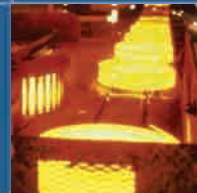


Energy Trends in Selected Manufacturing Sectors:

Opportunities and Challenges
for Environmentally Preferable
Energy Outcomes



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1. Introduction

1.1 Objectives

EPA's Sector Strategies Division (SSD) within the Office of Policy, Economics, and Innovation (OPEI) commissioned this analysis to meet the following objectives:

- Facilitate a general understanding of current energy usage and expected future energy consumption trends within 12 selected industrial manufacturing sectors.
- Assess where opportunities exist within these sectors to increase energy efficiency and use less emissions-intensive energy sources, resulting in improved environmental performance.
- Identify barriers to achieving improved environmental performance with respect to sector energy use, with a particular emphasis on regulatory barriers.
- Propose policy options EPA could pursue to address such regulatory barriers, promoting energy efficiency and less emissions-intensive energy sources in these 12 sectors.

Chapter 1. Introduction
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It is important to note that this report is an analytical document and does not convey Agency decisions. The report's findings and policy options are based on the available data used in this analysis.

1.2 Methodology

1.2.1 Sectors Addressed in This Analysis

Using North American Industry Classification System (NAICS) codes, 12 industrial manufacturing sectors are addressed in this analysis, as shown in Table 2.

Table 2: Manufacturing sectors addressed in this analysis

Sector	NAICS
Alumina and aluminum	3313
Cement	327310
Chemical manufacturing	325
Food manufacturing	311
Forest products ^d	321, 322
Iron and steel	331111
Metal casting	3315
Metal finishing	332813
Motor vehicle manufacturing ^e	33611
Motor vehicle parts manufacturing	3363
Petroleum refining	32411, 324110
Shipbuilding and ship repair	336611

^d Where data are available, this analysis provides detail on the two major subsectors of the forest products industry: pulp and paper and wood products.

^e Motor vehicle manufacturing (NAICS 33611) refers to automobile and light duty motor vehicle manufacturing and assembly.

Eight of these sectors—cement, chemical manufacturing (specifically, paint and coatings and specialty-batch chemicals), food manufacturing (specifically, agribusiness), iron and steel, metal casting, metal finishing, forest products, and shipbuilding and ship repair—currently participate in the Division’s Sector Strategies Program, which uses collaborative partnerships to promote widespread improvement in environmental performance with reduced administrative burden. Together, these 12 sectors represent a broad cross-section of the industrial manufacturing economy, and energy usage in these sectors constitutes a substantial fraction of total industrial energy demand in the United States. Energy-related environmental impacts include carbon emissions that contribute to climate change and criteria air pollutant (CAP) emissions that degrade local and regional air quality, potentially affecting attainment of National Ambient Air Quality Standards under the Clean Air Act.

Assessing energy usage trends and associated environmental impacts, as well as the viability of specific energy efficiency and clean energy opportunities, enables us to envision environmentally preferable energy outcomes. Understanding the ways in which regulations and statutes potentially create barriers to energy efficiency and clean energy investment suggests policy options EPA could pursue to promote environmentally preferable energy outcomes.

1.2.2 Data Sources and Caveats

This analysis relies on the best available and most recent public data sources in the following areas:

- **Historical and current energy consumption data:**
 - *Annual Energy Review (2005)*: For an overview of U.S. and industrial energy consumption trends, we relied on the most recent annual report containing historical energy statistics from 1949 to the present produced by the U.S. Department of Energy’s (DOE) Energy Information Administration (EIA).
 - *Manufacturing Energy Consumption Survey (MECS) (1998 and 2002)*: For detailed sector energy consumption data, including fuel use and energy intensity, we relied upon the two most recent issues of EIA’s survey of manufacturing energy use, which is conducted every four years.
- **Energy-related emissions data:**
 - *National Emissions Inventory (NEI) (2002)*: Data runs were conducted using the NEI database (*ALLNEI_CAP* dataset), prepared by EPA’s Emission Factor and Inventory group within the Office of Air Quality Planning and Standards, to produce sector-level data on energy-related emissions of CAPs, including sulfur dioxide, nitrogen oxides, particulate matter, and volatile organic compounds.
 - As NEI does not contain data on greenhouse gas (GHG) emissions, we also reference CO₂ emissions projections from the *Scenarios for a Clean Energy Future* (CEF) report and DOE’s most recent *Annual Energy Outlook* (AEO, described below under “*Energy consumption projections*”). Though EPA has compiled a *Greenhouse Gas Inventory* (April 2006) that includes some of the sectors addressed in this analysis, we used DOE sources for carbon emissions because they entail projections of future carbon emissions under business-as-usual and environmentally preferable energy scenarios.
- **Economic data:**
 - *Annual Survey of Manufacturers (2001 and 2004)*: U.S. Census Bureau data on economic production (in terms of value added and value of shipments) by sector were

