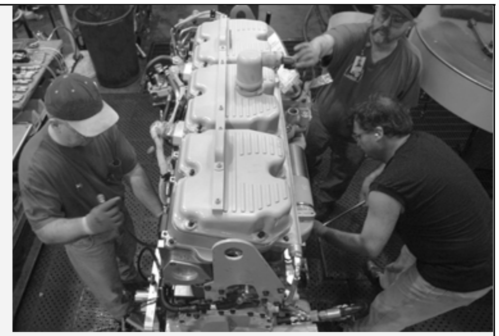
- The GWP of CO_2 is extremely low—about 1/1,300 of that of HFC-134a. Therefore, even if CO_2 is leaked from an air conditioner, the effect on the environment is negligible.
- CO_2 has an excellent heating capacity and can be used for a heat-pump system. This feature is effective especially for electric or hybrid vehicles that do not have a heat source sufficient for heating the cabin, thereby enabling greater use of this technology.
- CO_2 has an operation pressure that is seven to ten times higher than that of HFC-134a, and thus requires more robust components than the HFC-134a system.

SOURCE: National Association of Manufacturers

Some facilities invest in smokestack applications that trap process pollutants for subsequent treatment and disposal. Energy efficiency provides another option for meeting air quality goals in that combustion volumes are reduced proportionately with fossil fuel consumption. A combination of energy efficient technologies and practices are generally the cheapest, quickest and cleanest way to extend energy supplies and consequently offset high energy prices. Energy efficiency prevails economically when the unit price of fuel purchased exceeds the unit value of fuel wasted.

Energy innovations improve the emissions profile of manufactured vehicles as well as the processes that manufacture them. Caterpillar, a manufacturer of construction and mining equipment, diesel and natural gas engines, and industrial gas turbines, has set goals to reduce the emissions of its manufacturing facilities as well as its products (*see the following case study*).

Case Study: Caterpillar



Caterpillar products and components are manufactured in 49 U.S. facilities and in 59 other locations in 22 countries around the globe. The company has been a leader in minimizing environmental impacts by reducing greenhouse gas emissions from their facilities by 450,000 tons between 1991 and 2001. Caterpillar has pledged to reduce its global greenhouse gas (GHG) emissions 20 percent by 2010.

Also demonstrating its commitment to the environment, the company reduced on-highway diesel emissions by 90 percent since 1988. And with lower emissions standards on the horizon, the company is relying on its breakthrough ACERT® engine technology to be compliant with EPA regulations in 2007 and beyond, reducing on-highway diesel emissions by another 90 percent.

Recently, Caterpillar engineers invented a new air management system combined with precise valve control to reduce emissions at the point of combustion rather than downstream in the exhaust. A series of turbochargers and a variable valve actuation device optimizes combustion at various engine loads, thereby providing superior fuel economy. This invention, combined with advanced fuel systems, engine electronics and post-combustion treatment, cost-effectively reduces emissions.

Numerous Caterpillar customers are reporting positive business results using Caterpillar technologies. One U.S. fleet operator with more than 300 Caterpillar-powered engines expects annual fuel savings of up to $1.2 million. Another operator saw fuel usage go from 5.2 to 6.4 miles per gallon—a fuel economy increase of 23 percent.

SOURCE: National Association of Manufacturers

The Role of Technological Innovation

Manufacturers recognize technology as the primary driver of industrial productivity, which in turn drives the rest of the economy. According to the Bureau of Economic Analysis, every dollar spent on a manufactured consumer good represents $0.55 of manufacturing value and $0.45 in related legal, health care, accounting and other services. From 1977 to 2002, productivity in the U.S. economy overall rose 53 percent, while U.S. manufacturing productivity rose 109 percent. Investments in information technology are estimated to account for 60 percent of that increase in manufacturing productivity.[6]

Energy applications compete with information technologies and other activities for industrial R&D budgets. For the past 20 years, industrial R&D has favored refinements of existing products and production facilities. This reflects industry's preference for lower, short-term risks and a more immediate return on investment.[7] But this focus is at the expense of developing "next generation" technologies that will ensure long-term industrial competitiveness. Certain energy efficient technologies face developmental hurdles because of industry's investment priorities. To facilitate overall U.S. industrial R&D, the U.S. Department of Energy's Industrial Technologies Program partners with industry to mutually identify, sponsor and develop new technologies.

Industry's best R&D options for reducing energy costs were summarized in a study sponsored by the U.S. DOE.[8] This study identifies energy efficiency opportunities that yield energy, economic and environmental benefits, primarily for large volume, commodity/process industries. Opportunities were prioritized to reflect the magnitude of potential savings, broadness of

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[6] (DOC, 2004). See References section.
[7] (Eisenhauer & Garland, 2003). See References section.
[8] (DOE-ITP, 2004). See References section.

suitability across industries, and feasibility to implement. In total, these energy-saving opportunities represent 5.2 quadrillion Btu—21 percent of primary energy consumed by the manufacturing sector. These savings equate to almost $19 billion for manufacturers, based on 2004 energy prices and consumption volumes. Table 2 summarizes these leading opportunities. An expanded version of this information appears in Appendix A.

