THE NATIONAL ENERGY STRATEGY OF THE UNITED STATES: INDUSTRIAL ENERGY USE

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ABSTRACT

The industrial energy strategy of the United States is discussed. Past achievements and current research in progress are summarized.

GENERAL REMARKS

Improvement in energy end-use efficiency offers the largest opportunity of all alternatives to meet the energy requirements of a growing world. At the current rate of energy consumption, a universal one percentage point improvement in end-use efficiency, a perfectly do-able accomplishment, would be equivalent to discovering every five years forever a new oil supply equal to the 1990 oil proven reserves of the entire United States.

Presently, the satisfaction of the residential, commercial, transportation, and industrial energy needs of developed and developing societies is very inefficient. Thermodynamic analysis yields that the average efficiency of energy utilization is just about one tenth in industrialized nations, and even less than one tenth in developing countries. From the engineering standpoint, this is a very low efficiency, and the theoretical potential for improvement is enormous. Of course, energy end-use efficiency will never approach unity. Nevertheless, the present low value underscores the opportunity for large savings. No scientific barriers exist to prevent overwhelming improvements. For example, changing the average efficiency from about 10 to about 20 percent, not an unreasonable goal over the next few decades, would reduce energy consumption by one half without curtailing energy services.

Many cost-effective, energy-saving technologies exist for use in space lighting, heating, and air-conditioning, in new designs of large and small vehicles, and in industrial manufacturing processes. Examples are more luminous fluorescent lamps, 60- to 100-miles-per-gallon automobiles, cogenerators of heat and electricity, and

radically new process technologies, such as hardening of metal surfaces by laser irradiation rather than heat-treating.

In this paper, I will not discuss the generic and specific methods that can be used for cost-effective energy savings. They have appeared in many publications of the 1970s and 1980s. Instead, I will restrict my remarks to the current programs of the Department of Energy of the United States in industrial energy conservation. These programs are described in References 1 and 2, which are the sources for this paper.

ENERGY CONSUMPTION IN THE UNITED STATES

In 1990, the United States consumed over 80 quads of primary energy (Figure 1). About one quarter of this energy was consumed in the transportation sector, and the remaining three quarters were shared about equally between the industrial and buildings (commercial and residential) sectors.

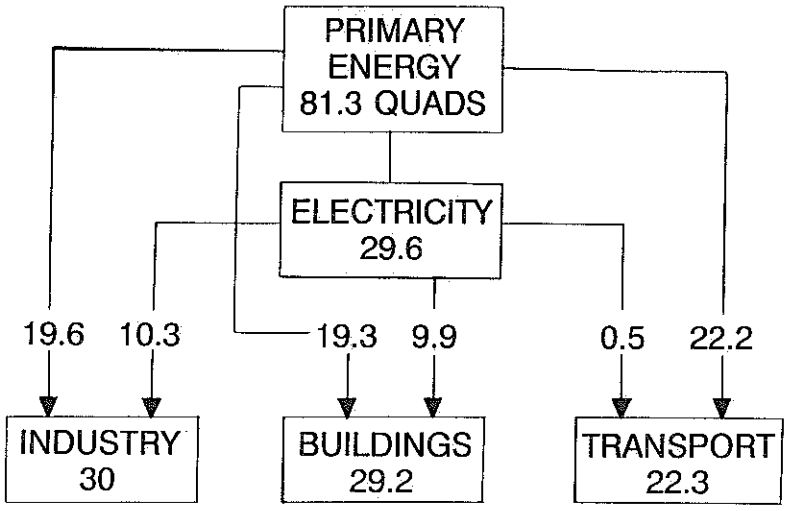
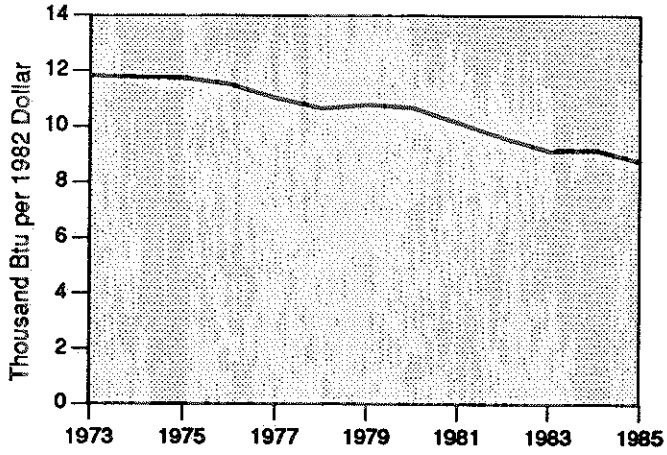


