ENERGY EFFICIENCY IN SPECIFIC INDUSTRIAL SEGMENTS

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Contents

Summary

Industry is a major consumer of energy worldwide. In the United States, industry accounts for more than one-third of all energy consumption. This article presents energy-use characteristics and efficiency opportunities for six select industries: aluminum, steel, glass, pulp and paper, petroleum, and chemical. In addition, the energy-use characteristics, efficiency opportunities, and future trends are presented in more depth for the aluminum and steel industries. The selected industries were chosen based on energy-use intensity, future worldwide application, and potential for energy efficiency. The selected industries account for more than 75% of industrial energy consumption in the United States.

1. Introduction

Industry accounts for a large percentage of worldwide energy consumption. For example, in the United States, industry is the leading energy end-use sector comprising 37% of total energy consumption. There are dozens of industrial processes that contribute to overall industrial energy use; however, a few specific processes dominate the sector. In addition, several specific types of industries are growing rapidly throughout the world and can be considered as industries of the future. Moreover, there are specific industries with exceptionally high potential for energy-efficiency improvements. Taking these considerations into account, six industries were selected for discussion in this article. The selected industries are: aluminum, steel, glass, pulp and paper, petroleum, and chemical. Other important energy-intensive industries with potential for significant energy efficiency improvements that are not discussed herein include (but are not limited to) mining, copper, cement, textile, and food processing.

Figure 1 shows the primary consumption of energy by industry in the United States in 1994. The six selected industries account for more than three-quarters of the energy consumption, according to 1994 statistics. Of the six industries, the petroleum and chemical industries consume the majority of energy, and account for 30 and 25% of total energy use, respectively. The pulp and paper and steel industries are the next largest consumers in the United States, comprising 12 and 8% of total consumption, respectively. Aluminum and glass each account for 1% of total energy consumption.

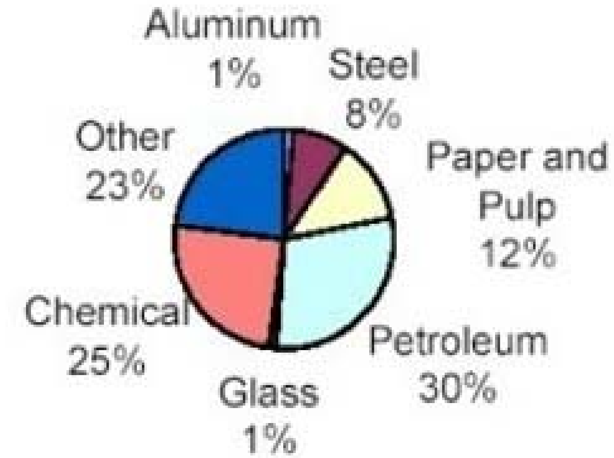

Figure 1. Primary consumption of energy by industry, 1994 (United States)
Source: Data compiled from Energy Information Administration (EIA), US Department of Energy (US DOE), (1994), 1994 Manufacturing Energy Consumption Survey, Table A1, available on-line at www.eia.doe.gov/emeu/mecs/mecs94/consumption/mecs5.html

The energy-use characteristics and energy-efficiency opportunities associated with the selected industries are summarized briefly in Section 2. General industrial energy efficiency trends are also provided. Sections 3 and 4 examine energy efficiency in the aluminum and steel industry in greater detail.

2. Selected Industries Overview

2.1. Perspective

The energy-use characteristics for six specific industries are briefly introduced in this section. The selected industries include aluminum, steel, glass, pulp and paper, petroleum, and chemical. These industries were chosen because of their high energy-use intensity and overall importance to the global economy. Table 1 shows the breakdown of energy use by fuel type for the industries in the United States in 1994. The petroleum and chemical industries account for the majority of total energy use in the United States. Together they comprise over half of all primary energy use. The chemical, pulp and paper, and aluminum industry are the predominant users of electricity. Natural gas use is most prevalent in the chemical, petroleum, pulp and paper, and steel industries. The largest quantity of fuel oil is used in the pulp and paper industry. Coke and coal, LPG, and refinery gas use are dominated, respectively, by the steel industry, the chemical industry, and the petroleum industry. The petroleum industry is also the primary user of petroleum coke.

Industry	**Net Electricity**	**Electricity Losses [a]**	**Natural Gas**	**Fuel Oil**	**Coke and Breeze**	**Coal**	**LPG**	**Refinery Gas**	**Petroleum Coke**	**Other**	**Total**
Aluminum SIC: 3334, 3353	207 (27)	437 (57)	77 (10)	NA	NA	NA	NA	NA	NA	46 (6)	767 (100)
Steel SIC: 3312	147 (7)	357 (17)	504 (24)	42 (2)	967 (46)	NA	NA	NA	NA	84 (4)	2102 (100)
Glass SIC: 321, 322, 323, 3296	45 (13)	95 (27)	210 (59)	4 (1)	NA	NA	NA	NA	NA	3 (1)	357 (100)
Pulp and Paper SIC: 26	225 (8)	NA	618 (22)	197 (7)	NA	337 (12)	NA	NA	NA	1434 (51) [b]	2811 (100)
Petroleum SIC: 2911	120 (2)	250 (4)	797 (12)	79 (1)	NA	NA	NA	1411 (21)	761 (11)	3438 (50) [c]	6856 (100)
Chemical SIC: 28	549 (8)	1104 (16)	2710 (40)	131 (2)	NA	309 (5)	1619 (24)	NA	NA	303 (5)	6725 (100)