Table 2:
TOP R&D OPPORTUNITIES FOR ENERGY SAVINGS IN COMMODITY/PROCESS MANUFACTURING
Initiatives That Provide the Largest Energy and Dollar Savings

*Type of Opportunity**	*Total Energy Savings*		*Total Cost Savings*	
	(trillion Btu)	*Percent of Total*	*($mill.)*	*Percent of Total*
Waste Heat and Energy Recovery	1,831	35%	$6,408	34%
Improvements to Boilers, Fired Systems, Process Heaters and Cooling Opportunities	907	17%	$3,077	16%
Energy System Integration and Best Practices Opportunities	1,438	28%	$5,655	30%
Energy Source Flexibility and Combined Heat and Power	828	16%	$3,100	16%
Improved Sensors, Controls, Automation and Robotics for Energy Systems	191	4%	$630	3%
TOTALS	**5,195**		**$18,870**	

SOURCE: U.S. Department of Energy, Industrial Technologies Program. See References section (DOE-ITP, 2004).
*See Appendix A for an expanded version of this table.

It is very important to note that this summary describes savings for the U.S. manufacturing sector as a whole. Individual manufacturing facilities have unique designs, operating protocols and maintenance histories, all of which affect energy saving potential. Individual facilities may save more or less than the industry average.[9]

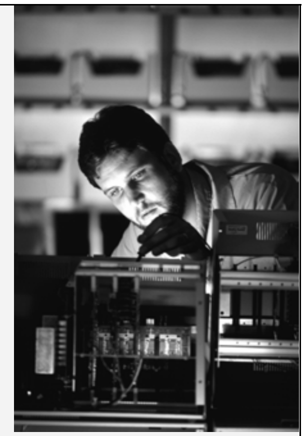
Note that about 30 percent of the potential savings (1.4 quadrillion Btu) described in Table 2 are derived from "best practices," which are generally low-cost opportunities to reduce the energy consumption of existing assets. Best practice savings come from changes in behavior and procedures. Facilities that sustain energy best practices can use the cash flow of savings to underwrite the cost of capital improvements that save even more money. The manufacturer that invests in best practice training can think of this as "intellectual R&D"—knowledge and skills that save energy with today's assets while preparing the workplace for the next generation of advanced technologies.

The other 70 percent of potential savings in Table 2 are equipment upgrades that typically require capital expenditure. Some of these are currently high-cost capital items, and not yet fully commercialized, so they are ideal elements for the U.S. DOE's R&D agenda. These investments may be most feasible as a part of new facilities construction.

Ingersoll-Rand recognized the opportunity to reduce electricity costs associated with industrial air compressors, which are widely used throughout industry (*see the following case study*).

[9] One study that illustrates the dispersion of possible savings comes from Enbridge Gas Distribution of Ontario, Canada (Griffin, 2004; see References section). Enbridge performed 66 steam system energy audits between 1997 and 2002 (42 were for industrial plants, while 24 were commercial/institutional plants). Identified fuel savings as a proportion (p) of annual energy bills were dispersed as follows: p<10%: 19 plants; 10%<=p<20%: 23 plants; 20%<=p<30%: 16 plants; and p=>30%: 8 plants. The weighted average savings for all plants was p=13.7 percent.

Case Study: Ingersoll-Rand



Ingersoll-Rand is a global manufacturer of air compressors and other industrial hardware. Their advanced Nirvana air compressor technology uses at least 28 percent less energy than traditional air compressor designs. Unlike traditional air compressor designs that offer only one fixed speed in response to varying workloads, the Nirvana's variable speed motor delivers constant pressure as its motor speed varies with each workload. The result is air compression that only draws power as needed, leading to lower energy expenses.

Ingersoll-Rand also manufacturers a line of microturbine generators called PowerWorks®. Microturbines provide the local generation of both electricity and thermal energy. The PowerWorks® microturbine can reduce energy costs by producing electricity at a cost lower than the price of power supplied by electric utilities. Heat from the microturbine exhaust can be applied directly to manufacturing processes, furnaces, boilers and dehumidification applications, thus reducing the need to purchase fuel for combustion processes. One company that installed a PowerWorks® microturbine saw net annual gas savings of more than $35,000 which allowed for a payback period of 12 months.

SOURCE: National Association of Manufacturers

Applying technology to new industry segments is another way manufacturers bring their innovations to bear, in this case helping the wind power industry to be more efficient in delivering new sources of power to communities across the country (*see the following case study*).

Case Study: The Timken Company

The Timken Company, a 106-year-old anti-friction bearing manufacturer in Canton, Ohio, is making great strides to develop new energy efficient applications for its bearings. One of the solutions: Harness the wind.

Whenever something is moved, it requires energy — whether it is a person's own physical exertion or energy that is generated from a machine. If a machine is being used to move something, chances are it contains an anti-friction bearing.

When two or more components come in contact with each other, the friction between them causes a force that slows them down, also slowing down the main object being moved, like a bicycle or a car. That friction requires more energy to be consumed. But, if the two surfaces can roll over each other, the friction is greatly reduced, and the amount of energy required to move an object is also reduced.

The Timken Company is using its extensive knowledge of bearings and gear drives to help leading U.S. and European wind turbine manufacturers and gearbox suppliers create new energy efficient designs to improve the reliability and efficiency of wind power. Bearing and bearing packages are used in the gearbox and main motor support of wind turbines.

Timken's anti-friction bearings do just that — reduce friction. And anytime friction is reduced, energy is conserved.

