Energy Trends in Selected Manufacturing Sectors:

Opportunities and Challenges for Environmentally Preferable Energy Outcomes








March 2007

SectorStrategies

U.S. Environmental Protection Agency

Energy Trends in Selected Manufacturing Sectors: Opportunities and Challenges for Environmentally Preferable Energy Outcomes

Final Report

March 2007

Prepared for:
U.S. Environmental Protection Agency
Office of Policy, Economics, and Innovation
Sector Strategies Division

Prepared by:
ICF International
9300 Lee Highway
Fairfax, VA 22031
(703) 934-3000

Executive Summary

Objective

The objective of this report is to assist the Sector Strategies Division (SSD) of the U.S. Environmental Protection Agency (EPA) in developing strategies to promote environmentally preferable outcomes with respect to energy consumption in 12 industrial manufacturing sectors. For the purposes of this analysis, environmentally preferable energy outcomes are achieved by reductions in energy-related air emissions through increased energy efficiency (which reduces fuel consumption and associated emissions) and/or transitioning to less emissions-intensive energy sources. This analysis focuses primarily on emissions of criteria air pollutants (CAPs), but it also includes some projections of carbon dioxide (CO_2) emissions. Other air emissions, such as air toxics, and water and land impacts are not included.

12 Industrial Manufacturing Sectors Examined in This Report

- Alumina and aluminum
- Cement
- Chemical manufacturing
- Food manufacturing
- Forest products
- Iron and steel
- Metal casting
- Metal finishing
- Motor vehicle manufacturing
- Motor vehicle parts manufacturing
- Petroleum refining
- Shipbuilding and ship repair

Across the 12 sectors, this analysis characterizes energy consumption within the context of recent and expected future energy trends and provides a broad overview of the environmental and economic context surrounding sector energy usage. Building on this overview, the analysis provides sector-specific "base case" and "best case" energy scenarios, identifying opportunities for promoting environmentally preferable energy outcomes as well as potential regulatory and nonregulatory barriers to improved environmental outcomes. To address potential regulatory barriers to investment in energy efficiency and clean energy technologies in these sectors, this analysis proposes a number of policy options that EPA could pursue—both internally at EPA and externally in coordination with other agencies and stakeholders—to remove or reduce the barriers.

Approach

Drawing upon the most recent publicly available data sources that address energy consumption in these 12 industrial manufacturing sectors, as well as perspectives and insights provided through interviews with internal and external stakeholders, this report provides a broad overview of sector energy consumption, economic trends, and the environmental impacts of sector energy consumption in terms of energy-related air emissions. In a summary of each sector, we describe current energy trends and associated environmental impacts in terms of air emissions of CAPs and carbon dioxide. We project how future energy trends and associated emissions could be impacted by implementation of key opportunities for energy efficiency and clean energy improvement. We then discuss the ways in which regulations and other nonregulatory factors may create barriers to energy efficiency and clean energy improvement, providing specific examples from the literature we reviewed and the stakeholder interviews we conducted. Finally, we set forth several policy approaches that EPA could explore to address regulatory barriers and promote environmentally preferable outcomes with respect to energy consumption in these manufacturing sectors.

Key Energy Trend Findings

This analysis produced the following overarching insights:

- Comprising the largest fraction of total U.S. energy demand, the industrial sector presents considerable opportunities for improving environmental performance through increased adoption of energy efficiency and clean energy technologies.
- Industrial energy use has been growing more slowly than energy use in the residential, commercial, and transportation sectors. This is because industry as a whole has become a smaller proportion of the economy, has shifted to less energy-intensive types of manufacturing, and has already implemented a number of energy-saving technologies.
- Under a business-as-usual energy scenario, aggregated energy consumption across many of the sectors[a] addressed in this analysis is projected to increase by 20 percent from 2004 levels by 2020, and CO_2 emissions are projected to increase by 14 percent.[1] Faster growth is projected for onsite consumption of fossil fuels and renewable energy (a projected increase of 60 percent over the period) than for purchased electricity (a projected increase of 12 percent over the period).
- Rising energy costs and the pressures of global competition pose continuing challenges for industrial manufacturing sectors but also create an opportunity for energy efficiency to play an increasing role in helping businesses' competitive positions.
- The types of fuel used by industry have changed over time. During the last 50 years, industry has decreased direct coal use and increased natural gas use. Recent increases in both the price and price volatility of natural gas may interrupt these trends, although over the short term, most sectors are not able to switch fuels easily. Industrial use of renewable fuels is growing, and is already higher than the use of renewable fuels in the residential, commercial, and transportation sectors.
- For each sector, this analysis compares energy-related CAP emissions with total CAP emissions, including those that result from manufacturing processes. The primary CAP emissions resulting from energy use are sulfur dioxide and nitrogen oxides. In general, the largest sources of energy-related CAP emissions are external combustion boilers and manufacturing process equipment. Upstream emissions from electrical generating units that supply industrial energy users with purchased electricity are not included in this analysis. Only onsite emissions resulting from energy use are included.
- Investment in energy efficiency and clean energy is fundamentally a business decision, and the success of strategies to promote environmentally preferable energy outcomes will depend primarily on the business case for such investments.
- Strategies for promoting energy efficiency and clean energy investment should be tailored to address sector-specific economic trends and characteristics such as declining/increasing productivity, sensitivity to energy cost fluctuations, average firm size, the homo- or heterogeneity of manufacturing processes within the sector, and the sector's geographic distribution.

---

[a] The projections referenced here are contained in supplemental tables to the U.S. Department of Energy's *Annual Energy Outlook 2006* and apply to aggregated energy consumption and carbon dioxide emissions across the following sectors: aluminum, cement, bulk chemicals, food manufacturing, iron and steel, metals-based durables (containing metal finishing), pulp and paper (part of forest products), and petroleum refining.

Key Opportunities for Environmentally Preferable Energy Outcomes

Our analysis focuses on five key opportunities for improved environmental performance with respect to energy usage in industrial manufacturing sectors. Following is a brief definition of each opportunity:[b]

- ***Cleaner fuels.*** Current fuel sources could be replaced with alternate fuels that have lower carbon and/or CAP emissions per unit of energy. This opportunity also includes self-generation of energy with renewable resources (biomass, solar, wind, and geothermal).
- ***Combined heat and power (CHP).*** A form of distributed generation also referred to as "cogeneration," a CHP system increases energy efficiency through onsite production of thermal energy (typically steam) and electricity from a single fuel source.
- ***Equipment retrofit/replacement.*** Energy efficiency could be improved by retrofitting or replacing existing equipment used for onsite heat or power generation and distribution, manufacturing processes, or meeting facility requirements such as lighting and heating, ventilating, and air conditioning (HVAC).
- ***Process improvement.*** Process improvement or optimization refers to either a wholesale process change that requires less energy for a similar level of manufacturing output or an adjustment to the manufacturing process that increases energy efficiency. The process improvement category also includes implementation of best practices in energy management.
- ***Research and development (R&D).*** R&D could focus on developing new energy-efficient or clean energy technologies and processes that could be commercialized within the next one to two decades.

Nonregulatory Barriers to Environmentally Preferable Energy Outcomes

Several nonregulatory factors, including financial, technical, and institutional barriers, limit broader application of the energy efficiency and clean energy technologies addressed in this analysis, and hinder the achievement of environmentally preferable energy outcomes in manufacturing industries:

- ***Financial barriers.*** Most of the energy consumed in the industrial sector is consumed in a few basic industries that produce commodity products—such as steel, basic chemicals, petroleum products, and paper—that are subject to stiff domestic and international competition. Some of these industries have already seen major declines in the United States and are concerned about their future viability. These industries have little appetite for new capital investment at this time, unless it is likely to bolster their future success. Given scarce capital resources in general, the greatest investment priorities are typically for equipment that maintains or increases production and product quality, or is necessary to meet regulatory requirements. Discretionary investments for energy efficiency or clean energy projects must often compete with these higher-priority investments.
- ***Technical barriers.*** Some energy efficiency or clean energy opportunities are not well suited to a given industry's manufacturing process. In other cases, process-related technical constraints affect the extent to which a given opportunity can be utilized.

