U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

2008 INDUSTRIAL TECHNOLOGIES MARKET REPORT

MAY 2009

CONTENTS

ABOUT THIS REPORT

This market report was sponsored by the Industrial Technologies Program within the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE). Market analysis is a critical component of EERE's planning and analysis activities. Market analysis examines factors that shape the markets for EERE products and technologies, and provides sector-specific information needed for benefits and policy analysis.

The report is neither a description of the Department's programs nor a comprehensive review of the entire U.S. industrial sector. Its intent, rather, is to document apparent market and energy trends in major manufacturing industries based on published data from government and select industry sources. The report quantifies recent trends in the industrial sector in the first of what is envisioned to be an ongoing series.

One of the challenges with manufacturing and industrial data is the infrequent nature and time lag between the data year and data availability for some of the more robust data surveys. In particular, the Manufacturing Energy Consumption Survey (MECS) by the Energy Information Administration is conducted every four years, with the latest survey representing data from 2002; and the Economic Census by the Commerce Department is conducted every five years, with the latest census report also representing information from 2002. Future editions of this market report will include data from the 2006 MECS and 2007 Economic Census reports.

Contributors and Acknowledgments

This report was prepared under the direction of Bhima Sastri from the U.S. DOE Industrial Technologies Program. Authors included Sabine Brueske, Pamela de los Reyes, Keith Jamison, Mauricio Justiniano, Nancy Margolis, Joe Monfort, Anand Raghunathan, and Ridah Sabouni, all from Energetics Incorporated. Graphics and document layout assistance were provided by Julie Chappell, Teresa Kowalczyk, and Stephen Namie of Energetics Incorporated.

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DATA IN THIS REPORT

Unless otherwise indicated, this report uses economic statistics from official government sources, including value of industry shipments, employment, trade balance, capital investment, etc. In some instances, industries collect their own industry statistics through trade associations, trade journals, or other means. For a number of reasons, this data will often differ from official government statistics.

In this report, the use of government statistics helps to ensure consistent industry definitions and uniform time intervals. This, in turn, helps to enable more reliable aggregation across industries and more dependable inter-industry comparisons.

Each section lists pertinent economic and environmental statistics where available. Exceptions are noted.

Overview

Establishments:

2002 Economic Census, U.S. Census Bureau, except data from various sources for the following: aluminum producers (2008), glass plants, steel mills (2007), mines (2007), and petroleum refineries (2008)

Employees:

2006 Annual Survey of Manufactures
U.S. Census Bureau

Production:

2007 data from various sources, except the following: Metal Casting, Mining (2006); Transportation Equipment (2005 and 2006); and Forest Products (2003)

Value of Shipments/Revenues:

2006 Annual Survey of Manufactures
U.S. Census Bureau

Trade Balance:

Dec. 2007 data accessed from
U.S. International Trade Commission Dataweb

Investments

Capital Expenditures:

2006 Annual Survey of Manufactures
U.S. Census Bureau

R&D Expenditures:

U.S. Business R&D Expenditures Increase in 2006; Companies' Own and Federal Contributions Rise
National Science Foundation

Energy Expenditures:

2006 Annual Survey of Manufactures
U.S. Census Bureau

Energy And Environment

Energy Consumption:

2002 Manufacturing Energy Consumption Survey,
U. S. DOE, Energy Information Administration

Estimated Carbon Emissions:

- Energy-Related Emissions: 2002 data from *Energy-Related Carbon Dioxide Emissions in U.S. Manufacturing*, U.S. DOE, Energy Information Administration, November 2006
- Process-Related Emissions: 2002 data from *Emissions of Greenhouse Gases in the United States*, U.S. Department of Energy, Energy Information Administration, 2007

Emissions of Criteria Air Pollutants:

2002 data accessed from AirData Website, Facility SIC Report: Criteria Air Pollutants, U.S. Environmental Protection Agency

Purchased Energy Costs for Heat and Power:

2006 Annual Survey of Manufactures
U.S. Census Bureau

Pollution Control Costs:

Pollution Abatement Costs and Expenditures: 2005
U.S. Census Bureau, April 2008

EXECUTIVE SUMMARY

The industrial sector is a critical component of the U.S. economy, providing an array of consumer, transportation, and national defense-related goods we rely on every day. Unlike many other economic sectors, however, the industrial sector must compete globally for raw materials, production, and sales. Though our homes, stores, hospitals, and vehicles are located within our borders, elements of our goods-producing industries could potentially be moved offshore. Keeping U.S. industry competitive is essential to maintaining and growing the U.S. economy.