SOURCE: National Association of Manufacturers

In many instances, the value of new technologies may not come from energy savings, but from the reliability of heat, power or work provided. In certain high-value production processes, the premium paid for energy reliability is more than offset by the risk of revenue loss from power failure. Merck & Co., a pharmaceuticals manufacturer, recently installed innovative yet expensive fuel cell technologies to power its Rahway, N.J., facilities because the reliability of power supply was worth the premium (*see the following case study*).

Case Study: Merck & Co.

On Oct. 29, 2004, Merck was the first pharmaceutical company in the United States to formally dedicate fuel cell operations. The electricity generated by the fuel cell is the equivalent of the power that would be used on a daily basis by 100 typical single-family homes. It acts as a supplemental source of energy for the Merck manufacturing and research operations at its 210-acre complex in Rahway, N.J.

Reliability of the technology was a major reason for Merck's interest. "We operate around the clock and many of our research materials require refrigeration, so a constant, reliable supply of electricity—99.999 percent free of the possibility of power outages—is critical to our operations," said Merck's Rahway plant manager Lawrence Naldi.

Given all the benefits, why aren't businesses rushing to install fuel cell technology in plants? The reason: because gas and coal are cheap. Currently fuel cells cost $1,600 to $4,500 a kilowatt, while fossil-fuel-powered generators can cost as little as $35 a kilowatt. So, when Merck investigated installation of an environmentally friendly energy generator, the price tag delayed the project. Fortunately, funding incentives made available from the New Jersey Clean Energy Program and the Department of Defense Climate Change Program helped offset the large start-up costs and enabled the project to move forward.

The interest in introducing fuel cells at Merck stems from the company's five-year energy reduction initiative and the search for new, environmentally sound power sources. "We tend to forget that petrochemical fuels are finite," says Mr. Gates. "Even if we locate and drill more oil and gas wells, this only forestalls the reality that clean and efficient alternative energy sources must be found. The fuel cell, through higher efficiency, allows us to make much better use of these finite fuels."

SOURCE: Alliance to Save Energy

Energy-saving technologies are not limited to commodity/process facilities. A study released in 2001 offers a list of 54 emerging technologies that offer the most potential to return value to industry through energy efficiency.[10] Many of the 54 technologies apply to specific industries. Others are widely applicable, and feature a variety of well-proven, low-risk technologies. An abbreviated list of those low-cost, quick-payback opportunities for end-product manufacturers appears in Table 3.

[10] (ACEEE, 2001). See References section.

Table 3: **BEST ENERGY SAVING TECHNOLOGIES FOR HIGH-VALUE, END-PRODUCT MANUFACTURING** **Initiatives That Provide the Largest, Quickest Payback With Lowest Risk**		
Emerging Technology	*Simple Payback* (years)*	*Likelihood of Success*
Advanced lighting technologies	1.3	High
Advanced lighting design	3.0	Medium
Compressed air system management	0.4	Medium; better if complemented by improved procedures/behavior
Motor system optimization	1.5	Medium; better if complemented by improved procedures/behavior
Pump efficiency improvement	3.0	Medium; better if complemented by improved procedures/behavior

SOURCE: Adapted from (ACEEE 2001). See References section. NOTE: The source document presents a total of 54 technologies, and that was a refinement of an even longer list. The technologies presented here were selected because they (1) are broad in their potential application, and not industry specific; (2) represent large savings potential, due in part to their broad applicability; and (3) offer additional non-energy benefits such as enhanced productivity, product quality or workplace safety.
*"Payback" refers to the number of years it takes for an investment to pay for itself through the savings it creates.

Industrial energy efficiency is not limited to exotic, new technologies. Note that the opportunities listed in Table 3—related to lighting and electric motor-drive systems—are routine technologies that pay for themselves quickly though the savings they generate. As energy prices rise, the payback on these opportunities becomes even more financially attractive.

Why would routine, everyday technologies top the list of energy efficiency opportunities? This is because powerhouses, which host energy support systems such as steam, air compressors and other "prime movers," remain literally on the periphery of management attention. This fact is underscored by the typical physical layout of industrial properties. For historic engineering safety reasons, the powerhouses that perform combustion duties are isolated from the structures that host core processes. Energy systems are secondary to manufacturing activities that make money. Alliance research indicates that the remoteness of industry's powerhouses—both physically and managerially—is why they get only the remainders of budget authority and talented investment analysis. When taken for granted year in and year out, these common plant utilities become a stealthy drag on financial performance as their integrity is allowed to slip.

Industry's near-term energy saving opportunities come from best practices (behaviors and procedures) applied to current energy systems. A company's investment in energy training and skills also helps to reduce the investment risk associated with new technologies.

The Role of Managerial Innovation

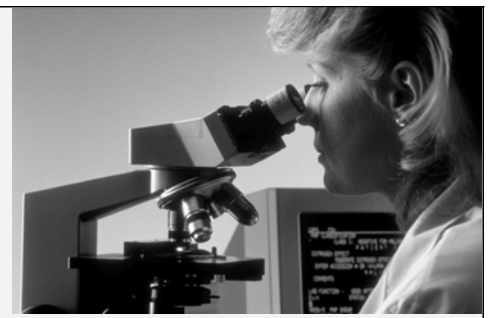
Information systems innovation begets managerial innovation. New information technologies allow managers to capture value from industrial costs—including energy—that were once considered "uncontrollable." A number of technical innovations pave the way for effective energy management.

