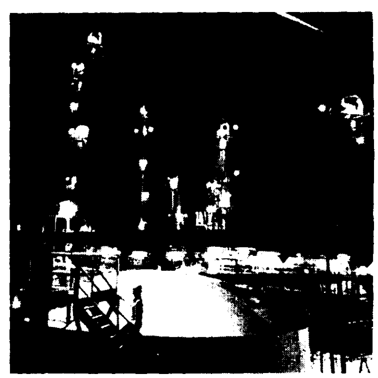
Introduction and Policy 1

Energy is an integral component of a modern economy. It is an essential ingredient in nearly all goods and services, but its use exacts heavy financial, environmental, and security costs. A key method of reducing energy's costs while retaining its benefits is to use it more efficiently.

Industry is a very large consumer of energy. U.S. manufacturing plants, mines, farms, and construction firms currently consume about 25 quads (quadrillion British thermal units or Btu) of energy each year, about 30 percent of the Nation's total consumption of energy. Industry thus has a major role in making the United States more energy efficient.

Industrial energy use and the opportunities for improving its energy efficiency depend on many technical, economic, institutional, and political factors. Many such factors have changed since the 1970s, when most Federal energy policy was formulated.

- Industrial energy intensity (box l-A) has declined over the last two decades (figure l-l) as a result of improvements in energy efficiency and shifts in industrial structure.
- Industry's petroleum consumption has fallen from its peaks of the late 1970s.
- Prices of petroleum, natural gas, and electricity have declined, when adjusted for inflation, after nearly a decade of increases.
- Utilities have assumed a new role in promoting energy conservation.
- Energy policy has been extended beyond the traditional issues of availability and price to include environmental quality and industrial competitiveness.



Box l-A–Energy Efficiency and Intensity

Efficiency and intensity are terms used to compare energy consumption and product output. Efficiency is a term that is sometimes ambiguous, because it has one meaning in engineering contexts and another in economic contexts. In this report, the terms efficiency and energy efficiency are used to denote the engineering sense of the word, while economlc ***efficiency is*** used when the economic sense is implied.

Engineering efficiency is the amount of useful work output that a process or a piece of equipment performs with a unit of energy input. It is expressed in units of physical output per unit of energy, or as a percentage of the input energy that is converted into useful output. Engineering efficiency is used to emphasize the engineering performance of equipment and processes. A machine or a process is more energy efficient than another if it uses less energy while yielding the same output. For example, a distillation column that requires 40,000 Btu to process a barrel of crude oil is more technically efficient than one that requires 60,000 Btu per barrel. A motor that converts 90 percent of the electricity input to mechanical energy output is more technically efficient than one that converts 80 percent.

Economic efficiency highlights the cost performance of equipment and processes. A machine or a process is more economically efficient than another if it is less costly and/or yields greater benefits. In the example above, the 40,000 Btu/barrel distillation column is more efficient than the 60,000 Btu/barrel column only if it processes the oil at a lower cost.

Energy intensity focuses on the energy use of entire industries or countries. It is expressed in units of energy per unit of physical or monetary output. It encompasses the effects of both engineering efficiency and indus ***structure.*** Industrial structure refers to the mix of plants and facilities in the industry or country, and manifests itself in the mix of raw materials, intermediate products, and finished goods that are produced. A country can lower its energy intensity by installing more energy efficient equipment and processes and/or shifting its industrial base away from heavy, processing industries toward light, fabricating ones. Processing raw materials, such as steel and petrochemicals production, generally requires much more energy per unit of output than does fabricating finished goods, such as computer and automobile manufacture.

SOURCE: Office of Technology Assessment, 1993.

- Environmental regulations have become increasingly stringent.
- Market-based policy instruments have attracted increased attention as potential mechanisms for mitigating pollution and influencing energy use.

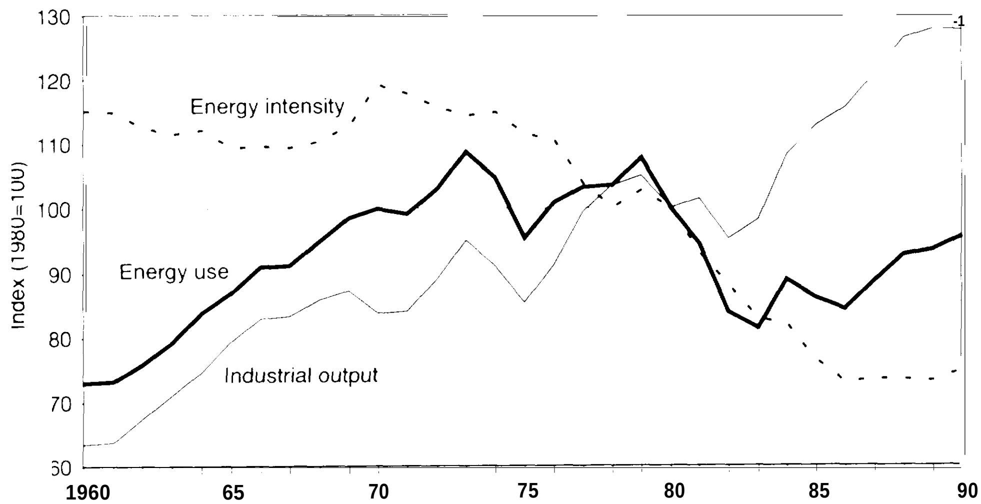
The Energy Policy Act, signed into law in October **1992,** begins to bring Federal energy policy into line with these changed conditions. The law's effects on industrial energy use, however, are expected to be small.

This report focuses on the prospects for further improving industrial energy efficiency in this new environment. It assesses available technologies for improving energy efficiency, discusses why these technologies are not more widely used, and offers policy options for encouraging their use. Among the questions explored are:

- How does industry use energy? What have been the trends in energy use? What is the outlook for future energy use? (chapter 2)
- What technologies are available to improve industrial energy efficiency? How much energy can they save? (chapter 3)
- How do corporations view energy? What are their incentives and disincentives for using more efficient technologies? (chapter 4)

The remainder of this chapter summarizes the key policy findings of the report and discusses policies Congress might wish to consider in order to further enhance industrial energy efficiency.

Figure 1-1—Industrial Output, Energy Consumption, and Energy Intensity, 1960-90



In 1980, industrial energy use was 25.4 quads, gross product originating (output) was $896 billion, and energy intensity was 28,300 Btu/$ output. Energy consumption includes coal, natural gas, petroleum, wood, and electricity used for heat, power, electricity generation, and feedstock purposes; and excludes waste, geothermal, wind, photovoltaic, and solar thermal energy and electricity y generation, transmission, and distribution losses. Gross product originating (output) data presented in the graph and used in intensity calculations are in constant dollars.

SOURCES: U.S. Department of Energy, Energy Information Administration, State *Energy Data Report, Consumption Estimates 7960-1990,* Report No. DOE/EIA-021 4(90), May 1992; and *Annua l Energy Review 7991,* Report No. DOE/EIA-0384(91), June 1992. Robert P. Parker, U.S. Department of Commerce, Bureau of Economic Analysis (BEA), "Gross Product by Industry, 1977-90," *Survey of Current Business,* May 1993; and BEA, "National Income and Product Accounts database."

FINDINGS

I Technical Potential for Saving Energy

1. Industry is a large energy consumer, and efficiency improvements have yielded large energy savings in the past.

In 1990, U.S. manufacturing plants, mines, farms, and construction firms consumed 25.0 quads of fuels and electricity. This accounted for 28 percent of the Nation's total use of fossil fuels, 31 percent of its renewable energy use, and 35 percent of its electricity use (figures 1-2 and 1-3).

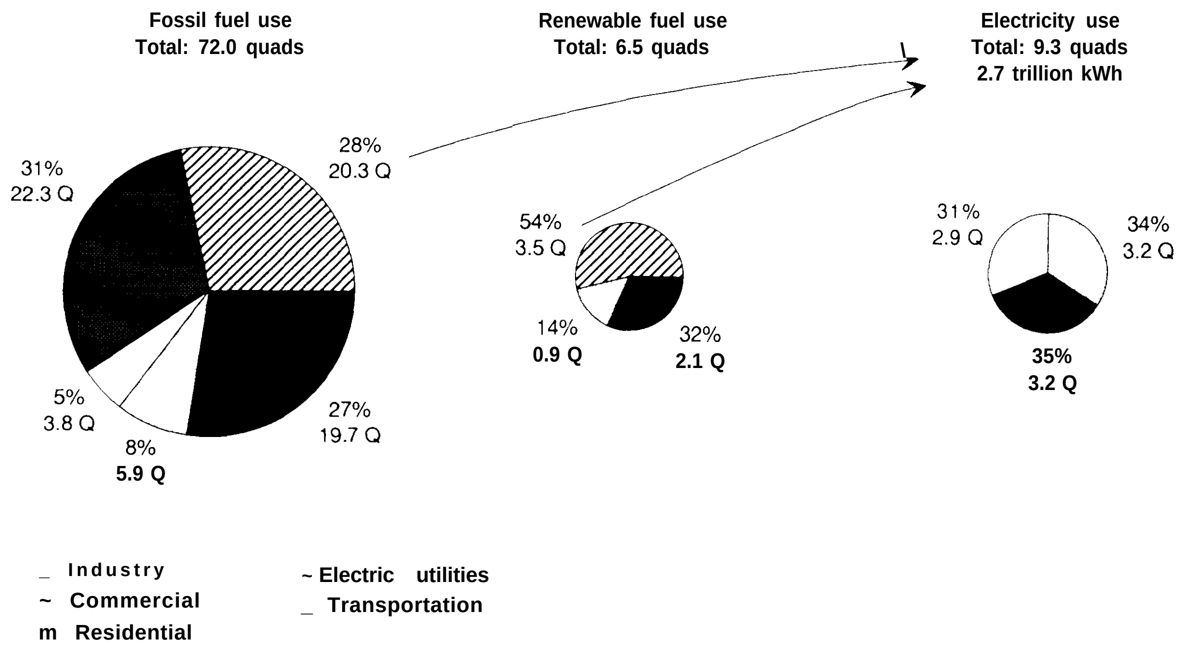
However, improvements in industrial processes and shifts away from the manufacture of energy-intensive products have kept consumption 10 percent below its 1973 peak, even though the value of industrial output has grown 30 percent since then.[1] The energy intensity of industrial production has dropped almost one-third from pre-1974 levels, reducing total U.S. energy consumption by about 11 percent.[2] Efficiency gains accounted for between one-half and two-thirds of the energy savings.[3]

1 Industrial output is measured as gross product originating (GPO), often referred to as value added. The change in GPO is calculated in inflation-adjusted (real) terms.

2 Industry's energy use in 1990 was about 10 quads less than it would have been had the intensity reductions not occurred.

3 U.S. Congress, Office of Technology Assessment, *Energy Use and the U.S. Economy, OTA-BP-E-57* (Washington,DC: U.S. Government Printing Office, June 1990). J.L. Preston, R.K. Adler, and M.A. Schippcr, U.S. Department of Energy, Energy Information Administration ''Energy Efficiency in the Manufacturing Sector, ' *Monthly Energy Review,* December 1992. G. Boyd, J.F, McDonald, M. Ross, and D.A. Hanson "Separating the Changing Composition of U.S. Manufacturing Production From Energy Efficiency Improvements: A Divisia Index Approach, "The *Energy Journal, vol. 8, No. 2,* pp. 77-96, 1987. C. Doblin, "Declining Energy Intensity in the U.S. Manufacturing Sector, " *The Energy Journal, vol.* 9, No. 2, pp. 109-135, 1988. R. Marlay, "Trends in Industrial Use of Energy, " *Science,* vol. **226,** pp. 1277-1283, 1984.

Figure 1-2—Energy Consumption by Sector, 1990



Arrows indicate fossil fuel and renewable energy sources used to generate electricity. In addition, 6.2 quads of nuclear energy was used to generate electricity. If the energy inputs to electricity generation are allocated to the sectors using the electricity: the industrial sector consumes 32.3 quads of energy (accounting for 38 percent of total U.S. energy use); the residential sector consumes 16.9 quads (20 percent); the commercial sector consumes 13.1 quads (16 percent); and the transportation sector consumes 22.3 quads (26 percent).

SOURCES: U.S. Department of Energy, Energy Information Administration, State *Energy Data Report, Consumption* Estimates 1960-1990, Report No. DOE/EIA-0214(90), May 1992; and *Annual Energy Outlook 1993,* Report No. DOE/EIA-0383(93), January 1993.