This report begins with an overview of trends in industrial sector energy use. In addition to being the largest energy-consuming sector in the United States, the industrial sector is almost the most diverse in terms of both the types of energy services required and the mix of energy sources used to provide those services. Trends in industry's emissions of greenhouse gases are also presented. Market and economic data for key industrial sectors provide the reader with a better understanding of the factors of production, including labor, capital, and energy.

The next section of the report focuses on some of the largest and most energy-intensive industrial subsectors. For these subsectors – including chemicals production, petroleum refining, steelmaking, pulp and paper, food processing, and others – the report provides market, financial, energy, and environmental data and trends. Each industry's supply chain and select stakeholders are also briefly described.

The report also highlights several emerging technologies that could transform key segments of industry. A brief near-term outlook for the industrial sector is also provided, but remains uncertain given the current economic environment. Finally, the report presents policies, incentives, and drivers that can influence the competitiveness of U.S. industrial firms. Technology innovation can help our Nation's industries advance their global competitiveness, keeping jobs in America and reducing our reliance on imported oil and other goods.

INTRODUCTION

Industrial Sector Energy Consumption Continues to Decline Gradually

In 2007, U.S. industrial sector energy consumption was 32.3 Quadrillion Btu (quads). This was about 32% of total U.S. energy use in 2007 and considerably less than the record 1997 level of 35.3 quads. Excluding electric utility generation and transmission losses, net industrial energy use was 24.9 quads.

Industrial energy intensity is often used to gauge trends in the efficiency of energy use. Energy intensity refers to the amount of energy used to produce a unit of output (typically, Btu of energy per dollar of output or gross domestic product (GDP)). Over the past 10 years, trends in energy consumption and intensity include:

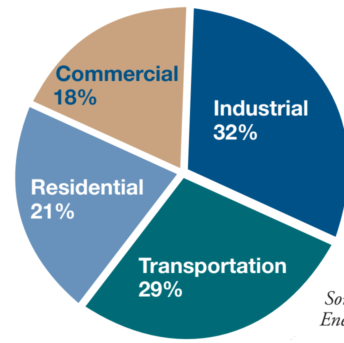
- Slowly declining industrial energy consumption as the economy continues to shift away from energy-intensive manufacturing industries.
- Nearly 20% improvement in energy intensity, which may stem from rising energy prices and increased concern about global warming.
- Overall increase in value added, which is the measure for productive services (such as labor and capital) that increase the value of materials being processed.

Energy Use Dominated by Fossil Energy Sources

Industrial sector energy use is dominated by fossil energy sources, primarily natural gas and petroleum. However, electricity is also a major source of energy as many fabrication and assembly industries, including electrical equipment and instruments, are more reliant on electricity than the basic material processing industries. About half the petroleum and nearly 10% of the natural gas consumed by industry are used as feedstock instead of heat and power. Other highlights include:

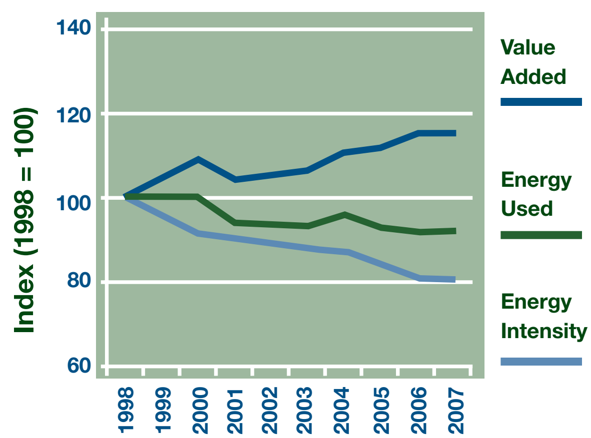
- Petroleum is currently the most popular source of energy because of its use as a feedstock.
- Natural gas is currently the largest energy source for fuel, in part due to its clean burning nature.
- Coal use continues to slowly decline.
- Biomass and other renewable forms of energy now account for more industrial energy use than coal.