Figure 1

The industrial sector accounts for approximately one quarter of all U.S. petroleum consumption, with more than one half of this consumption being used for such materials as plastics and petrochemicals. In 1990, excluding fuels used as nonenergy feedstocks (but including the energy used to generate and deliver electricity), the industrial sector accounted for 37 percent of all primary energy consumption.

Great progress has been made in the efficient use of energy in the industrial sector. Energy consumption per $ 1982 of industrial output has been steadily decreasing. From 1973 to 1985, the decrease in this important ratio is illustrated in Figure 2. It is seen from the figure that the decrease was about one third or, equivalently, that about 35 percent more industrial output was generated by the U.S. economy from 1973 to 1985 without an increase in energy consumption.



Source: Energy Information Administration, *Energy Conservation Indicators 1986 Annual Report*, February 1988.

Figure 2

It is estimated that about one half of the improvement of energy consumption per constant dollar of industrial output was due to cost-effective efficiency improvements made by industry in response to higher energy prices. The other half was due to structural shifts in U.S. demand, such as reduced consumption of energy-intensive products, and reduced production of energy-intensive goods — steel and automobiles. The reduced production was achieved by substituting imports for goods that were previously manufactured in the United States.

Past achievements by no means have exhausted the currently available opportunities for continued improvements in cost-effective energy utilization. In fact, the opportunities become even broader and larger and more challenging when considered together with the problems created by wastes. Currently, industrial practices in the United States produce more than 600 million tons of solid hazardous wastes per year, together with millions of tons of waste gases that contain chemicals worth $500 million per year. The Environmental Protection Agency estimates that approximately 11 billion tons of nonhazardous solid wastes and wastewaters are also produced per year.

These waste streams are potential feedstock sources. Presently, however, they are a serious environmental problem, and burden industry with growing disposal costs. To meet environmental regulations, industry spends about $46 billion per year on pollution controls. Transforming wastes into usable feedstocks can reduce the requirements of the United States for energy and improve the quality of the environment.

THE NATIONAL ENERGY STRATEGY

To continue the improvement in cost-effective energy use, the National Energy Strategy of the Bush administration has adopted three goals for industrial energy use: "(1) encourage increased energy efficiency and fuel flexibility in the industrial sector to reduce petroleum dependence; (2) encourage cost-effective measures to reduce

energy costs; and (3) reduce industrial waste generation, increase recycling of wastes, and increase the use of plant- and consumer-generated wastes as process feedstocks."

"The Strategy estimates that industrial energy use would be about 55 quads in 2030 without the National Energy Strategy initiatives. With the initiatives, the industrial sector is expected to be 5 percent more energy-efficient by the year 2005, 10 percent more energy-efficient by the year 2010, and 15 percent more energy-efficient by the year 2030. These improvements culminate in a reduction of about 9 quads per year by 2030."

Energy Efficiency and Fuel Flexibility

The National Energy Strategy claims that "energy efficiency and fuel flexibility will improve because of increased support for research, development, and demonstration, use of industry-Government cost sharing, and increased information and technology dissemination efforts through the Energy Analysis and Diagnostic Centers and other outreach projects. Industrial energy research and development will stress reduction of waste energy in industry and advanced industrial processes. Moreover, increased energy audits of industrial plants through the Energy Analysis and Diagnostic Centers will reduce energy use and help disseminate the results of Government and industry research and development."