[b] Section 2.2.6 contains a more complete definition of each opportunity with important caveats.

- ***Institutional barriers.*** Energy is a small component of the cost of production in most industries. Only in the most energy-intensive industries—such as aluminum, cement, segments of the chemical manufacturing industry, iron and steel, metal casting, and pulp and paper—do energy costs represent more than 3 percent of the industry's annual value of shipments.[c] This reality minimizes institutional incentives to devote organizational resources to pursuing energy efficiency opportunities.

Regulatory Barriers to Environmentally Preferable Energy Outcomes

Regulations also may limit broader application of energy efficiency and clean energy technologies and impede the achievement of environmentally preferable energy outcomes in manufacturing industries. Given EPA's role in developing and coordinating regulations and policies aimed at improving environmental performance, this analysis focuses on regulatory barriers, describing four ways in which regulations—issued by EPA or other agencies—may create barriers to energy efficiency and clean energy improvement:

- Regulations may fail to fully reward the environmental benefits associated with an energy efficiency opportunity, which restricts the potential for businesses to evaluate energy efficiency on an equivalent basis with other pollution control strategies such as add-on controls.
- Regulations may lack procedural flexibility that allows pursuit of energy efficiency or cleaner fuel opportunities, particularly in areas where permitting changes are required to implement an opportunity.
- The rulemaking process may fail to fully consider the energy implications of proposed regulations.
- Regulations or policies may contribute to unfavorable market conditions for energy efficiency or clean energy opportunities.

Sector Opportunity Assessment

For each sector, the report assesses the viability of the five key energy efficiency and clean energy opportunities discussed above, given the financial, technical, institutional and regulatory barriers facing each sector. The analysis ranks the viability of each opportunity as "low," "medium," or "high" based on a qualitative assessment of the magnitude of relevant barriers, rather than a quantitative assessment of energy-savings potential. Table 1 provides a summary of the opportunity assessment rankings for each sector.

Table 1: Sector opportunity assessment summary table

Sector	Opportunities				
	Cleaner Fuels	Combined Heat and Power	Equipment Retrofit/ Replacement	Process Improvement	Research and Development
Alumina and aluminum	Low	Low	Medium	Medium	Medium
Cement	Medium	Low	High	High	Medium
Chemical manufacturing	Medium	High	Medium	Medium	Medium
Food manufacturing	Medium	High	Medium	High	Medium

[c] See Table 9 for energy intensity metrics for each sector, including energy costs per dollar value of shipments.

Sector	Opportunities				
	Cleaner Fuels	Combined Heat and Power	Equipment Retrofit/ Replacement	Process Improvement	Research and Development
Forest products	Medium	Low	Medium	High	High
Iron and steel					
Integrated steelmaking	Low	Medium	Low	Medium	High
EAF steelmaking	Low	Low	Low	Medium	High
Metal casting	Low	Low	Medium	Medium	Medium
Metal finishing	Low	Medium	Medium	High	Medium
Motor vehicle manufacturing	Low	Low	Medium	High	Medium
Motor vehicle parts manufacturing	Low	Low	Medium	High	Low
Petroleum refining	Low	High	Medium	Medium	Medium
Shipbuilding and ship repair	Low	Low	High	High	Low

A key observation from this table is that the viability of a given energy efficiency or clean energy opportunity varies from sector to sector. In addition, for any given manufacturing facility the viability of an opportunity will depend on facility-specific characteristics and operating conditions.