TOTAL U.S. ENERGY USE, 2007
101.6 Quadrillion Btu



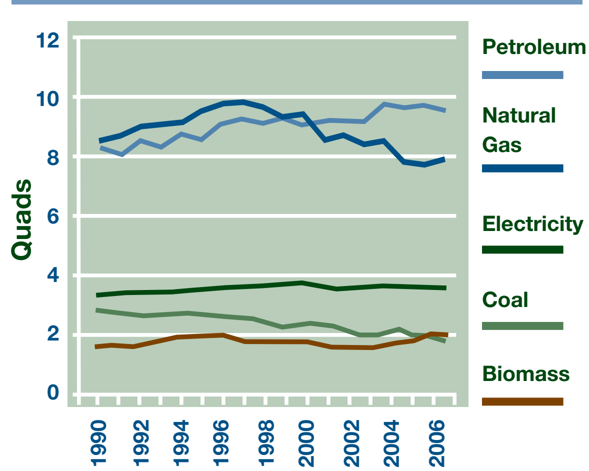
Source: EIA Annual Energy Review 2007

INDUSTRIAL ENERGY INTENSITY, CONSUMPTION, AND VALUE ADDED 1998-2007



Source: EIA Annual Energy Review 2007 & Bureau of Economic Analysis

INDUSTRIAL ENERGY CONSUMPTION BY SOURCE, 1990-2007



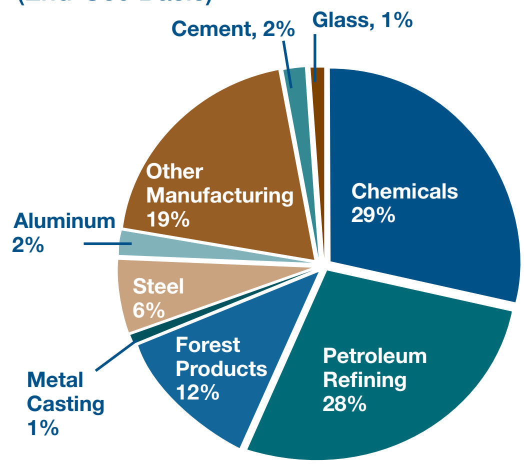
Source: EIA Annual Energy Review 2007

Energy-Intensive Industries Account For Over Two-Thirds Of Industrial Energy Use

Within industry, manufacturing accounts for about 85% of industrial energy use. The non-manufacturing industries – agriculture, mining, oil and gas extraction, and construction – account for the remainder. A few energy-intensive, basic material industries within the manufacturing sector – aluminum, cement, chemicals, forest products, glass, metal casting, petroleum refining, and steel – account for about 80% of manufacturing energy use (end-use basis). Including mining, these energy-intensive industries account for over two-thirds of all industrial energy use.

These industries use so much energy because they are involved in chemically or physically transforming matter, employing technologies that rely on heat to break and rearrange molecular bonds through chemical reactions. Massive amounts of energy are required for this transformation process.

MANUFACTURING ENERGY USE BY INDUSTRY, 2002
(End-Use Basis)



Total = 22.7 Quads

Source: EIA MECS

The Use of Energy

Industry uses energy in a variety of ways. Steam – produced in boilers and available from cogeneration – represents the largest use of energy. Direct process heat – generated in furnaces, ovens, kilns, and similar equipment – is used for melting and smelting, curing and drying, and other processes. Electricity is used for driving machines such as pumps, fans, compressors, materials handling equipment, as well as process heating. Other important uses of energy include electrolytic processing, space heating and lighting. In addition, petroleum products are also used as feedstocks in the chemical, steel, and petroleum refining industries.

Of reported energy consumption in 2002, manufacturing industries used:

- ~ 8,190 trillion Btu as feedstocks or raw materials
- ~ 3,600 trillion Btu for process heating
- > 3,100 trillion Btu as either boiler fuel or for cogeneration purposes
- ~ 1,560 trillion Btu to operate machines
- > 970 trillion Btu to operate facilities (lighting, heating/cooling, etc.)
- ~ 240 trillion Btu in electrochemical processes
- ~ 240 trillion Btu for process cooling or refrigeration

The end-use for over 6,300 trillion Btu was not reported; a large portion of this amount is assumed to be used to generate steam.