R&D on Waste Energy Reduction. "The Department of Energy will increase its support of research and development on equipment that will improve energy conversion efficiency, recover energy from industrial waste heat, and provide higher temperature structural materials and related technical information that support these advances. Opportunities exist in all industries to develop technologies that deliver energy services to industrial processes at higher efficiencies and with greater fuel flexibility than at present. Energy that is wasted in the manufacturing process can be captured and used, thereby reducing energy requirements to produce goods and services and increasing plant production. Therefore, savings are achieved from lower energy costs and more efficient plant utilization. The Nation will also derive substantial environmental benefits by reducing the energy that it requires to produce goods and services."

"Department of Energy research and development support will stress advanced chemical and mechanical heat pumps; process heat exchangers and ceramic recuperators; advanced materials such as continuous fiber-ceramic composites; advanced combustion systems for industry; and industrial cogeneration technology. These technologies will address a mix of near-, mid-, and long-term opportunities to save energy in the industrial sector. Research and development will be carried out through innovative cost-sharing arrangements with industry."

R&D on Industrial Processes. "The Department of Energy will increase its support of research and development on new industrial processes that offer significant opportunities for improving energy efficiency and increasing industry's flexibility in using alternative fuels — particularly, renewable fuels. The development of new industrial processes, from raw material to final product, presents a major opportunity for industry to improve its energy efficiency and fuel flexibility. Opportunities to save energy by redefining the production process exist within specific industries, such as steelmaking, as well as within process steps that cut across industries, such as separations technology."

"The Department of Energy supports the development of new industrial processes for advanced steelmaking, sensors and controls, improved membranes for separation systems, and process electrolysis. Department research and development focuses on technologies that offer energy savings and fuel flexibility in the near, mid-, and long terms. The Department of Energy will pursue cooperative cost-sharing arrangements to carry out Federal research and development programs. The Government will also be pursuing a permanent 25-percent research and development tax credit to encourage private industrial investment."

Energy Audits

Opportunities to save energy in an industrial plant can often be identified by a careful study of the flow of energy through the plant. Energy audits of industrial facilities reveal simple ways to cut energy use at practically no cost.

"Energy Analysis and Diagnostic Centers, operated by universities for the Department of Energy, have performed more than 2,800 preliminary plant energy audits for small- and medium-sized companies. The Department's expansion plan calls for adding 3 universities in fiscal year 1992 to the 18 already participating. In addition to helping smaller firms improve their energy efficiency, this program provides hands-on audit training for engineering students. The Department will encourage similar private-sector programs, such as utility-conducted industrial audits performed as part of a demand-side management program."

Waste Reduction, Waste Recycling, and Use of Wastes as Feedstocks

"The reduction of waste generation is an important strategy to control costs and improve productivity. Potentially dischargeable waste is not produced and therefore does not require treatment and disposal. Waste reduction ensures that more raw material becomes product, thereby reducing energy requirements, saving natural resources, and lessening environmental impacts. After wastes are reduced to their technical minima, industry may use or convert unavoidable wastes to feedstocks or fuels. If use or conversion is impossible, it may treat wastes and release them into the environment. More restrictive environmental regulations, rising energy costs, and the requirement for more economic waste control require developing and investing in technologies to reduce industrial wastes. Hundreds of U.S. companies have instituted waste reduction measures that have lowered production costs and raised corporate profits while reducing energy use and environmental impacts. Nevertheless, cost-effective waste minimization can be increased."

"Incomplete knowledge of the most advanced waste management practices is an important obstacle to more effective waste management. There are a wide variety of production processes that require individualized waste management strategies. In addition, implementation of new waste management techniques may require regulatory changes."

"The Government will continue to rely on private industry to make economic choices on waste management alternatives. However, to overcome the lack of advanced waste reduction and utilization technology, information barriers, and regulatory deficiencies, the following actions are required: support research and development on advanced process technology that reduces wastes, support research and development on waste use and conversion technology, determine which regulatory

changes may help foster improved waste management without compromising environmental quality, and develop an outreach program."