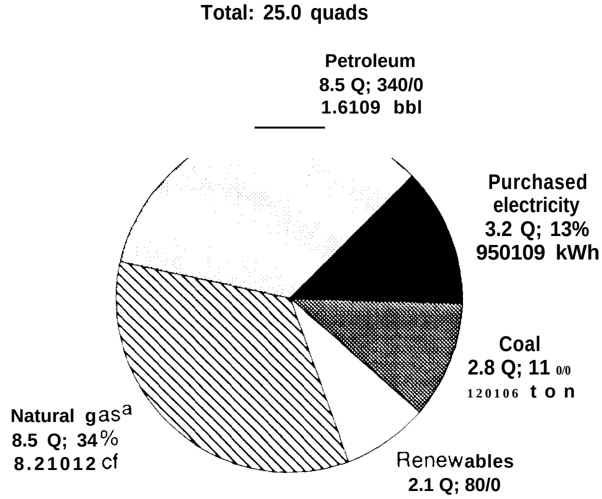
2. Many opportunities for further increasing industry's energy efficiency exist, and implementation of them would save substantial amounts of energy.

Chapter 3 describes many technologies and operating practices that could further improve the energy efficiency of industrial production. These range from generic technologies such as high-efficiency motors, cogeneration units, and computerized process controls to industry -specific technologies such as improved alkylation catalysts for petroleum refining, continuous digesters for pulp and papermaking, and ladle metallurgy for steelmaking. Efficiency gains during the late 1970s and early 1980s were achieved by installing improved technologies and instituting better operating practices in new and existing plants, and by closing inefficient facilities. As a result, the easiest and most cost-effective conservation measures, such as improved housekeeping, already have been implemented in most plants.

Implementation of the efficiency measures listed in chapter 3 would clearly yield large energy savings, but estimating how large is difficult. One technique for estimating potential energy savings is to compare the current stock of equipment and processes with the most modem, most efficient technologies available. Chapter 3 estimates that if all petroleum refining, pulp and paper, steel, aluminum, cement, and glass plants were state-of-the-art facilities, they would use 12 to 38 percent less energy than they do today.[4] The energy savings would represent about 10 percent of total industrial energy use at current production levels. Estimates derived by this method are very rough because they are based on a great amount of technical data that is difficult to obtain and keep up-to-date. Moreover, they do not address the economic viability of making every plant state-of-the-art.

Comparing the energy intensity of U.S. industry with its counterparts in other industrialized countries is an often used, but misleading, method for calculating potential energy savings. U.S. industry is more energy-intensive than most other industrialized countries, but this intensity gap is a poor representation of the ground U.S. industry could gain by implementing additional cost-effective, energy-saving technologies. Disparities in energy efficiency account for only apart of the intensity gap. The remainder is caused by differences in countries' industrial makeup and factor price levels (box l-B).

Figure I-3-industrial Energy Consumption by Fuel, 1990



[a] Natural gas includes lease and plant fuel, but excludes agricultural uses.

SOURCES: U.S. Department of Energy, Energy Information Administration, *State Energy Data Report, Consumption Estimates 1960-1990,* Report No. DOE/EIA-0214(90), May 1992; and *Annual Energy Outlook 1993,* Report No. DOE/EIA-0383(93), January 1993.

3. ***The cost-effectiveness of energy efficient technologies is the key to their implementation.***

The improved technologies and operating practices listed in chapter 3 enhance energy efficiency only if they are implemented, and they will usually be implemented only if they are cost-effective.[5] A technology or practice is cost-effective if its benefits outweigh its costs, Typical benefits include labor productivity, energy efficiency, and product quality enhancements. Costs include the initial capital outlays, costs of capital, and hidden costs, such as operator retraining and process adjustments and downtime during installation and startup. The costs and benefits depend on the performance, reliability, serviceability of the equipment and processes, and the prices of the energy, raw materials, labor, and capital.

The amount of cost-effective energy savings potential is difficult to assess, because the costs and benefits of technologies and processes are subject to many uncertainties and are often highly site-specific. Some analysts argue that industrial energy efficiency can be improved greatly because, in their view, many cost-effective improvements have not been implemented. In other words, energy efficiency can increase faster than it does in the normal course of business (Finding 4). Other analysts argue that the potential to improve energy efficiency is relatively small. This viewpoint has its roots in neoclassical economics theory that holds that industry irnple-

[4] The estimated efficiency gains from using state-of-the-art technologies are: 33 percent for petroleum refining; 17 to 32 percent for pulp and paper production; 34 to 38 percent for steel production; 16 percent for aluminum production 25 percent for cement production and 12 to 31 percent for glass production (see table 3-2). Purchased electricity was accounted for at its primary energy rate of 10,500 Btu/kWh.

[5] Technologies and practices that are not cost-effective are sometimes implemented because of legal requirements or political pressure from the community or stockholders.

Box I-B-international Comparisons of Energy Intensity

Industry is more energy intensive in the United States than in most other industrialized countries, but this does not provide direct evidence of inefficiency. The disparities in energy intensity among the countries are the result of differences in industrial structure, relative factor input prices, as well as energy efficiency.

The higher aggregate intensity of U.S. industry is partly a result of its larger proportion of heavy, energy-intensive sectors such as petroleum refining, chemicals, pulp and paper, steel, and aluminum. Such structural considerations also are valid in industry-specific comparisons. For example, Japanese pulp and paper manufacturers use less energy than U.S. companies to produce a ton of paper, in part because Japan imports, rather than produces, a greater portion of its pulp.

U.S. industry is also more energy-intensive because the prices it pays for energy generally are among the lowest in the industrialized world. Energy prices are linked to efficiency and industrial structure. Low prices increase energy intensity by: 1) acting as a disincentive to save, and 2) attracting energy-intensive industries.

The extent to which differences in structure, prices, and efficiency each explain the higher U.S. energy intensity holds important policy implications.

- Industrial structure differences do not represent an energy problem.
- Factor price *differences* indicate the potential energy savings from using taxes and other price-related measures to adjust the costs of energy, labor, and capital. These savings would result from both improvements in efficiency and shifts in industrial structure.
- Energy efficiency differences not caused by prices reveal the energy savings that would result if U.S. firms made as great a use of cost-effective, energy-saving technologies as do other countries.

Unfortunately, data is inadequate to quantify the effects of countries' industrial structures, factor prices, and efficiency on their energy intensity. international comparisons, therefore, cannot currently be used to estimate how much energy can be saved through improved efficiency. Disparities in energy intensity do little more than suggest the existence of energy-saving opportunities.

ments nearly all cost-effective measures, and that any projects not undertaken must therefore not be cost-effective.

This disagreement raises several considerations: For whom are the actions cost-effective, the corporate energy user or society as a whole? Are industrial decisions always financially rational? These matters are addressed in the Issues section of this chapter.

OTA believes that there exist technologies and practices that would boost efficiency and be cost-effective for corporate energy users to implement. In other words, industrial energy efficiency can be improved. If these cost-effective measures were implemented, annual growth in industrial energy use could be 0.3 to 0.6 percentage points slower than if current policies, practices, and trends continued.

4. ***Industry will likely become more energy efficient on its own, with or without new policy intervention.***

In the normal course of business, industry replaces worn out or obsolete equipment, processes, and operating procedures with new ones. The new technologies and methods are usually more energy efficient, though sometimes changes in raw materials quality, environmental regulations, or other factors cause them to be less so. In general, however, equipment turnover and modernization tends to increase energy efficiency.

Continuing efficiency improvements, coupled with higher growth of light industry relative to heavy industry, are expected to decrease the energy intensity of industry in coming decades. Efficiency will probably, however, increase at a slower rate than observed in the early 1980s, because many improvements have already been implemented. For these reasons, industrial energy intensity use is likely to decline about 1.2 percent annually over the next 40 years absent major changes in the energy prices and public policy.6 By comparison, intensity fell at a 3.7 percent annual rate from 1974 to 1986.

I Corporate Mechanisms for Saving Energy

5. ***Corporate concern about energy efficiency, though prominent in a few energy-intensive industries, is minimal in most businesses.***

Energy is a fairly small proportion of production costs in most industries, and so historically has played only a modest role in corporate decisionmaking. Energy accounts for 3 percent of total production costs for industry as a whole, and for 5 percent or less of production costs for 86 percent of industrial output.[7] Corporate concern about energy manifests itself when energy price increases or supply limitations are expected, but lies dormant in periods when prices and supplies are stable. Today's relatively low energy prices and stable supplies breed a general lack of corporate attention to energy. Corporate managements are typically less concerned about energy-focused projects than with "line-of-business" items, such as capacity adequacy, operational reliability and flexibility, product development and improvement, cost reduction, labor quality, supply reliability, regulatory compliance, and image enhancement. These nonenergy factors more directly affect corporations' primary goals of profitability, market share, stock price, and management stability.

Energy plays a substantially larger role in the corporate decisions of energy-intensive industries like petroleum refining, petrochemicals, pulp and paper, steel, and aluminum. These industries use large amounts of energy, both as fuel and feedstock. They are very sensitive to, and are constantly concerned with, increasing their energy efficiency, ensuring low energy prices, and minimizing their burden of complying with environmental regulations associated with energy use.

6. ***Indusrial energy use is diverse, and numerous changes are needed to yield large energy reductions.***

Industry's use of energy is heterogeneous. There are thousands of industrial processes, each depending upon a different amount and mix of energy for a variety of services (e.g., motor drive, process heat, steam and electricity generation, electrolysis, and product feedstocks). Moreover, industries vary greatly in their overall level of energy use, because of differences in industry scale and energy intensity. Four industries are particularly large energy users: petroleum refining, chemicals, primary metals-mainly steel and aluminum, and pulp and paper. They account for 68 percent of total industrial energy use and 78 percent of manufacturing energy use (figure 1-4).

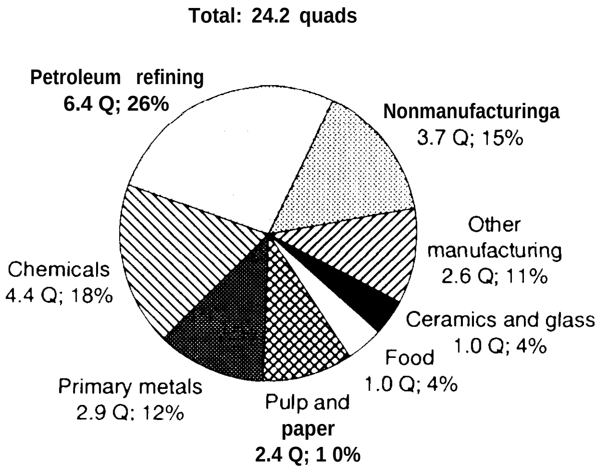
The methods available for raising energy efficiency are as varied as the ways industry uses energy, but can be grouped into four categories:

- *Operational* changes—maintenance, housekeeping, and accounting;

6 Based on the reference case scenarios in U.S. Department of Energy, Energy Information Administration, Energy Consumption *and Conservation Potential: Supporting Analysis for the National Energy Strategy*, Report No. SR/NES 9002, December 1990; and Alliance to Save Energy, American Council for an Energy-Efficient Economy, Natural Resources Defense Council, and Union of Concerned Scientists in consultation with the Tellus Institute, *America's Energy Choices: Investing in a Strong Economy and a Clean Environment: Technical Appendixes* (Cambridge, MA: Union of Concerned Scientists, 1992). These studies are discussed in chapter 2.

7 U.S. Department of Commerce, Bureau of the Census, 1990 *Annual Survey of Manufactures: Statistics for Industry Groups and Industries*, Report No. M90(AS)-1, March 1992; 1987 *Census of Agriculture: United States Summary and State Data*, Report No. AC87-A-5 1, November 1989; 1987 *Census of Mineral Industries: General Summary*, Report No. MIC87-S- 1, March 1991; 1987 *Census of Construction Industries: United Srafes Summary*, Report No. CC87-I-28, March 1990.

Figure I-4—industrial Energy Consumption by Industry Sector, 1988



a Nonmanufacturing includes natural gas used as lease and plant fuel, but excludes agricultural uses of natural gas.

SOURCES: U.S. Department of Energy, Energy Information Administration, *Manufacturing Energy Consumption Survey, Consumption of Energy 7988,* Report No. DOE/EIA-0512(88), May 1991; and *State Energy Data* Report, *Consumption Estimates 1960-1990,* Report No. DOE/EIA-0214(90), May 1992.