Industry Spends Over $200 Billion Annually For Energy

The U.S. industrial sector spent $227 billion on energy in 2006. Although this is a very large sum, it represents only about 3% of the sector's total output. Petroleum, purchased electricity, and natural gas accounted for the largest expenditures. Other items of interest include:

- Even though purchased electricity accounted for 26% of total energy costs, it represented only 14% of industrial sector energy use on an end-use Btu basis, in part due to losses during electricity production and delivery.
- Petroleum was significantly more expensive than natural gas on a Btu basis in 2006, though these fuels have considerable price volatility from year to year.
- Biomass and coal remained relatively inexpensive fuels on a Btu basis.

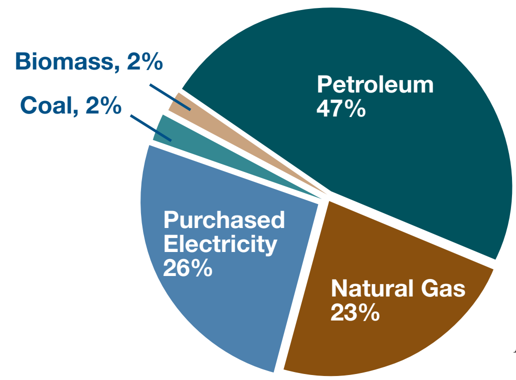
Energy-Intensive Industries Have Considerably Higher Energy Bills

Purchased energy costs vary substantially throughout the industrial sector. However, energy-intensive industries have much higher than average energy costs. In some industries, such as primary aluminum, cement, and portions of the chemical industry, energy costs can be 5 to 10 times the average of industry overall. Fabrication industries, on the other hand, generally have lower than average energy costs.

When energy prices are high, firms in energy intensive industries aggressively seek energy conservation measures and switch fuels to lower their energy costs. In times of relatively low energy prices, investment in energy efficient technologies typically also reflects substantial productivity or environmental benefits for the industrial user.

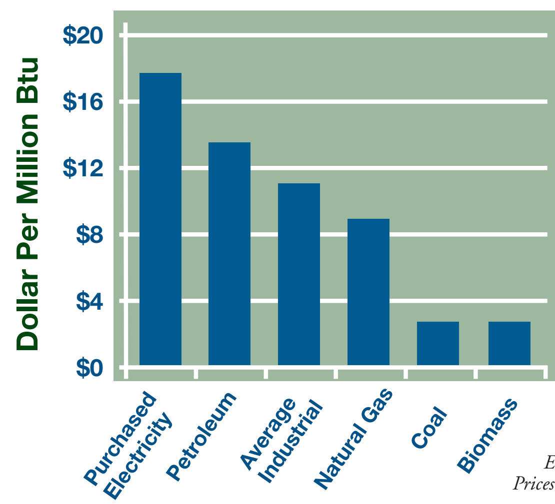
INDUSTRIAL ENERGY COSTS, 2006

Total Expenditures = $226.9 Billion



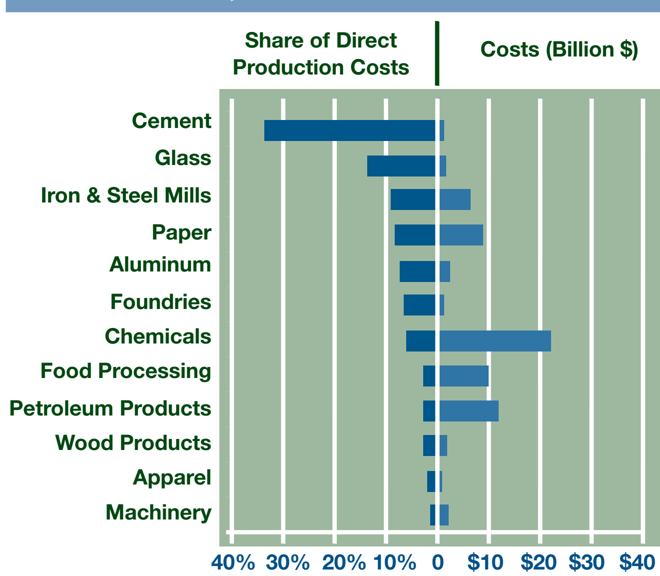
Source: EIA State Energy Data 2006: Prices and Expenditures

INDUSTRIAL ENERGY PRICES BY FUEL, 2006



Source: EIA State Energy Data 2006: Prices and Expenditures

PURCHASED ENERGY FOR HEAT AND POWER, 2006



Source: Annual Survey of Manufactures 2006, U.S. Census Bureau

Greenhouse Gas Emissions

Greenhouse gases comprise a group of gaseous wastes that are associated with global climate change. Major contributors include carbon dioxide (CO_2), methane, nitrous oxide, and chlorofluorocarbons (CFCs). The industrial sector emitted an estimated 2.61 billion metric tons of carbon dioxide equivalent in 2007, or nearly 36% of total U.S. greenhouse gas emissions in 2007.