- Computer modeling techniques allow managers to diagram energy uses and flows in a facility. This is a prerequisite to establishing an energy baseline from which all subsequent improvements will be measured.
- Monitoring, metering and database technologies allow plants to collect up-to-the-minute statistics on energy activities. This data is a continuous pulse on operations, with

- parameters that define "normal" results. Any data that exceeds normal parameters automatically signals the need to investigate possible lapses in equipment integrity.
- Benchmarking disciplines, such as Six Sigma™, merge statistics with management philosophies to become a way to engage staff in the continuous improvement of their facility operations.

"Benchmarking" is the ongoing, data-driven refinement of performance targets for common activities. It defines state-of-the-art performance measures for distinct, repetitive activities. Benchmarks allow a manufacturer to judge its progress in boosting productivity and minimizing costs against the best practices in other companies and industries. Some examples of industrial energy benchmarking may include (1) optimizing the frequency of cleaning soot from combustion chambers to minimize the combined cost of maintenance, fuel purchases and the production of unwanted emissions; (2) optimizing the frequency of boiler "blowdown," a process that removes accumulated solids from water used to make steam; or (3) determining the break-even point for reclaiming scrap castings, where the cost of energy used for melting is weighed against the salvage value of scrap material. DuPont, a major U.S. chemicals manufacturer, provides an excellent example of benchmarking techniques applied to energy management (*see the following case study*).

Case Study: DuPont



DuPont's Energy Engineering Technology group uses Six Sigma™, a benchmark-driven quality control methodology, to manage energy costs. DuPont used Six Sigma™ methodologies to identify and implement more than 75 energy improvement projects across its global operations between 1999 and 2002. These efforts continue today.

By using the Six Sigma™ methodology, DuPont intended to implement a managing process that would lower manufacturing costs, reduce variability in monthly energy costs, and to replicate best practices across the company. Six Sigma™ supports replication by prescribing the means for discovery, remediation, documentation and communication of innovative solutions.

The average DuPont Six Sigma™ energy project is estimated to save more than $250,000 per year. Data indicate that by 2002, DuPont achieved a 68 percent reduction of greenhouse gas emissions since 1990, thus exceeding its target level (65 percent) and target date (2010). Global energy consumption has been essentially flat since 1990, despite a 35 percent increase in production.

SOURCE: Alliance to Save Energy

The overall effectiveness of benchmarking increases with the depth and scope of its data. Multi-plant corporations are well suited to conduct internal benchmarking initiatives. Benchmarking saves each facility from "reinventing the wheel." In addition, each facility saves money by gaining access to the full benefits of others' knowledge, in return for contributing a fraction of that knowledge.

Kimberly-Clark, a personal-care products manufacturer, uses benchmarking technologies to share energy best practices among more than 165 production facilities (*see the following case study*).

Case Study: Kimberly-Clark Corporation (KCC)

This personal care products manufacturer has a broad mandate for environmental stewardship. A global population of more than 165 paper mills allows KCC to generate its own proprietary benchmarking discipline for energy efficiency, air emissions abatement, wastewater treatment upgrades, process water use reduction, packaging reduction, landfill elimination, toxic chemical elimination and environmental management system implementation. Five-year plans help coordinate benchmarking efforts around the world. KCC's energy conservation efforts are currently in the middle of a second five-year plan, which seeks to expand on the success of the first plan (1995-2000). The first plan led to a corporate-wide, 11.7 percent reduction in energy use per ton of product.

SOURCE: Alliance to Save Energy

Case studies and research conducted by the Alliance have articulated industry's energy management barriers and strategies.[11] The Alliance shares some major lessons:

- *Technology is crucial* to achieving energy efficiency, but industry is not fully convinced by even by impressive site demonstrations. This is especially true when managers feel that risks are involved.
- *Information is crucial* to adopting energy efficient solutions. But the best of engineering proposals, cash flow projections and even outright public grants cannot always overcome the barriers that manifest within manufacturing organizations.
- *Top management direction* does not always ensure that energy efficiency will be effectively carried out. The conflicting accountabilities that arise from a lack of cooperation across departments and production facilities within a company must first be recognized, then circumvented.

BARRIERS TO ENERGY EFFICIENCY

Human, technical, financial and organizational capacities all contribute to a manufacturer's ability to build wealth through energy efficiency. Similarly, the barriers to energy efficiency are evident when the manufacturer lacks these capacities. Manufacturers can and do make money despite inefficiencies. However, the burden of energy waste, lost income and increased exposure to operating risk are increasingly hard to bear in a globally competitive economy.

The Alliance to Save Energy has researched the organizational aspects of industrial energy efficiency for more than five years. From this ongoing study, certain barriers to energy efficiency are frequently encountered:

- **Misunderstanding of business value.** The term "energy efficiency" is easily confused with other concepts. Having dual-fuel capabilities in the powerhouse, for example, simply means the operator has a choice of fuels. Enlisting an energy marketer to purchase fuel usually helps to even out energy price fluctuations, but has no impact on efficiency of energy use. Consuming renewable energy sources such as wood byproducts is fine as an alternative to fossil fuel, but this consumption is equally susceptible to waste as it is converted to process work. The first hurdle to advancing energy efficiency is to understand that it is a business opportunity to reduce expenses, build revenues and control risk.

[11] (Russell, 2005). See References section.

- **Lack of staff and management awareness.** Staff doesn't always make the connection between energy choices and money. For example, compressed air leaks are often overlooked because "air is free," although this conclusion ignores that fact that five horsepower of electricity are consumed to generate one horsepower of compressed air. Steam system management is susceptible to similar thinking. Plant operators who assume that scrap rates are of no importance "because scrap can be melted down and used again" are not considering the excess energy consumption that this practice requires.