- *Equipment* changes-equipment improvement, equipment sizing, fuel switching, and energy management systems;
- *Process refinements and changes*-equipment integration, general automation, cogeneration, quality control, waste minimization and utilization, recycling, raw materials substitution; and
- *Product* shifts-product demand, domestic production and trade, product refinement, materials substitution, product quality and performance.

The reasons for these changes may or may not be related to energy, but energy use is affected nonetheless.

There is no single technology that can conserve large amounts of energy in all industries. A few technologies and practices (e.g., high-efficiency motors, steam and electricity cogeneration, process integration, recycling, and energy management systems) can improve energy efficiency to some extent on a broad basis, but most are applicable to a narrow range of industrial facilities.

7. ***Many projects undertaken primarily for nonenergy reasons produce energy efficiency gains as a secondary consequence.***

Modern equipment and processes tend to be more energy-efficient than older ones. Likewise, well-maintained machines are more efficient than those that have been kept up poorly. Therefore, projects that involve equipment turnover, maintenance, or adjustment often increase energy efficiency. Even projects undertaken to improve nonenergy characteristics such as production costs, product quality, and environmental compliance often have the side benefit of increasing energy efficiency.

Potentially, the greatest increase in energy efficiency may not be the result of direct efforts to reduce energy consumption but of indirectly pursuing other economic goals. This feature compensates, to some extent, for the generally low corporate concern for energy issues (Finding 5).

8. ***General capital investment plays a central role in improving energy efficiency.***

Energy efficiency can still be improved through greater attention to housekeeping and maintenance, but most of the gains that come from these management practices have already been realized. The key, therefore, to substantial increases in energy efficiency is investment in plants and equipment. Large efficiency increases come from major investments in new plants and processes. Smaller gains are obtained from retrofitting and optimizing existing facilities.

General capital investment is perhaps the most important route to increased energy efficiency, given the low corporate concern about energy (Finding 5) and the secondary efficiency gains yielded by nonenergy investments (Finding 7). In addition to yielding its own energy efficiency benefits, investment in plant and equipment can be a springboard for adopting other more energy-focused measures. Energy projects can be more cost-effective when coupled with larger projects, because the marginal costs of the extra effort are small. The Office of Technology Assessment (OTA) identified the importance of investment in

Industrial Energy Use (1983).8 That study examined energy use in the pulp and paper, petroleum refining, chemicals, and steel industries, It concluded that substantial gains in energy efficiency from technical innovation were possible, and that economic growth and the promotion of general corporate investment were the most effective ways of realizing those gains. This conclusion is still valid.

9 Policy Considerations for Saving Energy

9. The ability of electric utilities to influence industrial ***energy*** *efficiency has been increasing.*

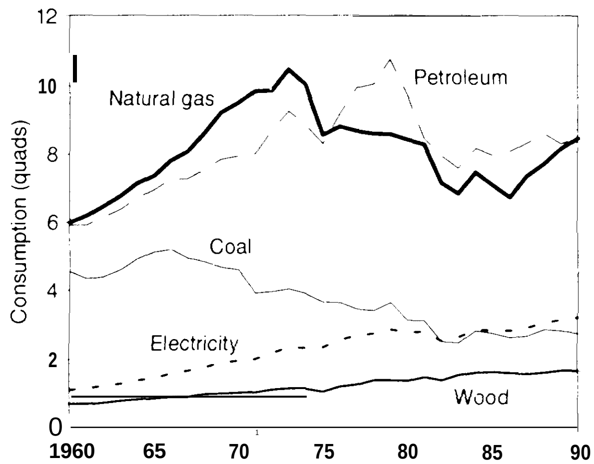
Industry is using an increasing amount of electricity, both in absolute terms and relative to other fuels (figure 1-5). Use of electric technologies is expected to continue growing at the expense of fossil-fired technologies because of air quality concerns. Existing environmental regulation, such as the Clean Air Act, will continue to push industrial processes toward decreased dependence on fossil fuel. This trend gives electric utilities and State regulators increasing influence over the energy efficiency of industrial energy users. It also reduces the pool of technologies that would be responsive to fossil fuel and clean air policies. In other words, the potential direct policy influence over industrial energy use is gradually shifting from the Federal level to the State level, where utilities are regulated.

10. Energy policy is increasingly addressing multiple objectives: energy security, environmental quality, and industrial competitiveness.

Industrial energy use is a mature policy area. There have been policy initiatives in place since the late 1970s. In the early years, the driving force behind policy was market security, keeping energy available and inexpensive. Increasingly, the policy emphasis is shifting toward environmental quality and industrial competitiveness. This trend is likely to intensify as concerns about carbon emissions from fossil fuel use grow and global trading and investment increase. These additional policy objectives raise the policy weight of energy issues. They draw greater attention to, and demand greater action from, energy policy. However, they also place extra constraints on policy, because they narrow the range of viable technical options. Furthermore, the multiple objectives require enhanced coordination among many Federal and State programs.

Energy efficiency can play a central role in this policy environment. Its strength lies in the links it forges between security, environmental, and competitiveness objectives. The links arise because energy efficient technologies and processes not only use less energy than standard technologies, but also often have lower costs and pollute less.

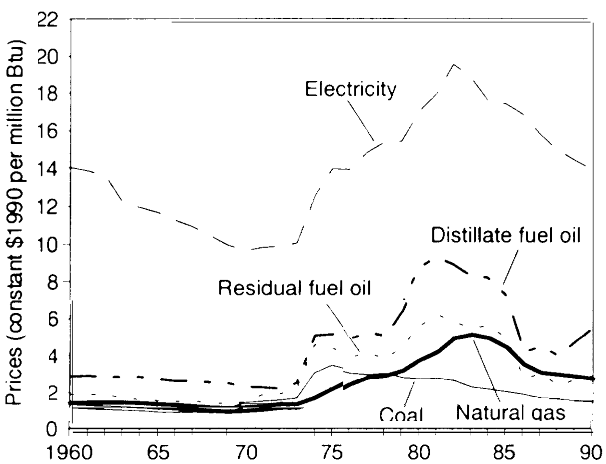
Figure 1-5--Industrial Energy Consumption by Fuel, 1960-90



SOURCES: U.S. Department of Energy, Energy Information Administration, *State Energy Data Report, Consumption Estimates 1960-1990,* Report No, DO13EIA-0214(90), May 1992; and Annual *Energy Review 1991*, Report No. DOE/EIA-0384(91), June 1992. U.S. Department of Commerce, Office of Business Analysis, "National Energy Accounts database."

[8] U.S. Congress, Office of Technology Assessment, *Industrial Energy Use, OTA-E-198* (Washington, DC: U.S. Government Printing Office, June 1983).

Figure 1-6—Industrial Energy Prices, 1960-90



1990 prices

Distillate fuel oil	$0.79/gallon	$5.68/million Btu
Residual fuel oil	$0.46/gallon	$3.10/million Btu
Natural gas	$3.03/1,000 cf	$2.94/million Btu
Coal	$40.71/short ton	$1.69/million Btu
Electricity	$0.047/kWh	$13.92/million Btu

SOURCES: U.S. Department of Energy, Energy Information Administration, *State Energy Price and Expenditure Report 1990*, Report No. DOE/EIA-0376(90), September 1992; and *Annual Energy Review 1991*, Report No. DOE/EIA-0384(91), June 1992. U.S. Department of Commerce, Office of Business Analysis, "National Energy Accounts database."

POLICY CONTEXT

I Technical and Economic Trends

Since the oil embargoes of the early 1970s, U.S. industrial energy use has evolved considerably. Fuel preferences have shifted, energy prices have risen and then fallen, and energy intensity has declined.

FUEL USE

Fossil fuels, especially petroleum, were the focus of much energy policy concern in the 1970s. Industrial consumption of fossil fuels has generally declined in the last two decades, though natural gas and petroleum still remain the two largest energy sources (figure 1-5). Petroleum use increased until 1979 and then declined until 1983. It has been rising in recent years, mostly because of its increased use as a feedstock. Overall industrial petroleum consumption, however, remains lower than in the 1970s by several measures: in total barrels used, as a percentage of total industrial energy use, and as a share of total U.S. petroleum use.[9] Natural gas use declined in most years until 1986 and has been increasing since. Coal consumption fell steadily until the mid-1980s and has been fairly level since. Electricity use rose steadily until 1979, fluctuated until 1988, and has been rising since. It is now a larger source of industrial energy use than coal. Wood, waste energy, and alcohol fuels use rose steadily until 1985 and have been fairly level since. Biofuels are still, however, much less used than traditional fuels.

9

PRICES AND SUPPLIES

Energy prices and supply availability were also of great policy concern during this period. Prices rose throughout much of the 1970s, reaching historic high levels in the late 1970s and early 1980s (figure 1-6). They then declined during the mid-1980s, offsetting much of the rise in the previous decade. From 1982 to 1990, prices fell 47 percent for oil, 43 percent for natural gas, 38 percent for coal, and 29 percent for electricity.[10] The 1991 Persian Gulf War prompted forecasters to reexamine energy price projections, especially those for oil. Many forecasters, though, continue to predict modest increases in energy prices.

Energy supplies were generally stable throughout most of the 1980s. Markets remained calm except for a brief period during the 1991 Gulf war.

9 In 1990, industrial consumption of petroleum was approximately 8.5 quads, representing 33.9 percent of total industrial energy use and 25.3 percent of U.S. petroleum use. In 1979, the peak year for industrial consumption of use, consumption was approximately 10.8 quads, representing 39.5 percent of total industrial energy use and 29.0 percent of U.S. petroleum use.

10 N references t. pfice Changm in this report are calculated in inflation-adjusted (real) t~s.

ENERGY INTENSITY

Prior to the early 1970s, the energy intensity of industrial production remained relatively steady (figure l-l). Growth in energy use was directly coupled with economic growth. From 1974 to 1985, energy intensity declined by 30 percent and the old relationship between industrial energy consumption and economic growth was broken. This "delinking" of energy use and growth was the result of: 1) improvements in energy efficiency, and 2) shifts in industrial structure caused by technical and economic changes.

Energy efficiency increases came from general housekeeping, regular maintenance, energy management systems, equipment changes, and process refinements and changes. These operational changes were frost prompted by high energy prices and supply instabilities, but were continued because of environmental mandates and cost-competitiveness challenges.

Shifts in industrial structure have changed the market basket of goods and services produced in the United States. For example, the production of steel and petrochemicals has declined relative to that of computers and financial services. The transition has been the result of changing product demand patterns, changing production networks, and the increasing globalization of business.[11] It has had a significant effect on industrial energy intensity, because industry's component sectors vary in their energy intensity by about a factor of 200.

Studies have shown that roughly one-third to one-half of the decline in manufacturings energy intensity between the mid-1970s and mid-1980s can be attributed to a shift in the mix of output, with ''smokestack' industries declining and lighter manufacturing industries gaining.[12] The remaining portion of the intensity decline can be attributed to energy efficiency improvements.

Since 1986, the decreases in U.S. energy intensity have virtually stopped. This suggests that energy consumption has once again become directly coupled with industrial output, albeit at a lower level than existed before 1974. The pool of potential efficiency-enhancing measures has decreased, because many improvements have already been implemented.

Nevertheless, the frontier of energy efficiency can still be advanced, despite the low and generally stable energy prices. Past improvements have "primed the pump" for further technological innovation. Considerable future gains in efficiency are possible with existing technology, and more substantial gains are likely with technologies currently under development.

Q Institutional Trends

Utilities are playing an increasing role in energy conservation because of the growing need for effective load management.[13] Electric utilities have used load control measures for more than 50 years, but interest in these measures increased significantly during the turbulent energy markets of the 1970s and 1980s. Rising construction costs, troublesome nuclear programs, cost disallowances, wholesale rate hikes, and new environmental requirements have prompted many utilities and commissions to employ integrated resource planning (IRP) methods and demand-side management (DSM) programs. Using DSM techniques, such as customer education, alternative pricing, and equipment rebates, utilities encourage their customers to conserve energy and shift

[11] OTA tis analyzed the structural changes in the U.S. economy and their implications for energy use in: *Energy Use in the U.S. Economy*, op. cit., footnote 3 and U.S. Congress, Office of Technology Assessment, *Technology and the Amen"can Economic Transition: Choices for the Future, OTA-TET-283* (Washington, DC: U.S. Government Printing Office, May 1988).

[12] Supra footnote 3.