obtained for the years 1997 to 2004. These sources also provided data on annual energy expenditures by sector.

- *CenStats Databases, County Business Patterns (2004)*: Information on the total number of establishments in each sector was obtained from the Census Bureau’s online searchable CenStats databases.
- **Energy consumption projections:**
 - *Scenarios for a Clean Energy Future (2000)*: This CEF report was commissioned by DOE with research conducted by the Interlaboratory Working Group for Energy-Efficient and Clean Energy Technologies. We used the report’s reference case and advanced energy case projections to illustrate how sector energy consumption trends might be different under what EPA considers an “environmentally preferable” energy scenario as compared to a business-as-usual energy scenario.^f
 - *Annual Energy Outlook (2006)*: For an overview of expected future trends for industrial energy consumption and associated CO₂ emissions, as well as energy projections for specific sectors, we referenced EIA’s most recent annual forecast of energy demand, supply, and prices through 2030. We also used the sector-specific projections of AEO 2006 to identify areas where recent energy trends may be expected to produce different outcomes than those projected by CEF in 2000.
 - *Natural Gas Outlook to 2020 (2005)*: This analysis was produced by the American Gas Foundation and contains consumption projections for certain industrial sectors that are heavily dependent on natural gas.^g
- **Energy efficiency and clean energy opportunities for industrial manufacturing industries:**
 - *Trade associations*: We consulted a number of online and hard copy materials produced by industry trade associations that describe technological and process opportunities for increasing energy efficiency.
 - *Voluntary programs*: Industry commitments to environmental improvement with respect to energy use—particularly through federal public-private partnership programs such as Climate VISION, which is supported by DOE, EPA, and the U.S. Departments of Transportation and Agriculture, and DOE’s Industrial Technologies Program—were reviewed for information on emerging industrial energy-efficient and clean energy opportunities for energy-intensive sectors, including developing technologies. Note that individual companies/facilities within each sector may also participate in other voluntary programs (e.g., ENERGY STAR, Performance Track, Climate Leaders, etc.); it was not the goal of this paper to research and reflect those individual commitments.
 - *National laboratories*: A number of national laboratory reports pertaining to industrial energy consumption were also reviewed and referenced in this analysis.

^f *Clean Energy Future* projections were available for 8 of the 12 sectors addressed in this analysis: alumina and aluminum, cement, chemical manufacturing, food manufacturing, forest products, iron and steel, metal casting, and petroleum refining.

^g *Natural Gas Outlook* projections were available for the following sectors: chemical manufacturing, food manufacturing, iron and steel, petroleum refining, and pulp and paper (within forest products).

- **Regulatory barriers to energy efficiency and clean energy improvement:**
 - *Trade associations:* We collected anecdotal information from the regulated community and reviewed industry trade association materials to identify key concerns with respect to federal, state, and local regulations that may pose barriers to energy efficiency or clean energy improvement.
 - *Government publications:* We also reviewed several analyses produced by federal regulatory agencies, including EPA, and national laboratories that discuss potential regulatory barriers to energy efficiency or clean energy improvement.