- **Lack of cross-departmental cooperation.** The manufacturer's first priority is to make product and get it out the door, not save energy. Every position on the company's personnel chart has a job description, accountabilities and incentives—all tied to production. Departments within a company often compete against each other in the budget process. For example, energy efficiency projects might be expensed from the maintenance budget, but the savings accrue to the production budget. When departments do not cooperate, waste is allowed to continue. Unless top management takes action, energy efficiency is a duty that occupies the blank space on the personnel chart—the space where there are no boxes.

- **Outdated accounting techniques.** Many industrial facilities still have only one utility meter to measure consumption for an entire plant. In this situation, traditional accounting practices treat plant-wide energy as an overhead cost, which is then allocated across departments according to their numbers of workers or square feet of space. Early 20^{th} century accounting techniques can obscure the results of 21^{st} century energy use. Moreover, the cost of any one department's energy waste is distributed to all departments. Even worse, this accounting system is a disincentive to any one department taking the initiative to improve energy efficiency, because that department's results will be diluted by the artificial allocation of costs. Improper allocation of energy costs may distort financial decisions such as product pricing, income and tax declarations, production mix, compensation and bonuses, and capital investment allocations. But today's advanced energy metering technologies can monitor actual consumption by substations within a facility, improving department managers' abilities to control their energy costs.

- **Restrictive budget and fiscal criteria.** A manufacturer's budget and finance functions can impose procedural barriers to energy efficiency initiatives. Operating budget strategies may simply trend each line item from year to year. The manager that saves energy this year will risk getting a reduced budget for the coming year. Low-bid or least-cost purchasing requirements may be imposed by front-office procurement personnel without thorough consultation with operations staff. Consequently, this arrangement leads to purchases based solely on upfront costs, ignoring energy and other operating costs over the life of the asset. Restrictive debt covenants can effectively limit corporate borrowing. In an effort to not "waste" borrowing capacity, debt financing may be limited to core process investments.

- **Lack of management accountability.** The rotation of management within companies often prevents the hard decisions from being made. "Not on my watch" is often the response to improvement proposals that won't pay off until after the current manager's tenure is over.

- **Lack of resources.** Because of limited time, money and skills, and with management accountability sometimes tied to short-term results, deferred maintenance is the order of the day. To "save money," some companies will release well-compensated, skilled workers, especially from non-core activities like energy support. The remaining, less-capable staff is ill-prepared to seek, promote and maintain energy system improvements.

- **Complacency.** It is easy for top managers to be lulled into complacency about energy and other support functions with which they are not familiar. Management indifference effectively abdicates control to trusted subordinates who know that it is better to report good news than bad. Who is a 35-year-old general manager to question the report of a powerhouse superintendent with 20 years on the job? These territorial relationships are barriers to energy efficiency, especially when tenured staff explains that "this is the way we've always done it."

The most durable barrier may simply be an organization's business culture. Few corporate leaders, if any, "save" on their way to the top. Their bias is for short-term revenue making, not cost saving. This thinking is evident in capital budgeting decisions, where growth-oriented projects are favored over expense-reduction initiatives. Decision-makers that dismiss energy efficiency overlook opportunities to grow revenue through the redirection of energy waste to more productive purposes.

INDUSTRIAL ENERGY MANAGEMENT: A CRITIQUE OF PREVAILING WISDOM

The pinch of today's high energy costs prompts many manufacturers to investigate energy management options more thoroughly. Some strategies focus on price control, some pursue capital investment projects and others seek savings through changes in procedure and behavior. It is possible to combine all of these strategies. The Alliance to Save Energy's research has identified the range of typical energy management strategies practiced by industry today. These strategies are as follows:

- **Do nothing.** Ignore energy improvement. Just pay the bill on time. Operations are business as usual or "that's the way we've always done it." The result is essentially "crisis management," in that energy solutions are undertaken in emergency situations without proper consideration of the true costs and long-term impacts. This strategy is pursued by companies that (1) do not understand that energy management is a strategy for boosting productivity and creating value, or (2) have management in such turmoil that energy management cannot be sufficiently supported, or (3) are extremely profitable and don't consider energy costs to be a problem. **Pros:** Manufacturers don't have to change behavior or put any time or money into energy management. **Cons:** Savings are forfeited. Income is increasingly lost to uncontrolled waste.

- **Price shopping.** Switch fuels, shop for lowest fuel prices. Make no effort to upgrade or improve equipment. Make no effort to add energy-smart behavior to standard operating procedures. Companies take this approach because they "don't have time" or "don't have the money" to pursue improvement projects. It is also preferred by companies that truly believe that fuel price is the only variable in controlling energy expense. **Pros:** Management doesn't have to bother plant staff with behavioral changes or create any more work in the form of data collection and analysis. **Cons:** Lack of energy consumption knowledge exposes the manufacturer to a variety of energy market risks.

The origin of waste is unknown, as are the opportunities to boost savings and productivity. Exposure to energy market volatility and emissions and safety compliance risks remains.