[a] Losses result from generation, transmission, and distribution
[b] Includes black liquor and wood residue
[c] Includes petroleum feedstock

Table 1. Energy use by fuel for selected industries, 1994 (United States) [1×10^6 GJ (%)]

Source: Data compiled from Energy Information Administration (EIA), US Department of Energy (US DOE), (1994), 1994 Manufacturing Energy Consumption Survey, Table A1, available on-line at www.eia.doe.gov/emeu/mecs/mecs94/consumption/mecs5.html

Table 2 summarizes the percentage of energy consumption by specific end uses. In most industries, a considerable portion of energy is consumed by process heating and cooling applications. Energy use in boilers is most significant in the chemical and paper industries in the form of steam. The percentage of energy consumed by machine drives is fairly equivalent among the industries, whereas the proportion of electrochemical end use is the highest in the aluminum industry. Section 2.2 lists the main energy efficiency opportunities associated with the six selected industries, and Section 2.3 describes general energy efficiency trends in industrial process applications.

Industry	**Process Heating & Cooling**	**Boiler Fuel**	**Machine Drive**	**Facilities**	**Electro-chemical**	**Other**	**Not Reported**
Aluminum SIC: 3334, 3353	23	NA	7	NA	63	7	NA
Steel SIC: 3312	24	7	4	NA	NA	4	61
Glass SIC: 321, 322, 323, 3296	68	NA	8	3	NA	20	NA
Pulp and Paper SIC: 26	5	32	7	2	NA	2	52 [a]
Petroleum SIC: 2911	15	9	3	NA	NA	4	69 [b]
Chemical SIC: 28	27	43	13	2	2	8	5

NA, not applicable
[a] Contributions to end-uses from black liquor and wood residue were not recorded
[b] Contributions to end-uses from petroleum coke and refinery gas were not recorded

Table 2. Heat and power consumption by end-use for selected industries, 1994 (%, United States)

Source: Data compiled from Energy Information Administration (EIA), US Department of Energy (US DOE), (1994), 1994 Manufacturing Energy Consumption Survey, Table A10, available on-line at www.eia.doe.gov/emeu/mecs/mecs94/consumption/mecs5.html

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Biographical Sketches

Clark Gellings' 30-year career in energy spans from hands-on wiring in factories and homes to the design of lighting and energy systems to his invention of "demand-side management" (DSM). Mr. Gellings coined the term DSM and developed the accompanying DSM framework, guidebooks, and models now in use throughout the world. He provides leadership in EPRI, an organization that is second in the world only to the Department of Energy (in dollars) in the development of energy-efficiency technologies. Mr. Gellings has demonstrated a unique ability to understand what energy customers want and need and then implement systems to develop and deliver a set of research and development programs to meet the challenge. Among Mr. Gellings' most significant accomplishments is his success in leading a team with an outstanding track record in forging tailored collaborations—alliances among utilities, industry associations, government agencies, and academia—to leverage research and development dollars for the maximum benefit. Mr. Gellings has published 10 books, more than 400 articles, and has presented papers at numerous conferences. Some of his many honors include seven awards in lighting design and the Bernard Price Memorial Lecture Award of the South African Institute of Electrical Engineers. He has been elected a fellow in the Institute of Electrical and Electronics Engineers and the Illuminating Engineering Society of North America. He won the 1992 DSM Achiever of the Year Award of the Association of Energy Engineers for having invented DSM. He has served as an advisor to the U.S. Congress Office of Technical Assessment panel on energy efficiency, and currently serves as a member of the Board of Directors for the California Institute for Energy Efficiency.

Kelly E. Parmenter, PhD is a mechanical engineer with expertise in thermodynamics, heat transfer, fluid mechanics, and advanced materials. She has 14 years of experience in the energy sector as an engineering consultant. During that time, she has conducted energy audits and developed energy management programs for industrial, commercial, and educational facilities in the United States and in England. Recently, Dr. Parmenter has evaluated several new technologies for industrial applications, including methods to control microbial contamination in metalworking fluids, and air pollution control technologies. She also has 12 years of experience in the academic sector conducting experimental research projects in a variety of areas, such as mechanical and thermal properties of novel insulation and ablative materials, thermal contact resistance of pressed metal contacts, and drag reducing effects of dilute polymer solutions in pipeflow. Dr. Parmenter's areas of expertise include: energy efficiency, project management, research and analysis, heat transfer, and mechanical and thermal properties of materials.

Patricia Hurtado, P. E. is a mechanical engineer with a master in thermal sciences and over 20 years experience in the energy sector. She has worked as an energy planner for more than 10 years, conducting projects related to energy conservation, pollution reduction, building analysis, engineering modeling, strategic planning, market evaluation, program development and performance assessment, distribution and retail sector analysis, privatization evaluation in the electric utility sector, as well as energy sector restructuring, rate design and analysis. Her consulting assignments have included clients in the United States, Puerto Rico, Mexico, Colombia, and Thailand. Ms. Hurtado's areas of expertise include: energy system design and analysis, engineering simulation models, end-use data and engineering analysis, economic analysis, utility resource and strategic planning, forecasting, rate design and analysis, distribution and retail sector analysis, and technology and market assessments of new products and services.