Though our research involved a thorough review of the most commonly referenced, publicly available information sources regarding energy consumption and associated environmental impacts, as well as energy efficiency and clean energy opportunities for industrial manufacturing sectors, this analysis did not involve an exhaustive literature search. Other important caveats regarding the data sources used in this analysis include the following:

- Sectors included in this analysis are defined according to the NAICS codes shown in Table 2. In some cases, the data sources consulted in this analysis do not align exactly with these sector definitions. In such instances, we use the closest available NAICS category to EPA's sector definition and note such differences between EPA's and the source's sector definition in a footnote.
- Though the *2002 Manufacturing Energy Consumption Survey* provides the most detailed data on sector energy consumption, energy prices have undergone major changes in the last four years, and the effects of such changes on sector energy consumption are not reflected in the 2002 MECS or other data sources used in this analysis.
- *Scenarios for a Clean Energy Future* provides the best available mechanism for illustrating how sector energy consumption might differ under an environmentally preferable energy scenario versus a business-as-usual scenario. At the same time, the study was produced in 2000 and thus does not reflect recent changes in economic production, energy prices, and technology advancements that affect industrial energy consumption.
- In this analysis, we seek to provide a structure for understanding the ways in which regulations can potentially serve as barriers to energy efficiency and clean energy improvement in industrial manufacturing sectors. Our research into regulatory barriers has focused on collecting anecdotal reports from the regulated community obtained through interviews with industry representatives and through a literature review, rather than a systematic survey approach.
- Our analysis of energy-related environmental impacts focuses primarily on a sector-by-sector assessment of potential changes in energy-related air emissions that could occur under business-as-usual and environmentally preferable energy scenarios. The report uses energy-related CAP emissions from the NEI database (where available). It also includes a more general assessment of opportunities to reduce GHG emissions, focusing on carbon dioxide. The report does not include emissions of hazardous air pollutants, or water or waste impacts resulting from energy use.
- The report first presents general trends in industrial energy consumption, and then current and future energy consumption and fuel use trends within each sector. It is important to note that this report indicates the amount of purchased electricity used by each sector, but does not attempt to quantify indirect energy-related emissions resulting from the

production of electricity by offsite electrical generating units. In other words, the energy-related emissions discussed in this report refer only to onsite emissions at industrial facilities.

- The analysis focuses on fuel inputs for energy use only and does not address feedstock fuel use. While some figures in the report represent total energy consumption data, which includes fuels used as feedstocks (i.e., raw material inputs in the manufacturing process), feedstock energy inputs may or may not contribute to CAP and GHG emissions. As feedstock fuel use does not represent an opportunity for reducing the environmental impacts associated with energy consumption, the reports focuses on energy inputs for fuel use only.

1.2.3 Organization of the Report

The major sections of this report are organized as follows, within “Insights” text boxes where appropriate:

- Chapter 2, *Current Energy Consumption*, characterizes sector energy consumption within the context of U.S. energy demand, assessing sector energy requirements in terms of fuel inputs, energy intensity, and end use applications. In assessing how energy is used and lost in industrial manufacturing processes, the section identifies five key opportunities for improving environmental performance with respect to energy consumption—cleaner fuels, combined heat and power, equipment retrofit/replacement, process improvement, and research and development. In addition, this section provides a broad overview of the environmental and economic context surrounding sector energy usage.
- Chapter 3, *Sector Energy Scenarios*, builds upon the overview of sector energy consumption, environmental impacts, and economic context developed in Chapter 2 and the energy projections described in Chapter 3 to develop “base case” and “best case” energy scenarios for each of the 12 sectors addressed in this analysis. The sections on each sector include the following:
 - A “situation assessment” that provides a general overview of the sector and describes key factors affecting sector energy use.
 - A “base case” energy scenario that describes (1) the expected future trend for sector energy consumption and (2) associated environmental impacts.
 - A “best case” energy scenario that assesses (1) key opportunities for improving environmental performance with respect to sector energy consumption, (2) potential barriers to implementing such opportunities, and (3) the ways in which an environmentally preferable energy scenario would differ from the “base case” scenario in terms of energy consumption and associated environmental impacts.
- Chapter 4, *Barriers to Environmentally Preferable Energy Outcomes*, provides an overview of financial, technical, institutional, and regulatory barriers to energy efficiency and clean energy improvement in industrial manufacturing sectors. In a focus on regulatory barriers, the chapter identifies key ways in which regulations can present barriers to investment in energy efficiency and clean energy opportunities.
- Chapter 5, *Policy Options*, sets forth possible actions EPA could take to address the regulatory barriers to energy efficiency and clean energy improvement discussed in Chapter 4.
- Appendix A, *Energy Projections*, provides an overview of the energy projections employed to develop business-as-usual versus environmentally preferable energy scenarios for the

12 sectors considered in this analysis. The appendix highlights key similarities and differences between the projections and includes a brief discussion of expected future trends in industrial energy consumption.