R&D on Waste Reduction Technologies. "The Department of Energy will increase funding of cost-shared research and technology development directed specifically at industrial waste reduction. Long-term waste solutions often involve redesign of major portions of an industrial process that may require significant research and development, and many small- and medium-sized companies do not have the necessary resources. Even firms that have sufficient resources must evaluate the relative merits of developing new production technology versus product-related research and development."

"The Department of Energy, in close coordination with industry, will target the cost-shared effort to key areas with potential for substantial energy reduction. Other criteria will include opportunities to reduce environmental impacts, to increase overall industrial productivity, and to save natural resources. Initially, the Department will target chemical processes because of the large amounts of wastes that they produce and the large investments that are being made in pollution control activities ($4.2 billion in 1988). Additional industries, such as the petroleum industry and the pulp and paper industry, will follow as additional analysis is done on their waste reduction opportunities and needs."

R&D on Waste Use and Conversion. "The Federal Government will increase its support for research and development on the innovative mechanical, biochemical, and thermochemical processes that industry needs to convert industrial wastes economically into feedstocks or fuels. All industries produce wastes at every stage, from raw material input through product distribution and servicing. Many opportunities exist for profitable recovery and conversion of some of these wastes rather than payment of continuing and generally escalating costs for their environmentally sound disposal. However, the lack of cost-effective recovery techniques to use the materials and energy content of industrial wastes efficiently limits their use."

"The Department of Energy will focus on techniques for improved recovery of metals and other materials from auto scrap, recovery of useful products from waste tires, recovery of adhesives and other useful materials from wood wastes, recovery of high-value products from food wastes, and separation and collection of useful gaseous materials. Solar technologies will be developed to decontaminate wastewater and destroy hazardous industrial chemicals. The Department will pursue near-, mid-, and long-term research and development objectives through cost-sharing with industry. Though strongly market oriented and well connected to the ultimate industrial users of the technology, the Department's approach in this area emphasizes bringing capabilities of the National Laboratories to bear on the complex technical issues involved."

Industrial Waste Regulation Reform. "The Department of Energy and the Environmental Protection Agency will determine the extend to which existing regulatory programs discourage investment in innovative waste and pollutant minimization technologies. The evaluation will include input from private industry on existing regulatory barriers and potential solutions. The Department and the Agency will then suggest legislative or regulatory changes to encourage waste minimization investments."

Waste Outreach Program Development. "The lack of good data, worker information programs, and auditing procedures may create significant barriers to widespread adoption of waste reduction practices. The Department of Energy will develop a coordinated outreach program to communicate research results, provide technical information and advice, and disseminate industrial waste stream data to the industrial sector. This effort will be coordinated with the Environmental Protection Agency, as well as with leading industry groups with interest in waste reduction and use."

RESEARCH IN PROGRESS

A bibliography of all scientific and technical reports sponsored by the U.S. Department of Energy Industrial Energy Conservation Program during the years 1988-1990 is given in Reference 3.

In fiscal year 1993, the funding of research and development projects in industry efficiency by the U.S. Department of Energy will be about $100 million. It will be shared by about 220 different projects addressing different aspects of industrial energy conservation. They are managed by the Office of Industrial Technologies. They are briefly described in Reference 4, and fall in the general program categories listed in Table 1.

CONCLUDING REMARKS

The interest in energy issues, both new sources of energy and more cost-effective energy uses, is no longer in the headlines. Reduced demand for OPEC oil has kept energy prices low. The reduced demand is due partly to energy savings, partly to world stagnant economies, and partly to the desire of oil producers to sell as much oil as they possibly can. In $ 1987, oil prices are only about 50 percent higher than in the '50s and '60s. So the desire to address the energy problem is not as acute as it was in the decade that spanned the seventies and eighties.

Despite these deficiencies, it is purposeful to continue our efforts in the area of cost-effective energy utilization because the results are important from the points of view of the environment, resource availability, and possible climatic changes.

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