Carbon Dioxide

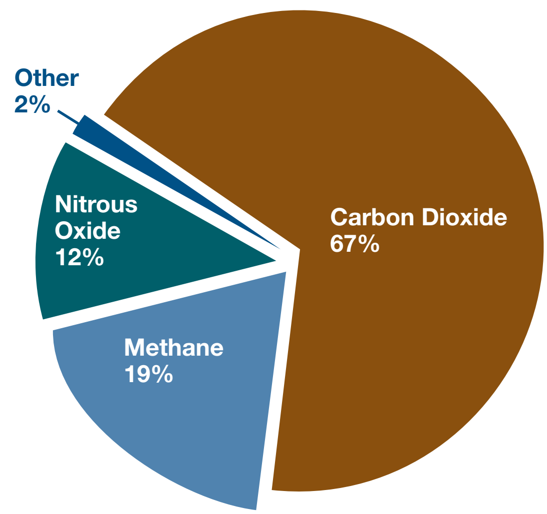
Carbon dioxide contributes the largest portion of greenhouse gases emitted by industry. It is produced by fossil fuel combustion and certain industrial processes (including cement manufacture, lime manufacture, limestone in steelmaking, carbon dioxide manufacture, soda ash manufacture and use, and aluminum production). In 2007, an estimated 1.76 billion metric tons of CO_2 was emitted by industry, slightly less than the amount emitted by industry in 1990. This represented 29% of total U.S. CO_2 emissions. Of this amount, energy use accounted for 94% of these emissions while industrial processes account for the remaining 6%.

Other Industrial Greenhouse Gas Emissions

Industrial methane emissions, which result from agricultural activities and energy production and use, were estimated at 498 million metric tons of CO_2-equivalent in 2007. Industrial nitrous oxide emissions, primarily from the agricultural sector, were estimated at 314 million metric tons of CO_2-equivalent in 2007. Other highly potent greenhouse gases, such as hydrofluorocarbons and perfluorocarbons, accounted for 39 million metric tons of CO_2-equivalent in 2007.