Additional findings from the sector opportunity assessment include the following:

- ***Cleaner fuels.*** Given the technical, financial, and regulatory constraints on fuel-switching, the extent of cleaner fuels opportunities is somewhat limited. However, renewable biomass fuels in the forest products industry, bio-waste in the food manufacturing industry, byproduct fuels in the chemical manufacturing industry, and waste fuels in the cement industry may represent opportunities for improved environmental performance as well as opportunities for reducing the cost of purchased energy for manufacturing industries.
- ***CHP.*** For sectors with high process thermal loads such as chemical manufacturing, food manufacturing, and petroleum refining, a key opportunity for reducing fuel use and associated CAP and CO_2 emissions lies with onsite generation of thermal and electric energy. In sectors that already meet the majority of their thermal or electric energy requirements with CHP, like the forest products industry, future opportunities may be limited.
- ***Equipment retrofit/replacement.*** Reduced fuel use through increased boiler efficiency represents an opportunity to reduce energy-related emissions across multiple sectors, as boilers are among the largest sources of CAP and CO_2 emissions in the industries covered in this analysis. According to National Emissions Inventory (NEI) data, the sectors with the largest energy-related CAP emissions from boilers are forest products, chemical manufacturing, and food manufacturing.
- ***Process improvement.*** Sectors with relatively low energy use and associated emissions represent smaller areas of opportunity for energy-related environmental improvement. Key energy-savings opportunities in these sectors lie with implementation of best practices in energy management as well as with energy efficiency upgrades to electric motors and compressed air systems, facility lighting, and HVAC systems.

- ***R&D.*** Transformational technologies and processes can potentially yield substantial energy savings in sectors such as forest products and iron and steel. In forest products, technologies to reduce drying needs in papermaking, improve fuel concentration in recovery boilers, and increase fuel efficiencies in lime kilns are among the most promising R&D opportunities. New technologies under development in iron and steel include molten oxide electrolysis, ironmaking by flash smelting using hydrogen, and the paired straight hearth furnace.

Policy Options

Based on the evaluation of clean energy opportunities and the potential barriers to those opportunities, as well as EPA's goal to promote environmentally preferable energy outcomes, the report outlines policy options EPA could pursue to address regulatory barriers to energy efficiency and clean energy investment. We offer the following policy options for discussion—both internal to EPA and involving coordination with other agencies—noting that the Agency will determine the definitive actions it intends to undertake:

- ***Develop and promote broader application of regulations that recognize the emission reductions resulting from increased energy efficiency*.** Create additional mechanisms for energy efficiency to serve as a pollution control strategy through the following regulatory approaches:
  - Promoting broader use of output-based emissions standards that account for CHP technology's thermal and electric energy output.
  - Promoting broader use of output-based emissions standards in regulations governing other combustion processes such as energy-generating and manufacturing process equipment.
- ***Increase procedural flexibility to promote environmentally preferable energy use.*** Address permit-related barriers to reducing energy-related emissions on a system-wide level through the following activities:
  - Expanding flexible permitting opportunities that promote reductions in energy-related emissions as part of a pollution prevention strategy, including developing a flexible permitting rule.
  - Promoting broader recycling of wastes and process byproducts for energy recovery.
  - Providing assistance to the regulated community as well as state and local permitting authorities in support of efforts to increase procedural flexibility in environmental regulations, including technical guidance on evaluating energy-related environmental tradeoffs at a system-wide level.
- ***Promote broader consideration of energy implications of rulemakings.*** Review methodologies currently used to assess energy impacts during the rulemaking process, assess how program offices are interpreting/implementing these provisions, and work across the Agency to develop a cohesive EPA position on how such impacts should be assessed and weighed against other Agency priorities.
- ***Promote the development of more favorable market conditions for energy efficiency and clean energy technologies.*** Strengthen policy support for energy efficiency and clean energy technologies by conducting the following activities:
  - Coordinating across federal agencies to support policies that promote the market viability of energy efficiency and clean energy technologies.

  - Offering additional grants to support clean energy applications in manufacturing industries.
  - Analyzing the environmental impacts of utility demand response programs and working to promote clean energy technologies as a strategy to reduce electricity demand.

- ***Provide additional incentives and assistance through a sector-based approach*.** Promote environmentally preferable energy outcomes in manufacturing industries through the following mechanisms:
  - Supporting energy efficiency and clean energy R&D opportunities through information-sharing and recognition of industry achievements.
  - Providing information regarding financial incentives that are available to support energy efficiency and clean energy opportunities, particularly for small businesses.