- **Occasional low-cost, non-capital projects.** Make a one-time effort to tune up current equipment, fix leaks, clean heat exchangers, etc. Avoid capital investments. Revert to business-as-usual behavior after one-time projects are completed. Companies that do this are insufficiently organized to initiate procedural changes or make non-process asset investments. They cannot assign roles and accountabilities for pursuing ongoing energy management. **Pros:** Very little money is spent when just pursuing quick, easy projects. **Cons:** Savings are modest and temporary because facilities don't develop procedures for sustaining and replicating improvements. Familiar energy problems begin to reappear. Energy bills begin to creep back up.

- **Capital projects.** Acquire big-ticket assets that bring strategic cost savings. But beyond that, daily procedures and behavior are business as usual. This strategy is adopted by companies that believe that advanced hardware is the only way to obtain real, measurable savings. Similarly, they believe that operational and behavioral savings are "weak" and not measurable. Such companies may also lack the ability or willingness to perform energy monitoring, benchmarking, remediation and replication as a part of day-to-day work. However, they have the fiscal flexibility to acquire strategic assets that boost productivity and energy savings. **Pros:** Obtain fair to good savings without having to change behavior or organize a lot of people. The risk of such investments is reduced if sustained by appropriate maintenance and skilled staff. **Cons:** Forfeit savings attributable to sustained procedural and behavioral efforts. Also, payback from the new assets may be at risk if not complemented by the appropriate maintenance, procedures and skilled staff.

- **Sustained energy management.** Merge energy management with standard operating procedures. Diagnose improvement opportunities and pursue these in stages. Procedures and performance metrics drive improvement cycles over time. Manufacturers with corporate commitment to continuous improvement can pursue this strategy. They have well-established engineering and internal communications protocols and an energy program that engages staff with roles and accountabilities. They encourage cooperation among departments. **Pros:** Maximize savings and capacity utilization. Increased knowledge of in-plant energy use is a hedge against operating risks. Greater use of operating metrics will also improve productivity and scrap rates while reducing idle resource costs. **Cons:** Companies need to recognize that there may be need for upfront investment in staff resources and training, new expertise, better cross-functional management and the time of senior managers.

Too many companies still take an occasional, low-cost, non-capital project approach to energy management in the United States. It is usually undertaken by mid-level managers, in limited scope, and without broader support from other functional areas of the company.

In 2005, Mercury Marine, a U.S. manufacturer of marine engines, is systematically building a robust energy management program (*see the following case study*).

Case Study: Mercury Marine

Mercury Marine has a solid foundation for corporate-wide energy management. Two powerful features provide excellent results to date: consolidation of energy management under the authority of a central facilities manager (CFM), and a power monitoring system that permits electricity costs to be tracked and billed to individual cost centers. Valuable energy flow data give the CFM leverage in gaining top management approval of energy technology upgrades. The centerpiece of these efforts in 2004 was the installation of a new, centralized compressed air system that saves roughly half a million dollars from a $7 million annual electricity expenditure.

The CFM's function and authority at Mercury's multi-plant campus is like that of a "landlord," in that the CFM charges plant managers for infrastructure services like waste management, roof repairs, painting and paving. Recently, the CFM added energy bills to the mix. There is no full-time energy management person or discrete energy management cost center. The company formed an energy steering management team, consisting of plant managers and plant engineers from each plant and is chaired by the chief of staff. Energy is a part-time pursuit for each member of this cross-functional and multi-disciplinary team, which meets regularly to discuss ideas and implementation.

The key to Mercury's ongoing energy management success is putting energy responsibility in the hands of the central facilities manager. Plant managers have been successfully "sold" on this delineation of duties, because it gives them more time to focus on production goals.

SOURCE: Alliance to Save Energy

INDUSTRIAL ENERGY EFFICIENCY: LESSONS LEARNED

There is no one-size-fits-all approach to industrial energy cost control. This simply reflects the fact that all companies have a unique combination of priorities, cultures, market positions, asset management histories, incentive and reward structures, liability exposures and other attributes. The best way to manage energy costs is to actively manage both price and consumption. Manufacturers will enjoy a wider range of energy management options by nurturing several key organizational attributes, including staff awareness, competence, leadership, commitment and removal of institutional barriers. It's important to develop an energy management strategy that suits an organization's unique character and attributes.[12]

Eight Attributes for Successful Energy Management

- **Fundamental business viability.** The manufacturer's front office stability is important. Companies that are the subject of a merger or acquisition, labor disputes, bankruptcy or severe retrenchment may have fundamental distractions that will interfere with the attention that energy management deserves. A preponderance of such conditions indicates management turmoil that makes energy management impractical.

[12] (Russell, 2005). See References section.

- **Ability to learn, document and replicate.** Manufacturers with multiple facilities should spread knowledge of energy efficient techniques and compare their ongoing results. The ability to cooperate—across multiple sites and across departmental boundaries—is required to maximize industrial energy management potential.

- **Energy leadership (or "champion").** Successful energy improvements are usually led by an "energy champion," a manager that (1) understands both engineering and financial principles, (2) communicates effectively both on the plant floor and in the boardroom, and (3) is empowered to give direction and monitor results.

- **Willingness to purchase energy in the open market.** This dimension is straightforward: Does the corporation wish to purchase energy through open-market activity, or just procure as usual from the local utility? If open markets are the choice, the corporation should be prepared to maintain sophisticated search and verification procedures to support its contracting activities. Purchasing decisions should reflect the collaboration of procurement, production and maintenance personnel.