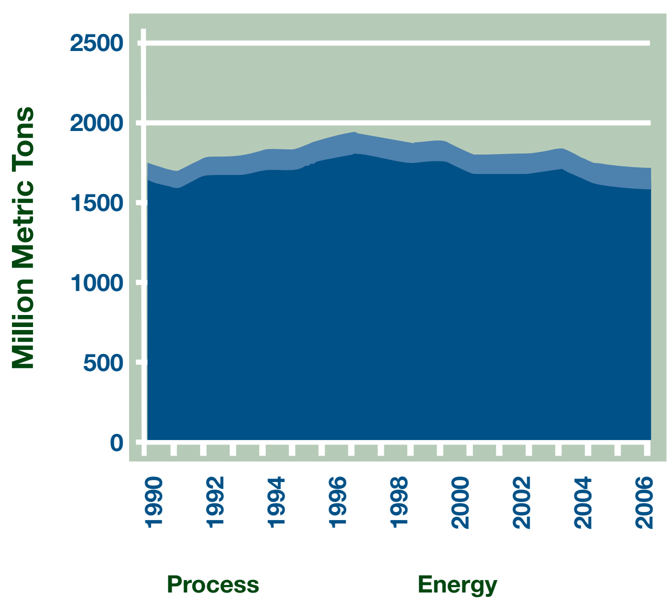
INDUSTRIAL GREENHOUSE GAS EMISSIONS ON A CARBON-EQUIVALENT BASIS, 2007

Total = 2.6 billion tons of CO_2-equivalent



Source: EIA Emissions of Greenhouse Gases in the United States 2007

INDUSTRIAL CO_2 EMISSIONS 1990-2007

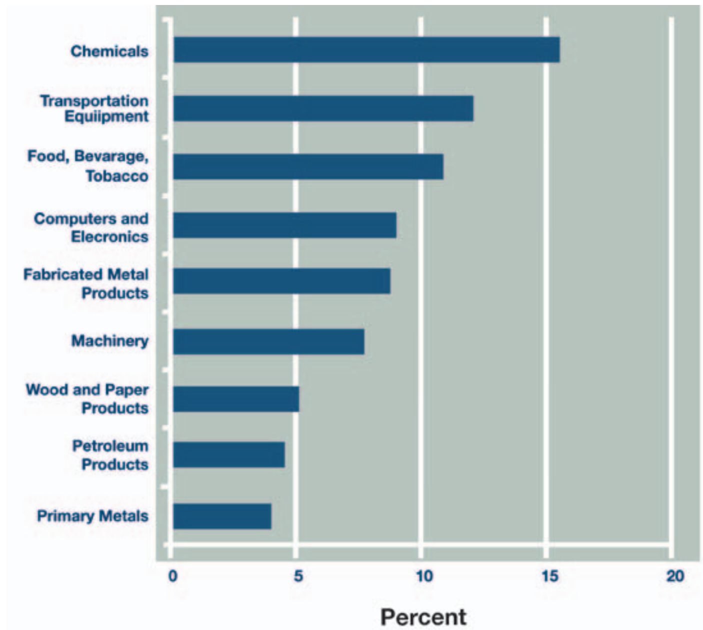


Source: EIA Emissions of Greenhouse Gases in the United States, various years

Role Of Industry In The Economy

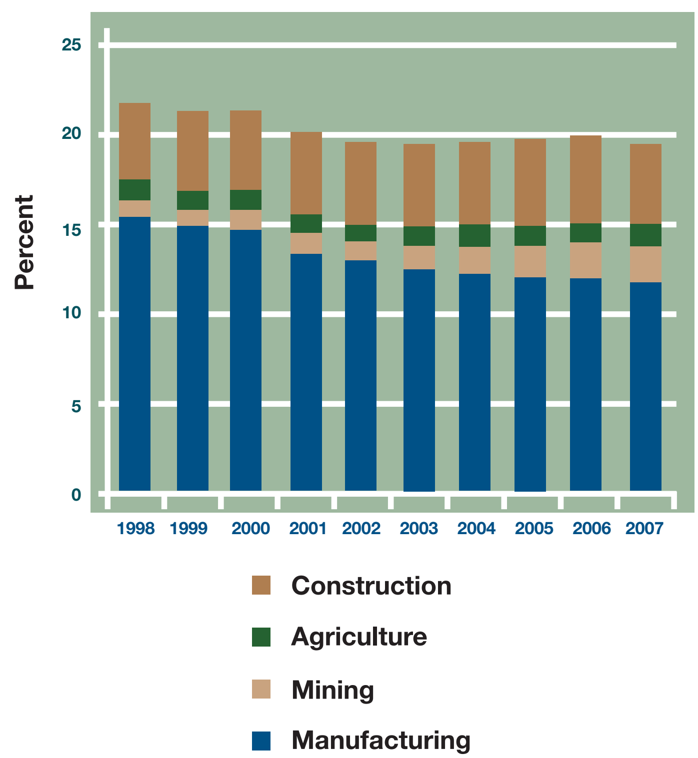
In 2006, energy-intensive industries shipped a total in excess of $1.5 trillion worth of products. This included about $657 billion in shipments by the chemical industry, $281 billion by the forest products industry, and $547 billion by the petroleum products industry. These industries, along with other manufacturing industries, directly accounted for about 12% of all U.S. economic output in 2007, down from 15% in 1998. Together with other goods-producing sectors (such as construction, agriculture/fishing/forestry), the industrial sector still represents nearly 20% of our Nation's total economic product.

CONTRIBUTION TO MANUFACTURING PORTION OF GDP FOR SELECTED INDUSTRIES, 2007



Source: Bureau of Economic Analysis

INDUSTRIAL SHARE OF GDP, 1998 - 2007



Source: Bureau of Economic Analysis

Capital Requirements

Manufacturers need to make large capital investments to increase productivity and remain competitive in the global marketplace. In 2006, manufacturers expended $135.8 billion for capital improvements, equivalent to about 2.9% of their value of products shipped. Due to size, throughput, and economies of scale, energy-intensive manufacturing industries are typically capital intensive. For example, the cement industry spent the equivalent of almost 9% of its value of shipments for capital improvements in 2006. On the other hand, the petroleum products industry only expended the equivalent of 2.2% of its value of shipments for capital in the same year.