[13] The role of electric utility programs is covered in U.S. Congress, Office of Technology Assessment, *Energy Use: Challenges and Opportunitiesfor Electric Utilities*, OTA-E-561 (Washington DC: U.S. Government Printing Office, in press).

usage to off-peak periods.[14] These efforts help utilities manage their load and reduces the need for new generating capacity. Energy efficiency advocates hold that these strategies are often cheaper for rate payers, and better for the environment and society, than building new power plants. Some industrial companies worry that DSM programs are costlier than the energy they save, and will thus lead to higher electricity rates.

Public utilities are well-positioned to promote the adoption of more energy efficient technologies. Their integrated operations, technical expertise, established ties to customers, and familiarity with customer energy use equip them with the technical skill, marketing tools, and information to identify opportunities to save energy. Their special status as regulated public utilities offers access to capital, a relatively secure cash flow, and a concomitant responsibility to provide cost-effective and reliable service to their customers. This status also makes them attractive targets for policy initiatives in pursuing energy efficiency.[15]

~ Political Trends

Energy policy concerns have expanded beyond the traditional issues of prices and availability to include issues of environmental consequences and industrial competitiveness. Acid rain, nuclear waste, carbon dioxide (CO_2) emissions, and other local and global environmental topics have supplanted security, in many instances, as the central issue in energy policy. Energy efficiency is an important policy option in this new multi-objective environment. Energy efficient technologies and processes use less energy, have lower costs, and often pollute less than standard technologies; furthering the three objectives of energy security, environmental quality, and industrial competitiveness.

A related development is the growing interest in using market mechanisms and other alternative approaches to deal with environmental problems. As U.S. environmental compliance costs have risen, Congress has come under increasing pressure to move away from traditional regulatory programs to newer and more economically efficient approaches. Alternatives to, or augmentation of, traditional command and control policy instruments can take many forms. These include ‘‘market-based’ or economic approaches, such as marketable pollution permits or emissions fees. Information programs are another set of alternatives. Even among what is traditionally termed “command and control, ” there is a wide variety of alternative approaches, including technology-based standards, design standards, end-of-pipe performance-based standards, and use restrictions. Implementation of these sorts of approaches to environmental problems would have direct and indirect impacts on industrial energy use.[16]

I Stakeholders and Interested Parties

Many individuals and organizations are interested in the issue of industrial energy use and efficiency. First and foremost are the industrial companies themselves. Their profitability depends in large part on keeping production costs low, which means being efficient with respect to energy and all other factor inputs. Attention to energy efficiency varies depending on company size and nature of business. Companies in the process industries and the materials-production sector, where energy is a large cost factor, pay close attention to their energy situation. Large companies in these industries often conduct in-house research and development to come up

14 Electric power Research Institute, *Demand Side Management, Volume 5: Industrial Markets and Programs,* EPRI EA/EM-3597 (Palo Alto, CA: Electric Power Research Institute, March 1988).

15 OTA, *Energy Use: Challenges and Opportunities for Electric Utilities,* op. cit., footnote 13.

16 OTA is assessing the effectiveness Of coremand-and-control regulations and the appropriateness of alternative policy instruments for handling various pollution problems in its study entitled New *Approaches to Environmental Regulation.*

with processes that are more efficient than their rivals. In less energy-intensive industries, concern about energy use is generally low.

Companies have numerous trade associations that provide them with technical support and represent their interests to the government and the public. Trade associations representing energy-intensive industries actively monitor energy policy developments. Among these are: the American Iron and Steel Institute, the Aluminum Association Inc., the Chemical Manufacturers Association, the American Petroleum Institute, the American Paper Institute Inc., and the Primary Glass Manufacturers Council. There is also a group, the Electricity Consumers Resource Council (ELCON), that focuses specifically on the energy interests of large industrial electricity users. ELCON works to curb electricity rate increases for industrial companies. It conducts research on actions affecting electricity rates and promotes its findings to suppliers, regulators, and State and Federal Government bodies. Energy-intensive companies and energy-producing companies are also represented by Global Climate Coalition. This association of business trade associations and private companies was formed to coordinate the active involvement of U.S. business in the scientific and policy debates concerning global climate change issues.

Electric and gas utilities, and the organizations associated with them, play a large role in industrial energy use. Utilities supply a large portion of the energy used by industry. In addition, many of them actively promote energy conservation. Public utility commissions (PUCs) set energy price rates and establish the incentives that encourage or discourage utilities' DSM efforts. Another group, interveners, represents the interests of particular groups at PUC ratemaking hearings. Among them are those who act on behalf of industrial energy users. There are others that represent environmental constituencies.

Utilities have two research organizations to assist them with their programs, the Electric Power Research Institute (EPRI) and the Gas Research Institute (GRI). These organizations conduct research into new or improved technologies that enhance the energy efficiency, cost-effectiveness, product quality, and environmental cleanliness of industrial processes. EPRI, which budgeted $9.2 million for industrial research in 1993, has programs researching technologies to enhance the productivity, product quality, and waste and water treatment characteristics of materials production and fabrication industries, process industries, and municipal services.[17] GRI, which budgeted $21.1 million for industrial research in 1993, has efforts aimed at industrial combustion technologies; processing equipment for the metals, glass, brick, cement, ceramics, and advanced materials industries; and sensor and control systems for industrial processes.[18] These organizations also assist their member utilities with design and implementation of DSM programs.

Environmental advocates are also involved. Among those who focus on energy use and its implications for the environment and the economy are: the Alliance to Save Energy (ASE), the American Council for an Energy-Efficient Economy (ACEEE), the Rocky Mountain Institute (RMI), and the Natural Resources Defense Council (NRDC). These organizations conduct research, disseminate information, and promote policies to encourage the use of energy efficient equipment and processes.

The Federal Government has several programs to improve the energy efficiency of the Nation's industrial sector. The lead agency in this effort is the U.S. Department of Energy (DOE), in particular the Office of Industrial Technologies of the Office of the Assistant Secretary for Energy

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17 Electric Power Research Institute, *Research, Development, and Delivery Plan 199.? -1997,* January 1993.

18 Gas Research Institute, *1993-1996 Research and Development Plan and 1993 Research and Development program,* April 1992.

Efficiency and Renewable Energy.[19] The Office of Industrial Technologies administers an auditing program for small-and medium-sized manufacturers, and sponsors cost-shared research at university and government laboratories into technologies that are energy-efficient, fuel-flexible, waste-minimizing, and waste-utilizing. DOE's Energy Information Administration (EIA) has responsibility for gathering and analyzing data on industrial energy consumption. DOE and the U.S. Environmental Protection Agency (EPA) cosponsor a program to demonstrate energy efficient technologies to potential industrial users. EPA also runs a program that publicly recognizes companies that install energy efficient lighting in their offices and plants. The Bonneville Power Administration (BPA), a Federal power-marketing authority, has a program to improve the electricity efficiency of aluminum producers in its service area in the Pacific Northwest.

Many States also have programs to provide technical assistance to companies. There are information programs to help industrial companies keep abreast of developments in energy efficiency and pollution prevention technologies. In addition, some States have agencies that research and develop energy efficient equipment and processes. These agencies are typically funded by utilities or State revenues or both, and they work closely with utilities, regulators, and State officials to target research areas most relevant to the State's needs.

Current Federal Policy

Many Federal energy initiatives of the late 1970s dealt with industrial energy use. Among them were:

- the Energy Policy and Conservation Act (EPCA), Public Law 94-163;
- the National Energy Conservation Policy Act (NECPA), Public Law 95-619;
- the Public Utility Regulatory Policies Act of 1978 (PURPA), Public Law 95-617;
- the Energy Tax Act of 1978, Public Law 95-618; and
- the Powerplant and Industrial Fuel Use Act of 1978, Public Law 95-620.

These policies focused on mitigating the economic and strategic effects of the oil shocks. Some programs-like energy-auditing, nonutility power generation rules, and conservation research efforts—still exist. Others, such as energy conservation targets, investment tax credits, and boiler-fuel restrictions, have been discontinued.

Between 1979 and 1992, there were few new policy initiatives specifically addressing industrial energy use. Two laws from this period, the Steel and Aluminum Energy Conservation and Technology Competitiveness Act of 1988, Public Law 100-680, and the Department of Energy Metal Casting Competitiveness Research Act of 1990, Public Law 101-425, sought to enhance the competitiveness of specific industries by focusing on Federal energy research, development, and demonstration (RD&D) efforts.

The next major energy law that contained industrial initiatives was the Energy Policy Act of 1992 (EPACT), Public Law 102-486. Among this legislation's provisions that focus on industrial energy use are those for: motor standards, trade association-based targeting, utility planning and conservation, and greenhouse-gas emissions tracking (box 1-C). It is estimated that the industrial energy savings from this law will be about 0.25 quads per year by 2000 and 0.77 quads per year by 2010.[20]

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19 The Office of Energy Efficiency and Renewable Energy was renamed from the Office of Conservation and Renewable Energy in early 1993.

20 Based on estimates from H. Geller, S. Nadel, and M. Hopkins, *Energy Savings Estimates From the Energy Efficiency provisions in the Energy Policy Act of 1992* (Washington DC: American Council for an Energy Efficient-Economy and Alliance to Save Energy, November 1992).

Box I-C-Industrial Energy Use Provisions of the Energy Policy Act of 1992

Technology research, development, demonstration, and commercial application (Sections 2101,2103, 2105,2106,2107,2108, 2201, and 2202)

The Department of Energy is directed to conduct a 5-year program of cost-shared RD&D and commercial application activities that: 1) accelerate development of technologies that will increase energy efficiency and improve productivity, 2) increase the use of renewable energy, and 3) reduce environmental impacts in the industrial sector. Such activities may be carried out for any industrial technology, but pulp and paper production processes, electric drives, and pollution-prevention technologies and processes are specified outright. Funding is extended for existing programs in the steel, aluminum, and metal-casting industries. in addition, DOE is authorized to undertake joint ventures to encourage the commercialization of technologies developed under its RD&D and commercial application programs. DOE is also directed to conduct a 5-year program including field demonstrations to foster the commercialization of advanced manufacturing technologies and techniques for processing, synthesizing, fabricating, and manufacturing advanced materials. The goal of these programs is to generally improve economic growth, competitiveness, and energy efficiency.

Motor standards, testing, and labeling programs (Section 122)

Minimum energy-efficiency standards and testing procedures are specified for motors sold in the United States after October 1997. The standards and tests apply to general purpose motors from 1 to 200 horsepower. Depending on motor size, the standards are 1 to 6 percentage points higher than the average efficiency of standard motors and roughly equivalent to the least efficient models of high-efficiency motors. DOE is charged with prescribing labeiing rules that indicate the efficiency of motors on their permanent nameplates and in marketing materials, such as equipment catalogs.

Reporting, voluntary targeting, and public recognition (Sections 171 and 131)

The frequency of DOE's data collection on industrial energy use (the Manufacturing Energy Consumption Survey) is raised from a triennial basis to at least once every 2 years. Collection of data on nonpurchased energy sources such as solar, wind, biomass, geothermal, waste byproducts, and cogeneration is to be improved. Also, the surveys are to be expanded in order to improve the evaluation of the effectiveness of energy efficiency policies and programs. The expanded surveys are to include questions regarding participation in government and utility-conservation programs and the use of energy efficiency and load-management programs.

DOE is authorized to make grants of up to $250,000 to industrial associations for support of workshops, training seminars, handbooks, newsletters, databases, or other such activities to improve industrial energy efficiency. To be eligible for these grants, an industry association must establish a voluntary energy-efficiency improvement target program. DOE is instructed to establish an awards program to recognize those industry associations or individual companies that have significantly improved their energy efficiency. DOE must report to Congress regarding the costs and benefits of establishing mandatory reporting and voluntary targets for energy-intensive industries.

Utility efforts that encourage industrial efficiency (Sections 132 and 1912)

DOE is authorized to make grants to States for promoting the use of energy efficient technologies in industry, training individuals in conducting process-oriented industrial assessments, and assisting utilities in developing, testing, and evaluating industrial energy-efficiency technologies and programs. To be eligible for such grants, States must have considered implementing Federal standards with respect to integrated resources planning (IRP) and demand-side management (DSM). in addition, the States must encourage utilities to provide companies with process-oriented assessments and with financial incentives for implementing energy efficiency improvements. The assessments are to be used to identify opportunities in industry for improving energy efficiency, reducing

(Continued on next page)

Box I-C-Industrial Energy Use Provisions of the Energy Policy Act of 1992-(Continued)

environmental impact, increasing competitiveness, enhancing product quality, and using renewable energy sources in production processes and in lighting, heating, ventilation, air conditioning, and associated building services. The Internal Revenue Code is amended to exclude from gross income 40 to 65 percent of the value of subsidies provided by utilities to industrial customers for the purchase or installation of energy-conservation measures.