- **Leadership intensity.** Quality of operations should be demanded, facilitated and recognized by top officers of the corporation. Adoption of professional and industry standards such as ISO 9000, are helpful in attaining this attribute. Energy-smart operations will hold employees accountable for adherence to energy management goals and other quality standards.

- **Positive and productive staff.** Energy efficiency is very much dependent on the behavior of line workers. Employee awareness of their impact on energy costs must be achieved. A positive, can-do attitude on the part of staff is helpful in attaining potential energy savings. Rewards and recognition can be harnessed to good effect.

- **Criteria for fiscal decisions.** Financial considerations involve far more than invoice quotes. Are purchase decisions made on first cost or lifecycle costs? Which department pays for improvements and which claims the savings? Do savings count only fuel bill impacts or include the value of material waste minimization and greater capacity utilization? What criteria determine adequate payback?

- **Strength of engineering discipline and procedures.** Successful energy management depends on an ability to understand energy consumption. This requires benchmarking, documenting, comparing, remediating and duplicating successful improvements. Internal skills, procedures and information services are engaged. The likelihood of building value through energy efficiency varies directly with the depth of these technical capabilities.

Without these attributes, a manufacturer's energy management will be less effective. Or worse, the company will be susceptible to false starts and disappointing results that will bias management against future efforts.

ExxonMobil, a global energy company, recognizes the benefit of energy efficiency for its customers as well as its own process activities (*see the following case study*).

Case Study: ExxonMobil

ExxonMobil is one of the world's largest energy and petrochemical companies with major manufacturing operations around the world. It is committed to reducing energy use because it will lengthen the time during which petroleum will be able to meet the world's energy needs and also reduces ExxonMobil's own manufacturing costs.

Its comprehensive Global Energy Management System (GEMS) focuses on continual improvements in energy efficiency. Over a 25-year period, their refineries and chemical plants have improved their energy efficiency by more than 35 percent. Opportunities to trim an additional 15 percent have been identified. The GEMS initiative is not limited to a few major industrial operations but is broadly directed to petroleum production, supply terminals, office buildings and even service stations.

Another way in which ExxonMobil improves efficiency is through cogeneration, the simultaneous production of electricity and steam using natural gas. Cogenerated power is nearly twice as efficient as traditional methods of producing steam and power separately. They have more than 80 cogeneration facilities around the world and are expanding current capacity by 30 percent.

A third energy efficiency initiative is through research on improved consumer products. Motor oils have been continuously improved to extend oil change intervals and help increase fuel economy. Other research is focused on improving the way internal combustion engines operate through technologies that could raise fuel efficiency by 30 percent over that achieved by today's engines. In addition, ExxonMobil's advanced plastics offer lower weight and, when used in vehicles, provide better fuel mileage. Since they are recyclable, energy is also saved when the plastic is reused.

SOURCE: National Association of Manufacturers

How To Start Managing Energy

Every manufacturer wishing to initiate an energy management program should begin with a plant-wide audit of energy consumption. Managers need to know how much energy their facility consumes. Audits are often free through utilities, state energy offices and university-based industrial assistance programs. This activity generates an inventory of energy-using devices, a map of energy flows within the facility and ratios of energy use to production units. Knowledge of energy consumption patterns will return value in many ways:

- The audit itself probably will reveal a number of low- or no-cost adjustments that pay for themselves immediately. A good example is shutting off steam mains that serve abandoned process lines.
- Armed with knowledge of their own energy consumption, manufacturers have a lot more leverage with marketers through whom fuel commodities are purchased. Marketers make money based on a percentage of the fuel they broker. Uninformed energy consumers give the marketer a blank check.
- Energy consumption knowledge is a baseline for quantifying the before-and-after impacts of energy improvements. Managers can't claim victory if they don't know where they started.
- Baseline energy data helps decision-makers prioritize improvement opportunities by targeting the prime movers that consume the most fuel.
- A facility inventory of energy-using devices helps managers assess the value and impact of new technologies as they become available.
- Similarly, an energy audit is also an inventory of emissions sources. The audit will present and prioritize opportunities to reduce the risk of non-compliance with emissions regulations.

Without an energy audit of facility-wide energy usage, the manufacturer is exposed to a number of energy-related risks. By not monitoring energy performance, facilities are more susceptible to lapses in mechanical integrity and plant reliability. A manufacturer with no knowledge of its energy consumption is essentially driving blindfolded on the twisting, turning road of today's energy marketplace.

Business Impacts of Energy Efficiency

What financial results can a company expect from energy management? Industry surveys indicate that the average plant can reduce its energy consumption by 10 to 20 percent, and a lot of that is from procedural and behavioral changes.[13] The cost of sustaining an energy management program (operations and maintenance costs only, omitting capital expense) is around 1 to 2 percent of total energy expenditures.

Energy management usually provides savings from a number of sources: (1) reduced fuel use; (2) reconciliation of errors in utility bills; (3) using consumption information to negotiate better fuel purchase contracts; and (4) reduced waste of raw materials, attributable to the enhanced precision of energy use. In addition to savings, many manufacturers enjoy the additional revenue generated from current assets when energy waste is captured and redirected back into process activities.

Case Study: Shaw Industries

Shaw Industries, a floor products manufacturer headquartered in Georgia, started an energy consumption management program in mid 2004. They have a corporate team of six individuals that provide energy procurement, bill reconciliation, energy audit and technical support for 53 facilities. The fully loaded cost for one or two of that staff is paid for by the bill reconciliation activities alone. All the energy benchmarking and technical assistance they provide to their plants pays for itself many times over through energy savings. During each month over the latter half of 2004, they found on average about $1 million in annual savings opportunities. By the end of February 2005, projects representing about $100,000 worth of annual energy savings were implemented, with projects worth another $2 million of annual savings soon to follow.

