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Industrial Energy Conservation, An Overview

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EXTENDED ABSTRACT

The Industrial Sector in the United States uses about one-third of all energy use, a total of more than 29 Quads in 1989. This energy use is distributed among various industries of the sector as shown in Table 1.

Industry	Percent of Energy Use
Petroleum	20.1
Chemicals	16.9
Primary metals	14.1
Pulp & paper	9.9
Food	4.9
Stone, clay, glass	4.3
Transportation equipment	2.2
Fabricated metal	1.9
Textiles	1.7
Other manufacturing	8.8
Non-Manufacturing	
Agriculture	4.5
Construction	3.2
Mining	7.3
Total	99.8

Table 1. Energy Consumption by Major Industry.

(Source: Energy Information Administration, Manufacturing Energy Consumption Survey.)

As can be seen from Table 1, six large industries (petroleum; chemicals; primary metals; paper; food; and stone, clay, and glass) account for over 70% of the energy usage. The majority of this energy usage is supplied by electricity (34%), natural gas (28%), and petroleum (28%). The remaining 10% is supplied by coal or other sources.

Over a 16 year period from 1973 to 1989, the use of energy in the industrial sector declined from 32 to 29 quads, while there was a 1.7 percent (real) annual growth in industrial output. The Congressional Office of Technology Assessment estimated that the energy use in 1985 was 15 to 20 quads lower than would have been projected if the energy trends in place in 1972 had continued. This dramatic change was in response to the oil crisis of the early 1970s, and the reduction of energy use in the industrial sector is composed of two parts. Somewhat more than half of the energy drop per unit industrial production is due to efficiency improvements in the industrial sector, and the remaining reduction is due to a shift of some of the energy intensive industries from the U.S. to other countries. During the period from 1973 to 1987, the total primary energy required per unit of gross domestic product in the United States declined from 12,000 to 8,000 (Btu per dollar of industrial output). The fact that we have improved is good news, but the competition has improved also, for instance, Japan used approximately one-half as much energy per dollar of industrial output as the U.S. in 1987.

DOE's Conservation and Renewable Energy, Office of Industrial Technologies funds work in several areas, with the objective of improving the energy efficiency and minimizing the amount of waste that is produced in the industrial sector. The organization of the Office is shown in Figure 1.

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Figure 1 Major Elements and Research Areas of the Office of Industrial Technologies

Industrial Technologies is composed of two offices, the *Office of Waste Reduction* seeks to improve the utilization of energy and materials that are currently reporting to industrial waste streams, and to reduce the generation of wastes in processing and manufacturing industries. The *Office of Industrial Processes* seeks to improve the overall efficiency of industrial processes by major industry.

Office of Industrial Processes

The Improved Energy Productivity Division has R&D projects that seek to raise the efficiency of major processes in the iron, steel, aluminum, glass and papermaking industries. As an example, a major project with the American Iron and Steel Institute is the development of a direct steel making process using coal that will eliminate the need for coking ovens. This technology is expected to be economical in smaller sizes (1000 Ton/Day minimum capacity as opposed to 5000 Ton/day currently), eliminate the need for coking ovens, reduce energy consumption from 17.5 Million Btu/Ton to 13.5 Million Btu/Ton, reduce NO_x production by over 99%, and result in a 50% reduction in the capital cost per ton of steel produced.

Another major area of work is in the Advanced Industrial Concepts Division. These programs in Materials, Thermal Sciences, Combustion, and Catalysis/Biocatalysis function in the role of bridging technology from the basic work of Energy Research, to the applied programs in waste reduction and improved energy productivity. The materials program looks at developing new materials for high temperature applications, such as Nickel-Aluminides that have found application in a number of high temperature and corrosive environments. The thermal sciences program is targeting an understanding of the processes involved in organic fluid fouling, enhanced heat transfer surfaces, and the design of compact heat exchangers. The combustion program has developed analytical and experimental tools that allow better understanding of the combustion processes occurring in the cylinder of an internal combustion engine. Finally, the catalysis/biocatalysis program is developing biological and conventional catalysts of improved specificity and efficacy.