Auditing and insulation (Section 133)

DOE is to establish voluntary guidelines for the conduct of energy efficiency audits and the installation of insulation in industrial facilities.

Electricity transmission access (Sections 721 and 722)

The Federal Energy Regulatory Commission is authorized to order utilities to wheel wholesale power for electricity generators when it is in the public interest. Wholesale wheeling is the activity of moving electric power from a generator to a utility via the transmission system of another utility. Access to transmission services allows cogenerating facilities to sell their power outside of their utilities' service area. This makes cogeneration more attractive, because the excess power can be sold to utilities offering higher prices than those of the local utility.

Greenhouse policy planning (Sections 1604 and 1605)

DOE must report to Congress on alternative policy mechanisms for reducing the generation of greenhouse gases. Among the mechanisms to be considered are Federal standards for energy efficiency for industrial processes. The policy assessment must include a short-run and long-run analysis of the social, economic, energy, environmental, competitive, labor, and agricultural costs and benefits of such policies. DOE must also develop a voluntary reporting system to track greenhouse-gas emissions and their reductions. Reported reductions could potentially be credited against any future mandated cuts.

SOURCE: Energy Policy Act of 1992, U.S. Houea of Representatives, Conference Report to aooompany H.R. 776 Report 102-101S, Oct. 5, 1992.

Most programs that focus on industrial energy use are administered by DOE. Other agencies such as EPA are also involved, but to a lesser extent.

ENERGY AUDITING AND TECHNICAL ASSISTANCE

Energy audits conducted by outside experts are a direct way of informing companies, especially smaller ones, about energy-saving techniques. The Federal Government provides free audits to small and medium-sized companies through DOE's Energy Analysis and Diagnostic Centers (EADCS) located at 25 universities. Faculty and students perform energy audits and make energy-saving recommendations to the manufacturers. The program is funded at $3.9 million (FY 1993).[21] From its initiation in 1976 until 1992, about 4,100 energy audits were performed in 37 States. These audits have yielded energy savings of 77 trillion Btu and cost savings of $419 million at a cumulative cost to the Federal Government of $18 million.

EPACT extends DOE's role in auditing. The act requires the agency to establish voluntary guidelines for the conduct of energy efficiency audits and the installation of insulation in industrial facilities.

The Federal Government also offer companies technical assistance through the seven National Institute of Standards and Technology (NIST) Manufacturing Technology Centers (MTCs). These

21 U.S. Department of Energy, *Congressional Budget Request, FY 1994, Volume 4*, April 1993.

centers work directly with small fins, both on-site and in central demonstration facilities, to help improve their competitiveness through use of advanced technologies and techniques. Other Federal technology extension services and information programs include: the National Appropriate Technology Assistance Service in DOE; the Extension Service in the Department of Agriculture; and various pollution-prevention hotlines, databases, and publications in EPA.

REPORTING AND TARGETING

Energy-use reporting and targeting programs encourage energy efficiency by giving it a higher profile in industrial firms. A program in which large energy-intensive manufacturers reported their annual energy use to the government and agreed to voluntarily improve their energy efficiency to specified targets was established by EPCA in 1975 and expanded by NECPA in 1978.[22] Companies reported the energy data to their trade associations, which compiled it and then sent it on to the government. The program was begun in 1977 and eliminated in 1986.[23] The program's data-collection effort was reestablished in the form of the Manufacturing Energy Consumption Survey (MECS). Since 1985, MECS data has been collected every 3 years. Unlike the earlier program, companies report the data directly to DOE.

EPACT raises the frequency of MECS to at least once every 2 years. It also expands the scope of data collection in order to improve coverage of renewable fuels and to enable better evaluation of energy efficiency policies and programs. The act authorizes grants to be made to industrial associations that establish voluntary energy-efficiency improvement target programs for their members. The grants are for support of workshops, training seminars, handbooks, newsletters, databases, or other such activities to improve industrial energy efficiency. The act also requires DOE to develop a voluntary reporting system to track greenhouse-gas emissions and their reductions. Reported reductions could potentially be credited against any future mandated cuts.

PUBLIC RECOGNITION

EPA's Green Lights program, begun in January 1991, enlists major corporations to install more energy efficient lighting in their facilities in exchange for technical assistance and public recognition. Program participants voluntarily agree to retrofit lighting in at least 90 percent of the total square footage of their U.S. facilities within 5 years of signing the Green Lights agreement. Retrofits are required only in cases where they will be cost-effective and will not compromise lighting quality. As of September 1992, over 500 companies had enrolled in the program.

EPACT instructs DOE, as part of its industry association grants program, to establish an awards program to recognize those industry associations or individual companies that have significantly improved their energy efficiency.

EQUIPMENT STANDARDS, TESTING, AND LABELING

In 1978, NECPA instructed DOE to report to Congress on the practicability and effects of minimum energy efficiency standards for electric motors. Early drafts, written during the Carter administration, showed that motor efficiency standards were likely to be beneficial. The final report, written during the Reagan administration, concluded that the potential benefits would be small and did not recommend standards. EPACT mandates minimum efficiency standards for gen-

22A similar program had been developed in 1974 by the U.S. Department of Commerce. It was a voluntary program that encouraged manufacturers to: obtain the commitment of top management to energy conservation; undertake a thorough energy audit; develop voluntary conservation goals and programs designed to meet them; and conduct energy awareness campaigns aimed at employees, suppliers, customers, and the community at large.

23 Two trade associations, the American Paper Institute and the Chemical Manufacturers Association, have continued collecting the energy data for their own purposes.

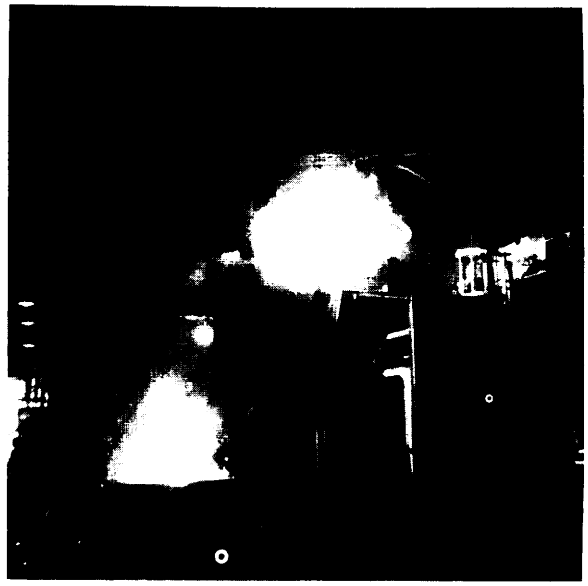
eral purpose motors sold in the United States after October 1997.

TECHNOLOGY RESEARCH, DEVELOPMENT, AND DEMONSTRATION

Industrial energy efficiency can be improved by implementing current state-of-the-art technologies, but continuous advancement requires a constant flow of new and improved technologies. Many organizations, including technology-using companies, equipment suppliers, utility groups, and government and academic laboratories conduct RD&D to advance production technologies and processes.

The Federal Government's principal RD&D directed at the energy use of industrial technologies is administered by the DOE Office of Industrial Technologies. The stated mission of the effort is to: 1) increase energy end-use efficiency, promote renewable-energy use in industrial applications, and improve industrial productivity; 2) reduce industrial and municipal waste-stream volume and the associated environmental impact; and 3) identify, support, and transfer the results of its research. Potential projects are identified in collaboration with private industry, and selected for funding based on their ability to improve energy efficiency and fuel flexibility in industry. Priority is given to technologies not being aggressively pursued by the private sector. The research is carried out under contract with university and government laboratories, or cost-shared contracts with private industry. DOE has a technology-transfer role, but much of the information dissemination and technology promotion is actually left to the organizations that perform the research.

In FY 1993, DOE's industrial RD&D program was appropriated at$112.8 million for work in the areas of industrial waste, municipal solid waste,



U.S. DEPARTMENT OF ENERGY

Tapping from pilot-scale research smelter near Pittsburgh. The direct steelmaking program is funded by the American Iron and Steel Institute and the U.S. Department of Energy,

cogeneration, materials processing, separation techniques, sensors and controls, bioprocessing, enabling materials, improved combustion efficiency, and process heating and cooling (see appendix A for details) .24 A funding increase of 22 percent has been requested for FY 1994. Part of the program, the $17.9 million (FY 1993) "Metals Initiative" directed at technologies for the steel, aluminum, and metals-casting industries, was explicitly mandated by Congress.25 DOE estimates that its research efforts in industrial technologies result in energy savings of 80 trillion Btu per year; competitiveness benefits of 8,300 person-years of increased employment and $540 million of increased capital productivity; and pollutant emissions reductions of 6 million tons of particulate, 32 million tons of sulfur

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24 U.S. Department of Energy, op. cit., footnote 21.

25 These programs are mandated by the "Joint Resolution making further continuing appropriations for the fiscal year 1986' (Public Law 99-190), the Steel and Aluminum Energy Conservation and Technology Competitiveness Act of 1988 (Public Law 100-680), the Department of Energy Metal Casting Competitiveness Research Act of 1990 (Public Law 101425), and the Department of the Interior and Related Agencies Appropriations Act, 1991 (Public Law 101-512).

26 U.S. Department of Energy, Office of Industrial Technologies, *Summary of Program Impacts*, December 1992.

dioxide, 17 million tons of nitrogen oxides, and 7 billion tons of carbon dioxide (1991).[26]

From FY 1976 through 1992, DOE spent $854 million (current dollars) for industrial RD&D. The Department estimates that the cumulative energy savings of more than 35 completed industrial projects have been approximately 419 trillion Btu, representing a net production cost savings for industry of $1.15 billion (current dollars). DOE expects these projects to save almost 1.1 quads of energy annually by 2010, The more successful industrial energy-saving technologies have been: coal-fired steam turbine cogeneration units, improved diesel engines, boiler workshops, irrigation systems, coil-coating ovens, computer-controlled ovens, high-temperature ceramic recuperators, and slow-speed diesel cogeneration units.[27]

EPACT specifically extends DOE's industrial RD&D responsibilities to pulp and paper production processes, electric drives, pollution-prevention technologies and processes, advanced manufacturing, and advanced materials. It also authorizes DOE to undertake joint ventures to help commercialize the technologies that it has supported.

Another federally-funded technology demonstration effort is the National Industrial Competitiveness through efficiency: Energy, Environment, and Economics (NICE^3) program. This grant program, administered by DOE and EPA, supports new technologies that can significantly reduce high-volume wastes, conserve energy, and improve cost-competitiveness in industry. It is designed to demonstrate the new processes and equipment, identify barriers to industrial pollution-prevention techniques, and develop and implement strategies to overcome these barriers. The costs of the demonstration projects are shared by industry, States, and the NICE^3 office. NICE^3 was funded at $1.4 million in FY 1992 by DOE and EPA.

EPA requested funding in 1993 to establish a pollution-prevention demonstration program called Waste Reduction Innovative Technology Evaluation (WRITE) .28 These demonstration projects will be carried out to encourage the transfer of technical information among industries.

NONUTILITY POWER GENERATION

Cogeneration, the simultaneous production of both electricity and steam, usually consumes less fuel than would be needed to produce both separately. Many companies that produce and use steam find it profitable to cogenerate and to sell any unneeded power. PURPA, enacted in 1978, encourages cogeneration by mandating that utilities purchase the excess electricity at rates set by the avoided cost of procuring additional power. Prior to PURPA, companies that sold cogenerated electricity to another user were subject to burdensome public utility regulations.

EPACT further encourages cogeneration by increasing electricity transmission access. This will enable cogenerators to sell their power to utilities offering prices higher than those of the local utility.

UTILITY EFFORTS ENCOURAGING INDUSTRIAL ENERGY EFFICIENCY

EPACT authorizes grants to be made to States that encourage their utilities to adopt Federal standards regarding IRP and DSM. The utilities must provide companies with process-oriented assessments and with financial incentives for implementing energy efficiency improvements. The Federal grants are for promoting the use of energy efficient technologies in industry, training individuals in conducting process-oriented industrial assessments, and assisting utilities in devel-

27 Ibid.

28 U.S. Environmental Protection Agency, *Fiscal Year 1993 Justification of Appropriation Estimates for Committee on Appropn"ations*, Report No. PM-225, 1992.

oping, testing, and evaluating industrial energy-efficiency technologies and programs.