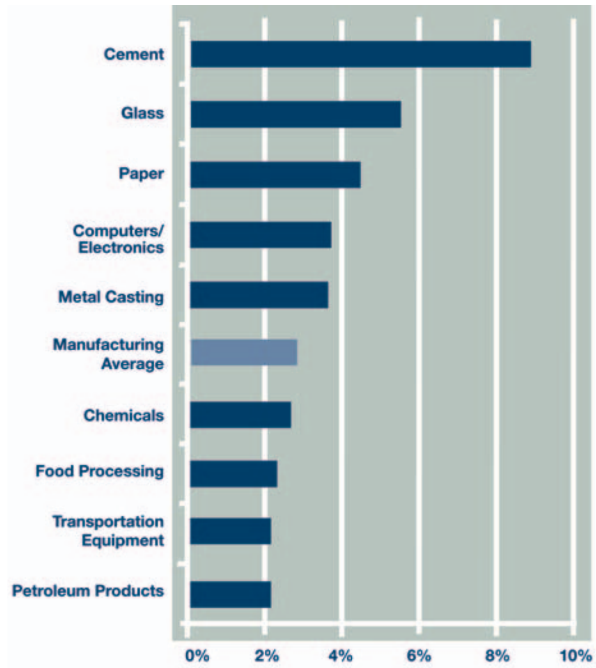
Although capital expenditures will vary for a given industry from year-to-year, investments can be made to:

- expand production through new plants,
- upgrade or automate existing facilities, or
- implement new technology or pollution control equipment.

Overall, Production Increases Are Lagging in Manufacturing

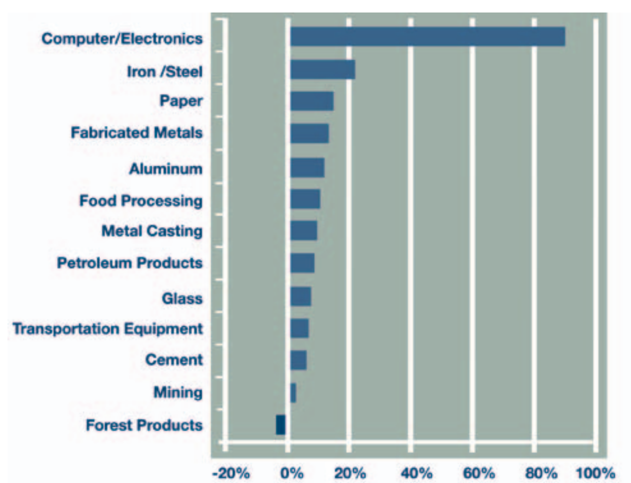
As one might expect from mature, commodity-based industries with substantial foreign competition, many energy-intensive industries lag overall gains in production. In part this is because of the high growth of several other manufacturing industries, most notable the high technology area (including computers and electronic equipment) which has increased its production by about 90% from 2002 to 2007.

CAPITAL EXPENDITURES AS A PERCENT OF SHIPMENTS FOR SELECT INDUSTRIES, 2006



Source: Annual Survey of Manufactures 2006, U.S. Census Bureau

CHANGE IN PRODUCTION LEVEL, 2002 AVERAGE TO DECEMBER 2007



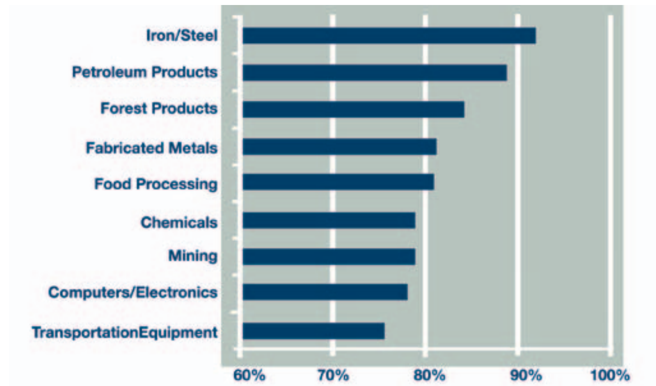
Source: Federal Reserve, Publication G.17 (Industrial Production and Capacity Utilization)

Capacity Utilization Varies Among Industries

Accompanying production is the capacity available for increased output. Utilization rates vary significantly among energy-intensive industries and vary depending on the overall health of the economy. On the whole, most energy-intensive industries operate at capacities greater than the manufacturing average. Normally, above 85% utilization indicates the potential for bottlenecks and delays to develop, which can lead to higher customer prices and increased waiting times for products. In December 2007, of particular note were the very high utilization of iron and steel facilities and petroleum refineries (though currently, utilization levels are much lower). And while the computer and electronics and chemical industries exhibited high production growth, they had ample capacity to meet customer needs.