Office of Waste Reduction

The Industrial Energy Efficiency Division is concerned with improved recovery and utilization of thermal energy, through the development of advanced heat exchangers, use of ceramics for high temperature heat exchange applications, improved combustion processes, and the industrial application of heat pumps in the process industry.

An example of improved combustion processes is the Oxygen-enriched Diesel Project, in which a semi-permeable membrane is used to enrich the oxygen content of air supplied to a diesel engine. Enriching the oxygen from 21% to 25% has a dramatic effect on engine performance:

- Engine power density (horsepower per liter of displacement) increases by at least 50%
- Diesel smoke is virtually eliminated, and hydrocarbons, particulate matter, and Carbon Monoxide emissions are drastically reduced.
- The thermal efficiency of the engine is increased by 5%
- NO_x emissions are increased as a result of the higher-temperature combustion, but can be controlled by water injection or other means currently under development.

The Waste Material Management Division targets the *materials* used in process and manufacturing industries, and seeks to increase the degree of recycle and utilization (Waste Utilization and Conversion) or to decrease the amount of materials that are produced as waste in processes (Industrial Waste Reduction) and manufacturing. The Municipal Solid Waste Program is structured to recover both materials and energy from post-consumer waste.

The objective of the Waste Utilization and Conversion program is to convert waste products from industry into useful materials that can serve as feedstocks to other industries. An example is a project at Argonne National Laboratory that is being performed joint with a number of industries on the recovery of metals and materials in vehicle recycling. ANL is working with the Vehicle Recycling Partnership (VRP) composed of Ford, GM, and Chrysler, the American Foundryman's Society, Metals Recovery Inc., the Aluminum Recycling Association, the Institute of Scrap Recycling Industries, and the Brass and Bronze Ingot Manufacturers. The program is taking a comprehensive approach to the recovery of materials from scrap automobiles and other durable products. The current mix of projects includes:

- Lead removal from brass and bronze castings to meet anticipated changes in lead content allowances
- Removal of zinc from galvanized sheet steel to yield "clean black scrap" and resalable zinc, instead of having the zinc report to the baghouse as a zinc-oxide dust requiring disposal
- Development of methods of handling the Antimony in aluminum castings from foreign manufacturers to avoid contamination of Strontium doped aluminum from domestic manufacturers
- Recovery of aluminum and salts from the slags and fluxes used in secondary aluminum casting operations
- Recovery of plastics as polymers from the Auto Shredder Residue (ASR) for recycle and reducing the amount of materials that need to be landfilled.

All programs are driven by industrial needs and constraints, and are initiated by establishing a dialogue with an industry or association, determining what the industry's problems are, and then jointly developing technologies with industry cost-share and research participation.

The Industrial Waste Reduction Program (IWRP) has the objective of reducing the generation of wastes in the manufacturing and processing industries by improved processes, improved design, or materials substitution. An example from the program at Argonne is concerned with the recovery of H_2 for recycle within a petroleum refinery.

Petroleum refineries are typically processing heavier and increasingly sour crude feedstocks. As a result, there is an increased need for hydrogen for sweetening the crude by removing the sulfur. The current process for treating the resulting hydrogen sulfide (H_2S) is to use a Claus-SCOT unit, which converts the H_2S into water and sulfur. The ANL process that is currently being developed uses a microwave plasma to split the H_2S into H_2 (gas) and S (liquid). The H_2 is available for recycle in the refinery, and the Sulfur is marketable on the open market. Substantial energy savings are expected to result by reducing the need to reform feedstocks to form hydrogen for the refinery. ANL is currently working with Wavemat, the Kurchatov Institute in Russia, and some U.S. industrial companies to develop the concept for the commercial market.

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