The act also allows industrial customers to exclude part of the value of utility-provided, energy conservation subsidies from their gross income for tax purposes. This make the subsidies more powerful motivating tools, because companies can retain their full benefit.

H Goals

Energy issues have matured significantly during the last two decades. Early on, the goal of U.S. energy policy was confined to market security—keeping energy available and inexpensive. Policy dealt primarily with foreign petroleum dependence and regulation of the electricity and natural gas markets. Later, energy policy came to encompass two additional goals, environmental quality and economic competitiveness. Current and future energy policy interests include slowing the increase of oil imports, holding down energy costs, improving the international competitiveness of U.S. goods and services, and addressing environmental concerns of acid rain, urban ozone, and global warming.

Many studies by OTA and others have identified energy efficiency as a critical cornerstone to an energy policy framework that addresses these various issues. Even though this central role for energy conservation and efficiency has been identified, most of the Federal Government's energy efforts have focused on improving energy supplies. Only about 7 percent of DOE's nondefense appropriations are channeled toward conservation and efficiency activities.[29]

Energy efficiency can be raised through policies that prompt industry to conserve fossil fuels and electricity, to cogenerate electricity, and to reuse products and recycle materials. These same policies, plus those that induce industry to change the types of energy it uses (i.e., shifts among fossil fuels and from fossil fuels to electricity or renewable), can be used to reduce $C0_2$ emissions. In some instances, the policies can meet the objectives of economic vitality, environmental quality, and national security simultaneously. In other cases, proposals may -pursue conflicting goals. For example, increased reliance on coal could reduce oil import dependence, but exacerbate problems of air pollution and global climate change. It is necessary, therefore, to be clear about the role energy policy is to play in meeting these goals.

MARKET SECURITY

U.S. dependence on foreign supplies of petroleum has been a national security concern for decades. Curtailing industrial use of petroleum through conservation, fuel switching, and recycling are several means to enhance energy security.

Industry uses petroleum for two principal purposes, as a fuel for process heat and steam generation, and as a feedstock for petrochemicals, lubricants, solvents, waxes, and asphalt. Roughly the same amount of petroleum is used for each of these two purposes, but feedstock consumption appears to be growing, while fuel use seems to be remaining fairly steady. Reduction of fuel use is amenable to conservation and fuel-switching efforts. Feedstock use reduction, which is much less tractable by these strategies, is best approached through recycling of motor oil, plastics, and other petroleum-based products and through research to find suitable nonpetroleum substitutes.

ENVIRONMENTAL QUALITY

Air, land, and water degradation occurs at various points in the energy cycle. First, there are the problems associated with producing and transporting energy, and disposing of nonfuel energy products. Among the concerns are: oil spills; nuclear accidents; natural gas explosions; harmful electromagnetic fields; and land, river,

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29 Based on FY 1977 to 1991 data compiled by the Congressional Research Service. F. J. Sissine, Congressional Research Service, Library of Congress, *Energy Conservation: Technical Efficiency and Program Electiveness,* CRS Issue Brief IB85 130, Oct. 28, 1992.

and wildlife disturbances. Second, there are the air quality problems associated with the burning of fossil fuels. Here the concerns are acid rain, urban ozone, and $C0_2$ emissions.[30] Conservation, recycling, and fuel switching can play important roles in reducing both types of adverse environmental effects.

Energy conservation is the most straightforward of the strategies. It can alleviate environmental problems at all points in the energy cycle. Recycling can be used to mitigate problems with the disposal of nonfuel energy products. Fuel switching involves the most tradeoffs. In the area of energy production and transport, fuel switching merely substitutes one environmental problem for another. In the area of air quality, the goal of a fuel-switching strategy would be to shift from the dirtier, carbon-intensive fuels (e.g., coal and petroleum) toward the less intensive, cleaner energy sources (e.g., natural gas and renewable). One type of energy switching, electrification, requires special attention. Electricity is always cleaner than other energy forms at the point where it is used. However, it may or may not be cleaner from a wider perspective, because of inefficiencies involved in fossil fuel-based electricity generation.

ECONOMIC COMPETITIVENESS

U.S. industrial competitiveness depends on domestic companies holding down their production costs and improving the quality of their products. Energy efficiency improvements and energy price modifications can help boost competitiveness by reducing costs.

Companies can lower their costs by using efficient equipment, processes, and practices to conserve energy. In some cases, efficient technologies can have additional benefits, such as lower labor or environmental costs or better product quality.

Businesses can also reduce their costs by seeking out low-priced sources of energy. However, from a public policy perspective, enhancing industrial competitiveness by lowering or raising energy prices is particularly tricky. On the one hand, low energy prices translate directly into low energy costs. This helps competitiveness in the short term. On the other hand, high energy prices act indirectly to hold energy costs down by encouraging conservation and energy efficiency. This can advance competitiveness in the long run, if the costs can be successfully held in check through efficiency gains. High energy prices also *further* other goals of energy security and environmental quality.

MULTIPLE OBJECTIVES

Having multiple goals is itself an important aspect of energy policy. Linking the goals of energy security, environmental quality, and economic competitiveness gives great weight to energy policy in general and efficiency programs in particular. This positive characteristic is diminished somewhat, though, by the additional policy problems and constraints that come with multiple objectives. Program formulation is more challenging, because more criteria must be met. Program evaluation is more difficult, because there is no single measure of success. Moreover, the need for program coordination becomes vital. There must be good coordination among all of the programs and all of the decisionmakers in the relevant policy areas. This requires resolution of jurisdictional issues among congressional committees on energy, commerce, science, technology, environment, and finance. It also requires coordination and cooperation among executive agencies such as DOE, EPA, and the U.S. Department of Commerce. Without proper attention, these coordination challenges engender inaction.

[30] Note that feedstock uses of fossil fuels do not contribute to these air quality problems unless the products are later incinerated.

1 Issues

Industrial energy efficiency is enhanced by any cost-effective action, regardless of purpose, that reduces energy use per unit of output. The degree to which various policy options foster such actions in an equitable and effective manner turns on several fundamental controversial issues. For whom should the actions be cost-effective, the corporate energy user or society as a whole? Are there industrial inefficiencies that need to be corrected? Are industrial decisions always financially rational? What effects do energy prices have on efficiency?

COST-EFFECTIVE FOR WHOM?

The cost-effectiveness of a potential efficiency measure depends on which costs and benefits are considered. From the corporate perspective, the only relevant costs and benefits are those borne by the energy user. The costs include the expenditures for equipment, engineering, and installation as well as charges for production downtime. The benefits include the energy cost savings, plus any other net benefits, such as enhanced labor productivity, environmental compliance, or product quality, that accrue to the firm. These are the traditional accounting costs and benefits that directly affect the fro's bottom line. Basing policy on this narrow view of cost-effectiveness directly addresses the goal of economic competitiveness.

From a societal viewpoint, there is a wider range of relevant costs and benefits. All monetary, health, and ecological costs and benefits accrued to society are pertinent. Certain societal benefits, such as reduced local air pollution, diminished global warming, and avoided military conflicts over oil supplies, are very controversial. They are external to the markets and are very difficult to quantify. Moreover, they accrue to society at large, not to the particular party implementing the efficiency measure. This wider definition of cost-effectiveness is the more important measure for policy aimed at energy security and environmental quality. ,

Energy efficiency measures generally appear more cost-effective from the societal perspective than from the corporate view. This happens because more benefits are accounted for in the societal perspective. Consequently, environmental advocates and others taking the societal view are usually more optimistic than those with the corporate view about the potential energy savings that can be cost-effectively achieved.

This report adopts the traditional, more widely accepted, corporate perspective of cost-effectiveness. This view is chosen not to dismiss the value of societal costs and benefits but to examine where traditional market forces lead.

IS INDUSTRY ALREADY ECONOMICALLY EFFICIENT?

Analysts dispute the existence of significant cost-effective energy savings in industry. Some argue that companies minimize their costs by undertaking all cost-effective improvements and are, therefore, already as efficient as the market demands. A corollary is that all managers make rational, cost-minimizing, decisions. In this view, unimplemented energy savings must by definition not be cost-effective. Analysts that find industry already economically efficient believe that additional energy savings will be expensive and harmful to competitiveness.

The counterargument is that companies do not minimize their total costs in practice and are, therefore, not economically efficient. Many cost-effective energy savings are not pursued because of lack of information on relevant technologies, capital constraints caused by budgeting methods, inattention to energy issues, and general aversion to change. This behavior ultimately arises from disparate goals of management and stockholders, managers' personalities as they relate to external competitive pressures, managerial inertia, and organizational entropy. Analysts that take this view are generally more optimistic about the level of cost-effective energy savings that can be achieved.

WHAT ROLE DO ENERGY PRICES PLAY?

The influence of energy prices on industrial energy use is another disputed topic. Macroeconomic theory holds that prices should have a strong effect on energy use. Increases in energy prices lead to improved energy efficiency, because they raise the cost-effectiveness of implementing energy-saving technologies and processes. Price rises also lead companies to look for alternative energy sources through least-cost supply procurement, fuel switching, and cogeneration. In extreme cases, they may prompt companies to migrate to regions where prices are lower. These effects are more pronounced for the more energy-intensive companies and industries.

Several studies have examined the extent to which price effects are reflected in historical energy-use patterns. Typically, they compare the energy-intensity trends of the oil embargo period from 1973 to the early 1980s with those of earlier periods. Differences in the trends can be attributed to some degree to the high prices that existed during the oil embargo period. The data presented in figure 1-1 show that overall energy intensity declined more quickly during the high-price period than it did in earlier periods. This data is not conclusive, however, because it includes the effects of both efficiency improvements and structural changes. Analysts who have examined the efficiency and structural components of the energy intensity trends in this period disagree about the influence of the oil embargo period, Some have shown that efficiency (real-energy intensity) improved faster after the 1974 oil embargo than before it.[31] Others have suggested that efficiency improved steadily from 1958 to 1985, and that the energy shocks of the 1970s did not significantly accelerate the improvement.[32] The disparity appears to stem in large part from differences in the measures of industrial output that are used in the calculations.

Understanding the relationship between energy prices and industrial energy use is very important for assessing the effects of price-related policy initiatives. It holds the key to estimating how various energy and carbon-tax proposals would affect industry's energy use and carbon emissions.

POLICY OPTIONS

Strategies

Crafting policies to enhance energy efficiency is more challenging for industry than for other sectors of the economy. The greater difficulty arises from the diversity of industrial energy use—there are thousands of industrial processes each having unique energy characteristics-and from the interconnections between energy and production costs, product quality, environmental compliance, and other sensitive business factors. Several points are clear, however. First, energy efficiency is best promoted through policies that: 1) increase investment in industrial plants, and 2) focus that investment in a manner that encourages adoption of efficient technologies and production methods. Second, the energy conservation and efficiency activities and investments should be consistent with sound business strategy. Energy taxes or mandated investments that are too costly can put domestic companies at a competitive disadvantage, unless the costs are offset by import tariffs, export subsidies, or commensurate cost increases for foreign firms. Third, the relevant technical objectives for policy include: increasing the use of energy-conserving equipment, processes, and practices; spreading the practice of electricity cogeneration; expanding the reuse of products and recycling of materials; and decreasing the carbon-intensity of the industrial energy mix through fuel switching or electrification.

31 G. Boyd et al., op. Cit., footnote 3.

32 R.B. Howarth, "Energy Use in U.S. Manufacturing: The Impacts of the Energy Shocks on Sectoral Output, Industry Structure, and Energy Intensity," *The Journal of Energy and Development,* vol. 14, No. 2, pp. 175-190, 1991.

The first major objective-increasing investment in industrial plants-depends on a healthy business and financial climate. The business environment must include both economic growth and competition to compel investment. Without market growth, corporations have neither the resources nor the incentive to invest. Without competition, companies are under little pressure to invest, If companies' profits are secure, there is little need for them to invest in plants and equipment. Competition that is vigorous but fair signals to companies that being profitable depends on being efficient. The financial environment must include low capital costs and a long-term outlook, both of which depend on interest rates and tax codes, to encourage investment in industrial plants. In the United States, high capital costs and stock-market pressures favor short-term profits over long-term investment. OTA examined how macroeconomic policies affect the business and financial climate in an earlier report.[33]

The second major objective for improved energy use is that efficient technologies and production methods are implemented when investment occurs. Efficient technologies that are both cost-effective and reliable must exist and be available at the time of investment. Also, they must be given adequate consideration in investment decisions. Investments can be focused to advance the various technical objectives—conservation, cogeneration, recycling, and energy shifting-through financial incentives, regulations, information programs, and technology RD&D (table l-l).