SOURCE: The Alliance to Save Energy

Energy management is a process of continuous improvement. Initial savings pay for subsequent rounds of improvement. Companies that develop best practices with current assets are more capable of absorbing new technologies. There are scale economies in waste management—the discipline that saves energy can be extended to water and materials consumption.

Energy management bears a striking resemblance to financial planning:

- Identify goals;
- Select the investments needed to reach the goals;
- Establish a blueprint and strategy for goal attainment;
- Start early, if only with small efforts;
- Maintain regular contributions over time;
- Keep track of earnings; and
- Defeat risk through reinvestment and diversification of earnings.

[13] (Griffin, 2004; DOE-EERE, 2002). See References section.

Here, “diversification” means expanding beyond one-time energy projects to make energy management part of standard operating procedures, bumper to bumper, throughout the organization. The financial and energy planning analogies share the same result—the growth and preservation of wealth.

Today’s forward-thinking corporations improve their business performance through better stewardship of energy and other resources. This strategy allows companies to improve their income performance while reducing operating risk. It is imperative that people working in today’s industries learn waste minimization principles.

APPENDIX A:
TOP R&D OPPORTUNITIES FOR ENERGY SAVINGS IN COMMODITY/PROCESS MANUFACTURING
Initiatives That Provide the Largest Energy and Dollar Savings

	Type of Opportunity	*Leading Industry Recipients*	*Total Energy Savings*		*Total Cost Savings*	
			(trillion Btu)	*Percent of Total*	*($mil.)*	*Percent of Total****
	Waste Heat and Energy Recovery		**1,831**	**35%**	**$6,408**	**34%**
	...from gases and liquids, including hot gas cleanup and dehydration of liquid waste streams.	chemicals, petroleum, forest products	851	16%	$2,271	12%
	...from drying processes	chemicals, forest products, food processing	377	7%	$1,240	7%
	…from gases in metals and non-metallic minerals manufacture (excluding calcining), including hot gas cleanup	Iron and steel, cement	235	5%	$1,133	6%
	…from by-product gases	petroleum, iron and steel	132	3%	$750	4%
	…using energy export and co-location (fuels from pulp mills, forest bio-refineries, co-location of energy sources/sinks	forest products	105	2%	$580	3%
	…from calcining (not flue gases)	cement, forest products	74	1%	$159	1%
	…from metal quenching/cooling processes	Iron and steel, cement	57	1%	$275	1%
	Improvements to Boilers, Fired Systems, Process Heaters and Cooling Opportunities		**907**	**17%**	**$3,077**	**16%**
	Advanced industrial boilers	chemicals, forest products, petroleum, steel, food processing	400	8%	$1,090	6%
	Improved heating/heat transfer systems (heat exchangers, new materials, improved heat transport)	petroleum, chemicals	260	5%	$860	5%
	Improved heating/heat transfer for metals, melting, heating, annealing (cascade heating, batch to continuous process, improved heat channeling, modular systems)	iron and steal, metal casting, aluminum	190	4%	$915	5%
	Advanced process cooling and refrigeration	food processing, chemicals, petroleum and forest products	57**	1%	$212	1%
	Energy System Integration and Best Practices Opportunities		**1,438**	**28%**	**$5,655**	**30%**
*	Steam best practices (improved generation, distribution and recovery), not including advanced boilers	all manufacturing	310	6%	$850	5%
*	Pump system optimization	all manufacturing	302**	6%	$1,370	7%
*	Energy system integration	chemicals, petroleum, forest products, iron and steel, food, aluminum	260	5%	$860	5%
*	Energy efficient motors and rewind practices	all manufacturing	258**	5%	$1,175	6%
*	Compressed air system optimization	all manufacturing	163**	3%	$740	4%
*	Optimized materials processing	all manufacturing	145**	3%	$660	3%
	Energy Source Flexibility and Combined Heat and Power		**828**	**16%**	**$3,100**	**16%**
*	Combined heat and power onsite in manufacturers' central plants, producing both thermal and electricity needs	forest products, chemicals, food processing, metals, machinery	634	12%	$2,000	11%
	Energy source flexibility (heat-activated power generation, waste steam for mechanical drives, indirect vs. direct heat vs. steam)	chemicals, petroleum, forest products, iron and steel	194	4%	$1,100	6%
	Improved Sensors, Controls, Automation and Robotics for Energy Systems	chemicals, petroleum, forest products, iron and steel, food, cement, aluminum	**191**	**4%**	**$630**	**3%**
	TOTALS		**5,195**		**$18,870**	

SOURCE: DOE-ITP, 2004. See References section.

NOTE: All are R&D opportunities EXCEPT for items denoted by an asterisk (*), which are near-term best practices, applicable to current assets.

*** Energy savings figures include the corresponding recapture of losses inherent in electricity generation, transmission, and distribution.*

****Totals may not add up due to rounding.*

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"We must find smarter ways to meet our energy needs, and we must encourage Americans to make better choices about energy consumption. We must also continue to invest in research, so we will develop the technologies that would allow us to conserve more and be better stewards of the environment."

George W. Bush, President of the United States
April 16, 2005

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