These policy options vary widely in their energy savings and their costs to the government, businesses, and consumers. To illustrate the range of effects, the specific options are grouped into three distinct levels, in order of increasing Federal involvement and energy savings. The *basic* level includes relatively low-cost, simple policy options that require little or no new legislation or change from present practice. If Congress determines that changes are needed to effect improvements in energy efficiency, then the basic level could be considered as a first step. The *moderate* level includes several options that are more ambitious and in many cases would require modifying existing legislation and increasing Federal spending. The *aggressive* level includes options that are quite ambitious, would require new legislation, or would require an increased Federal role in energy regulation; the options on this level would require additional funding.

1 Information Programs

The general lack of concern afforded energy in many corporations is a major barrier to investment in energy efficiency improvements. This problem can be addressed through policies that raise the profile of energy efficiency as a national and corporate goal. The Federal Government could assist by providing technical assistance, supporting education and advertising programs, and establishing equipment-labeling requirements.

TECHNICAL ASSISTANCE

Many companies, especially smaller ones, are unaware of many of the ways they could improve their energy efficiency. Energy audits and training programs can help companies recognize opportunities for improving their energy efficiency. Many utilities provide audits to companies in their service territories. In addition, the Federal Government currently provides low-cost

33 U.S. Congress, Office of Technology Assessment, *Making Things Better: Competing in Manufacturing*, OTA-ITE-443 (Washington, DC: U.S. Government Printing Office, March 1990). Among the options suggested by this report to improve the financial environment were: decreasing the Federal budget deficit; granting inducements for increased personal and business savings; extending tax inducements (credits and accelerated depreciation) for technology development and capital investment; providing incentives for investors to hold investments longer; and increasing the stability and predictability of the financial and political environment.

Table 1-1—Policy Options for Improving Industrial Energy Efficiency

		Conservation of fossil fuels	Conservation of electricity	Cogeneration	Fuel switching and electrification[a]	Level of Federal involvement and energy savings
Information programs						
Technical assistance	Expand government-supported auditing and diagnostic assistance to small-and medium-sized industrial plants.	X	X	X	X	Basic
	Develop training and certification programs for energy managers and auditors.	X	X	X	—	Basic
	Continue assistance to electric utilities with industrial DSM program design.	—	X	—	X	Basic
	Offer assistance to natural gas utilities with industrial DSM program design.	X	—	—	X	Basic
Education and advertising	Promote energy-conserving technologies through workshops and technical literature.	X	X	X	X	Basic
	Expand public recognition program for corporate commitments to efficiency (such as Green Lights program).	X	X	—	—	Basic
Equipment labeling	Study effectiveness of implementing energy-efficiency labeling program for generic industrial equipment such as pumps, fans, compressors, and boilers.	X	X	—	—	Basic
Financial incentives						
Loan assistance	Guarantee loans and/or subsidize interest rates for energy efficiency investments.	X	X	X	X	Moderate
Investor income tax provisions	Grant tax-free status to dividends earned on bonds used to finance energy efficiency investments.	X	X	X	X	Moderate
Energy and carbon taxes	Research effects of taxation on industrial competitiveness and viability of methods, such as export rebates, for mitigating competitive harm.	X	X	X	X	Basic
	Tax fossil fuel use • fuel specific (e.g., petroleum) • based on heat or carbon content of fuels.	X	X	X	X	Moderate or aggressive
	Tax imports of petroleum.	X	—	—	X	Moderate or aggressive
	Tax CO_2 emissions • from industrial processes • exempt cogeneration units.	X	—	X	X	Moderate or aggressive
Corporate income tax provisions	Grant tax credits and/or accelerated depreciation for efficiency investments.	X	X	X	X	Moderate

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Regulations						
Efficiency standards	Study effectiveness of implementing energy efficiency standards for generic industrial equipment such as pumps, fans, compressors, and boilers.	X	X	—	—	Basic
Utility oversight	Provide incentives to State utility regulatory commissions for encouraging natural gas utilities to adopt aggressive industrial DSM programs.	X	—	—	—	[illegible]
	Further relax electricity-transmission rules to allow sales/transfers of cogenerated power directly to other industrial plants.	—	—	X	—	Moderate
Reporting and targeting	Establish government-run efficiency reporting and targeting programs.	X	X	—	—	Moderate
Environmental permits	Require permits for CO_2 emissions • from industrial processes • exempt cogeneration units.	X	—	X	X	[illegible]
Research, development an demonstration	Expand technology demonstration efforts.	X	X	X	X	[illegible]
	Expand efforts to improve energy efficiency of industrial equipment and processes.	X	X	—	X	[illegible]
	Support efforts to develop alternative, nonfossil, feedstock materials for plastics and fertilizers.	X	—	—	—	Moderate

[a] Shifts in the energy mix: from high-carbon to low-carbon fossil fuels, and from fossil fuels to electricity or renewable energy sources.

KEY: DSM = demand-side management; CO_2 = carbon dioxide.

SOURCE: Office of Technology Assessment, 1993.

audits to small and medium-sized companies. This program is small, but very cost-effective. The government could enhance these efforts by opening additional Energy Analysis and Diagnostic Centers and Manufacturing Technology Centers, and by developing training and certification programs for energy managers and auditors.

Many energy utilities have instituted IRP and DSM programs. These programs raise energy awareness and assist in identifying and funding energy-saving investments. However, relatively few of these programs are aimed at industrial consumers. The Federal Government, in providing technical assistance to utilities, could expand its efforts in the area of industry program design and monitoring.

EDUCATION AND ADVERTISING

The Federal Government could raise energy awareness by providing information on energy efficient technologies through technical literature, workshops, and meetings. EPA could continue to expand its voluntary energy-conservation programs (e.g., Green Lights) to include more types of equipment. The government could also actively recognize companies and industries that have made large energy efficiency gains; for example, those that have met or surpassed their voluntary efficiency targets or have kept their conservation commitments to EPA.

EQUIPMENT LABELING

Product labeling makes information about equipment-performance characteristics, such as energy consumption and operating costs, easily available. Labels assist equipment purchasers in making informed decisions, while increasing the attention paid to energy use. Labels are especially useful for small items, which are often purchased without much study. EPACT contains provisions for labeling electric motors. Congress could request DOE to examine the effectiveness of labeling other generic equipment such as pumps, fans, compressors, and small boilers.

H Financial Incentives

Financial measures can be used to alter investment patterns in order to promote the various technical objectives. These policy instruments include loan assistance, revisions to the income tax code, and taxation of energy consumption or CO2 emissions.

LOAN ASSISTANCE

In many companies, lack of funds constrains investment. A loan pool with funds earmarked for energy-saving projects could be used to increase efficiency investment. The pool could be financed from a combination of Federal, State, and utility sources. lending could occur under a variety of terms. Interest terms could be set at market, or perhaps below-market, rates, To ensure good faith, companies could be required to put up matching finds or agree to undertake a minimum investment in efficiency.

INVESTOR INCOME TAX PROVISIONS

Investment funds could also come from private sources by making dividends earned on bonds floated for energy efficiency projects tax-free. This would increase the pool of low-cost capital available for these projects. Such funds might be used to assist companies that have limited access to capital or have little use for tax credits because of profitability problems.

ENERGY AND CARBON TAXES

Energy prices, despite their disputed effects on energy efficiency trends, can be an important factor in investment decisions. They are a major influence on energy-focused investments and a lesser factor in general investment projects. By increasing energy prices, energy or carbon taxes raise the attention paid to energy use and spur implementation of energy-saving technologies and processes by increasing their cost-effectiveness.[34] They also lead companies to look for alternative energy sources such as cogeneration, fuel switching, and least-cost supply procurement. The energy effects, however, have been secondary to the issues of revenue generation and burden equitability in the public debate about such taxes.

Several different energy and carbon taxes have been proposed. Some are broad-based taxes, which would be levied on the Btu value, sales value, or carbon content of all energy sources.[35] Others are more fuel-specific taxes. These include taxes on gasoline and tariffs that establish a price floor on oil imports, meant to address issues of petroleum use, production, and importation. President Clinton's Btu tax proposal and foreign energy taxes and prices are discussed in box l-D.

The various energy and carbon taxes would affect the fuels used by industry in different ways. The Btu tax and carbon taxes would (if assessed at the same rate on all fuels) fall heaviest on coal, because its price per Btu and per carbon content is the lowest. Natural gas would be favored over residual oil under a carbon tax, while the opposite would be true under a Btu tax. A sales (ad valorem) tax would affect all fuels equally. It should be noted that applying energy and carbon taxes to petroleum-based feedstock materials would do little to reduce CO2 emissions at industrial production facilities. Such materials are not burned at these sites. They are, however, sometimes burned as post consumer waste at incinerators. Taxes on virgin feedstocks would encourage plastics recycling, rather than burning, thus reducing CO2 emissions.

The Congressional Budget Office (CBO) has estimated that a tax of $100 per ton of carbon would reduce overall energy consumption in the industrial and commercial sectors by 6 to 8 percent below current levels by 2000.[36] However, the costs could be quite high, both to companies and to the economy as a whole. CBO estimated that the tax would lower the annual gross national product (GNP) by about 0.5 to 2.0 percent ($40 to $130 billion) below what it would be otherwise by the end of the frost decade, and that the effects could be 5 percent or more in the frost few years of a suddenly instituted tax.

The costs would depend on revenue disposition as well as the tax rate. DOE estimated that a $1 per million Btu tax instituted in 1991 would decrease GNP in 2000 by 0.7 percent ($39 billion) if the revenues were used for deficit reduction.[37] The GNP decrease was estimated to be 0.6 percent ($35 billion) if the revenues were offset by a reduction in payroll taxes and the deficit was not reduced, the deficit neutral case.[38] A study by the American Council for an Energy-Efficient Economy (ACEEE) estimates that with an energy tax that generates $25 to $30 billion in Federal revenues, total U.S. energy expenditures could decrease over the coming decade if 15 percent of

34 Energy price controls are another policy tool that can be used to encourage conservation and fuel switching. They have been employed during inflationary periods, but are rarely considered today.

35 The environmental intent of carbon taxes would be to tax CO_2 emissions, but the tax would probably be levied on fuels at the point of purchase for convenience reasons, This is justified because nearly all of the carbon in fossil fuels is emitted into the atmosphere when the fuels are burned. There are no viable CO_2 scrubbers or other carbon fining technologies to prevent release into the atmosphere. The higher carbon fuels, such as coal, would be taxed heavier than the lower carbon fuels, such as natural gas.

36 U.S. Congress, Congressional Budget Office, *Carbon Charges as a Response to Global Warming: The Effects of Taxing Fossil Fuels* (Washington DC: U.S. Government Printing Office, August 1990).

37 U.S. Department of Energy, Energy Information Administration, *Studies of Energy Trees,* SR/EMEU/91-02, 1991.

38 DOE made similar estimates for a $45/ton carbon tax, which would generate roughly the same *Federal* revenues as a $1/million Btu tax. The carbon tax was estimated to decrease GNP by 0.8 percent ($43 billion) in the deficit reduction case and by 0.7 percent ($38 billion) in the deficit neutral case.

Box I-D—Energy Taxes

Clinton Btu Tax Proposal

In February 1993, President Clinton announced plans for instituting an energy tax as part of his economic revitalization program, ***A Vision of Change for America.*** The proposed energy tax would be levied at the rate of $0.599 per million Btu for petroleum products and at $0.257 per million Btu for most other fuels. Electricity generated from nuclear and hydro sources would be taxed at their input Btu rates, Energy materials used as feedstocks would be exempted from the tax. The tax would be phased in over 3 years and would be indexed to inflation beginning in the fourth year.

The following table shows the proposed assessment rates for various fuels. The actual price increases caused by these taxes would depend on their energy supply and demand effects in addition to their assessed rates.

Fuel	Ciinton proposal ($)	Percent of price	industrial prices 1991 ($)
Natural gas	**$.27/mcf**	10.3%	$2.63/mcf
Light fuel oil	**.08/gallon**	**11.4**	**.70/gallon**
Heavy fuel oil	**.09/gallon**	**30.0**	**.30/gallon**
Coal (steam)	**5.66/ton**	**16.9**	**33.51/ton**
Electricity (fossil or hydro)	**.003/kwh**	**6.1**	**.049/kwh**
Electricity (nuclear)	**.004/IM/h**	**8.2**	**.049/kwh**

Foreign Taxes

The overall rate of current energy taxation in the United States is difficult to determine because energy is taxed differently in each State. However, energy taxes are probably lower in the United States than in other industrialized nations. Regardless of the actual rates, U.S. energy taxes are not great enough to raise industrial energy prices above those of other highly industrialized countries. On average, U.S. industry pays lower energy prices than its major foreign competitors, except in t he case of natural gas and electricity in Canada. Complete data on industrial ***energy prices*** in developing countries, some ***of*** which are major competitors in energy-intensive industries, are not available to make a similar comparison for all U.S. competitors.

	United States	Japan	Germany	France	United Kingdom	Canada
Tax (1991)						
Natural gas ($/m@...	**NA**	**.32**	**.56**	**0**	**0**	**0**
Light fuel oil ($/gallon)	0	**.03**	**.16**	**NA**	**.09**	**0**
Heavy fuel oil ($/gallon)	**0**	**.02**	**.06**	**.08**	**.06**	**0**
Coal (steam) ($/ton)	**NA**	**1.84**	**0**	**0**	**0**	**NA**
Electricity ($/kWh)	**NA**	**.008**	**.007**	**0**	**0**	**NA**
Price (including tax) 1991						
Natural gas ($/mcf)	**2.63**	**11.04**	**5.23**	**3.94**	**4.19**	**2.26**
Light fuel oil ($/gallon)	**.70**	1.02	**1.02**	**NA**	**.84**	**.72**
Heavy fuel oil ($/gallon)	.30	.86	.49	.41	.44	.37
Coal (steam) ($/ton)	33 .51	63.29	165.49	91.84	69.82	54.92
Coal (metallurgical) ($/ton)	48.83	56.10	56.45	58.32	**NA**	**51.60**
Electricity ($/kWh)	**.049**	**.136**	.088	.054	.071	.039

NOTE: **Coal prices for Canada are for 1989.**

SOURCES: Office of the President, *A Vsion of* Change for America (Washington, DC: 1993). International Energy Agency, *Energy Prices and Taxes, Third Quarter 1992.*

the energy tax revenues were recycled into energy efficiency programs.[39]

Energy-intensive industries would be hit particularly hard by the levying of energy or carbon taxes. In these industries, energy prices play a large role in the competitiveness among nations. Taxes could damage these industries' competitiveness and could lead to migration of production facilities to offshore regions where energy prices are low. This could be countered by border adjustments, such as duties on imports containing large amounts of embedded fossil energy (with offsets for any nonrefunded energy taxes paid in the exporting country) and rebates for exports of such products.

Most economists prefer taxes over other policy tools as the means for encouraging greater energy efficiency. Taxes send clear economic signals and allow varied technical approaches to achieving goals. Moreover, they can be rationalized as the transference of some of energy's external costs from society as a whole to energy users themselves.

CORPORATE INCOME TAX PROVISIONS

The corporate income tax code can be used to make energy-conserving investments appear more cost-effective to corporate decisionmakers. Granting tax credits, accelerated depreciation, or other tax-reducing devices to energy efficiency expenditures would increase the financial attractiveness of these investments. The benefits of such tax provisions would have to be weighed against the lost revenues to the Treasury.

From 1978 until 1985, a 10 percent tax credit was in effect for investments in: 1) specified equipment, such as boilers that use coal or alternative fuels; 2) heat conservation equipment; and 3) recycling equipment.[40] These tax credits have been found by OTA and other researchers to have little effect on corporate investment decisions.[41] Credits were taken for eligible projects, but they rarely caused a company to implement one technology rather than another. They did little to shift companies' perceptions of the cost-effectiveness of various technologies. These credits have also been criticized for specifying technologies, thus discouraging the use of new technologies and concepts.

If tax credits were tried again, the rates would have to be considerably higher and the list of eligible conservation technologies would have to be greatly expanded in order to significantly alter investment patterns. Credits could also be applied to process-oriented RD&D expenditures. It is important to recognize, however, that credits can influence companies' investment only in profitable years. They do little in unprofitable years when no taxes are paid.

Accelerated depreciation schedules can also be used to facilitate investments that improve energy efficiency. Shortening the depreciation period for conservation investments could improve their cost-effectiveness.

Regulations

Regulations are the most direct method of changing industrial behavior. Among the most

[39] H. Geller, J. DeCicco, and S. Nadel, Structuring *an Energy Tax So That Energy Bills Do Not Increase* (Washington, DC: American Council for an Energy-Efficient Economy, 1991).

[40] The tax credits were enacted as part of the Energy Tax Act of 1978, Public Law 95-618 and expanded by the Crude Oil Windfall Profits Tax Act, Public Law 96-223. The eligible heat conservation equipment (specially defined energy property) included recuperators, heat wheels, regenerators, heat exchangers, waste heat boilers, heat pipes, automatic energy-control systems, turbulators, preheater, combustible gas-recovery systems, economizers, and modifications to alumina electrolytic cells. In addition, the law denied tax credits for the installation of oil- and gas-fired boilers and granted rapid depreciation allowances for their early retirement. Proposals were made, but never enacted, to extend the credits to industrial insulation industrial heat pumps; modifications to burners, combustion systems, or process furnaces; batch operations conversion equipment; product separation and dewatering equipment; and fluid-bed driers and calciners.

[41] OTA, op. cit., footnote 8. Alliance to Save Energy, *Industrial Investment in Energy Efficiency: Opportunities, Management Practices, and Tax Incentives,* July 1983.

viable regulatory options for influencing industry's use of energy are equipment efficiency standards, pollution permits, reporting and targeting requirements, and utility oversight.

EFFICIENCY STANDARDS

Efficiency standards can be used to raise the average energy efficiency of certain types of industrial equipment. Excluding substandard equipment from the market limits purchasing options to higher efficiency equipment. Thus, average energy efficiency rises in the normal course of equipment turnover. Because higher efficiency equipment is costlier than standard equipment, efficiency standards exact an initial financial penalty on equipment buyers. However, this initial penalty is usually more than offset by the cost savings over the life of the equipment. Furthermore, efficiency standards act to lower the purchase prices of higher efficiency equipment by increasing the size of its markets.

Standards make sense only for new or replacement equipment, not for existing equipment. Upgrading all existing equipment to meet standards would be extremely expensive and difficult to manage.

Further, most industrial equipment is not amenable to standards, because of the diversity in the types of equipment and the operating environments. There are, however, some generic types of equipment that are amenable to standards. EPACT contains provisions for standards on new electric motors. Congress might request DOE to examine the practicality and effectiveness of efficiency standards for other generic equipment, such as pumps, fans, compressors, boilers, cogenerators, and rewound motors.[42]

UTILITY OVERSIGHT

Utilities, through their DSM efforts, can be a great source of information and funding for energy efficient technologies. Currently, most DSM programs are operated by electric utilities. Under EPACT, the Federal Government can offer financial incentives to States to pressure their PUCs and utilities to more aggressively pursue DSM. Further incentives or technical assistance could be provided to expand the DSM efforts of natural gas utilities.

REPORTING AND TARGETING

Requiring companies to periodically report on their energy consumption draws their attention to the importance of energy efficiency. The reporting also provides government with data that it needs to plan its various industrial energy programs. Setting energy efficiency targets for industries adds still more pressure for improvement. EPACT specified that DOE's current reporting program, the Manufacturing Energy Consumption Survey, be conducted at least every 2 years. The act also provided incentives for voluntary targeting programs to be established within trade associations. If the targeting programs do not gain wide acceptance, then Congress might consider establishing a government-based program in which the targeting would be mandatory.

ENVIRONMENTAL PERMITS

Companies could be required to obtain permits for their CO2 emissions. Limiting the number of available permits, perhaps to a set percentage of 1990 emissions, would encourage conservation and fuel switching. Under this system, companies would be free to choose the most cost-effective strategy for curtailing their $C0_2$ emissions. They could implement energy efficient technologies, fuel switching, or possibly some other emissions-cutting technique. Making the permits marketable would further enhance companies' options. Firms could trade their unused carbon permits to other

42 DOE studied pump standards in the late 1970s. It did not recommend them, but a revisit of the issue may be in order.

firms whose emissions exceed permit levels, thereby creating a market for carbon emissions.[43]

EPACT calls for DOE to establish a voluntary reporting system to track greenhouse-gas emissions. This emissions baseline will help make permit allocations more equitable. Basing allocations on a long period of prior emissions reduces the disincentives for companies to make emissions cuts before the program begins.

Marketable permits are the basis of the U.S. regulatory approach for phasing out emissions of chlorofluorocarbon compounds (CFCs) and for reducing sulfur dioxide emissions to control acid rain. Marketable carbon permits are likely to be more difficult to implement than permits for CFCs or sulfur dioxide; nevertheless, such a system may still be less intrusive to firms than mandated emissions standards or technology standards. Use of marketable permits would entail a great amount of data collection and monitoring of industrial plants.

Other environmental policies that target air and water emissions, recycling, and hazardous and nonhazardous waste disposal also affect industrial energy use. Environmental directives are a very powerful tool in this regard, because energy-consuming technologies and processes tend to be major sources of pollution.

The cost to industry of environmental regulation is a major policy consideration in this area. If the costs are too onerous, industrial competitiveness can be severely impaired.

Research, Development, and Demonstration

Continuous improvement in energy efficiency requires a constant flow of advanced, commercially available technologies, which in turn requires a sustained RD&D effort. The Federal Government already supports this effort through the industrial energy conservation and efficiency RD&D program at DOE. Greater gains could be achieved by expanding the program and increasing the efforts to understand and overcome technology implementation hurdles. DOE's RD&D efforts should continue to stress technologies that achieve multiple goals. Technologies and processes that combine energy efficiency with more prominent corporate goals (e.g., product quality, labor productivity, or environmental compliance) generally have greater cost-effectiveness and are more likely to be adopted in industrial facilities.

Product Reuse and Materials Recycling

Product reuse and materials recycling have received considerable attention because of their role in reducing the need for additional landfills. A less publicized benefit is that reuse and recycling conserve energy.[44] For energy-intensive products, reusing them (e.g., refilling beverage bottles and copier cartridges) or producing them from recycled materials (e.g., reprocessed steel, aluminum, plastics, and paper) usually consumes less energy than producing them from virgin materials. There are many options for policies that would increase product reuse and materials recycling. The following options are mentioned for illustrative purposes:

- Resource subsidies, such as mineral depletion allowances and U.S. Forest Service below-cost timber sales, currently favor the use of virgin materials. These subsidies could be reduced or eliminated to promote the use of recycled materials. To ensure fair trade, goods containing virgin materials

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[43] U.S. Congress, Office of Technology Assessment, *Changing by Degrees, Steps to Reduce Greenhouse Gases,* OTA-O-482 (Washington, DC: U.S. Government Printing Office, February 1991).

[44] OTA has considered these issues at length in other reports. U.S. Congress, Office of Technology Assessment, *Green Products by Design: Choices for a Cleaner Environment,* OTA-E-541 (Washington DC: U.S. Government Printing Office, October 1992); *Managing Industrial Solid Wastes From Manufacturing, Mining, Oil and Gas Production, and Utility Coal Combustion-Background Paper,* OTA-BP-O-82 (February 1992); *Facing America's Trash: What Next for Municipal Solid Waste?* OTA-O-424 (October 1989); and *Materials and Energy From Municipal Waste,* OTA-M-93 (July 1979).

would need to be subject to duties when imported and granted rebates when exported.

- Grants and technical assistance could be offered to help States and municipalities establish recycling programs.
- Government procurement programs could promote product reuse and materials recycling. By requiring a minimum recycled and recyclable content in certain of the products it buys, the government could foster the markets for recycled materials.
- Grants and technical assistance could be given for the development and implementation of a plastics identification system that would facilitate plastics recycling,
- Funding could be given for RD&D efforts to improve the viability of scrap-processing equipment and the quality of recycled materials.
- A FederaI deposit-refund system for beverage containers, automobiles, and other recyclable products could be established.
- Manufacturers, wholesalers, and retailers could be required to collect and recycle the packaging used to deliver their products to market. The program could be extended to require that businesses collect and recycle their own products when discarded. A model for this might be Germany's nationwide packaging take-back program.