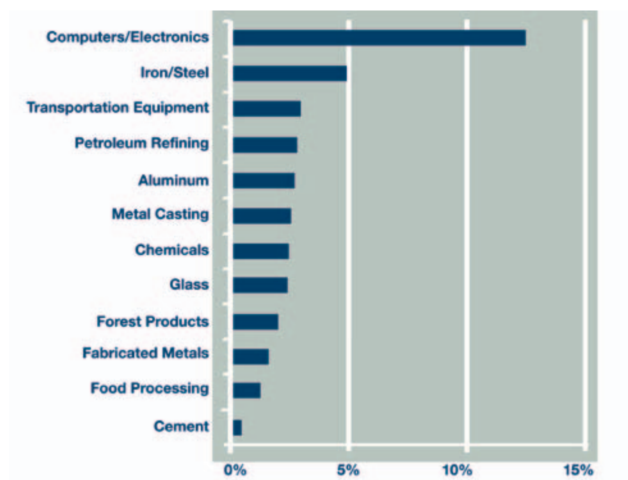
In many instances, expenditures on capital also bring about increases in productivity. On a long-term basis, adjustments will be made to balance labor and capital needs. And unfortunately, while capital investments are necessary for competitive reasons and provide economic benefits, they can also bring about a reduced need for human capital in individual manufacturing facilities.

CAPACITY UTILIZATION, DECEMBER 2007



Source: Federal Reserve, Publication G.17 (Industrial Production and Capacity Utilization)

ANNUAL PRODUCTIVITY INCREASE, 1987-2006



Source: Bureau of Labor Statistics

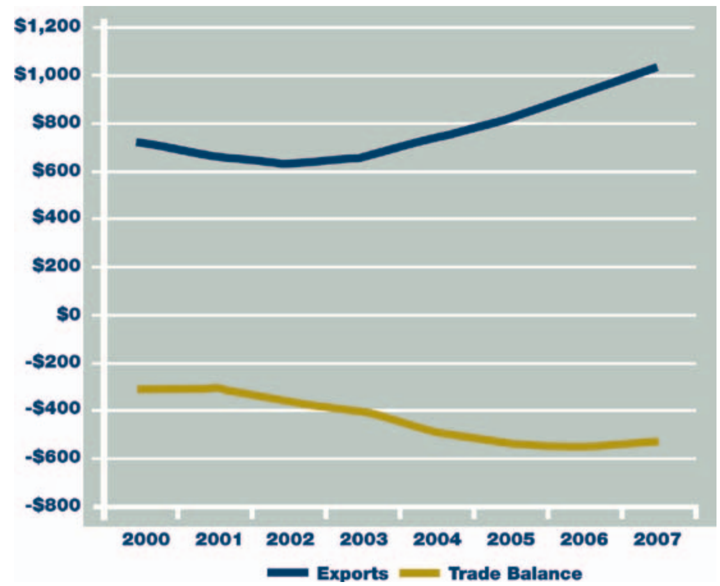
Manufacturing Exports Are Growing

Manufacturing accounts for the majority of U.S. exports, though the U.S. has run a trade deficit in manufactured goods for many years. Total manufacturing exports in 2007 were $1.02 trillion and were substantially exceeded by the $1.55 trillion in imports of manufactured goods. However, exports have risen over the years, up from $622 billion in 2002.

Individually, even though energy-intensive industries are considered among the most technologically advanced and competitive in the world, they all face intense foreign competition. This is especially true for commodity-oriented products that are easily transportable. For example, petroleum refining, which is subject to capacity constraints and depends on foreign crude oil, and steel, which has strong political support in other countries, have substantial trade deficits. In addition, resource-rich developing countries want to add greater value to raw commodities such as oil, minerals, and lumber.

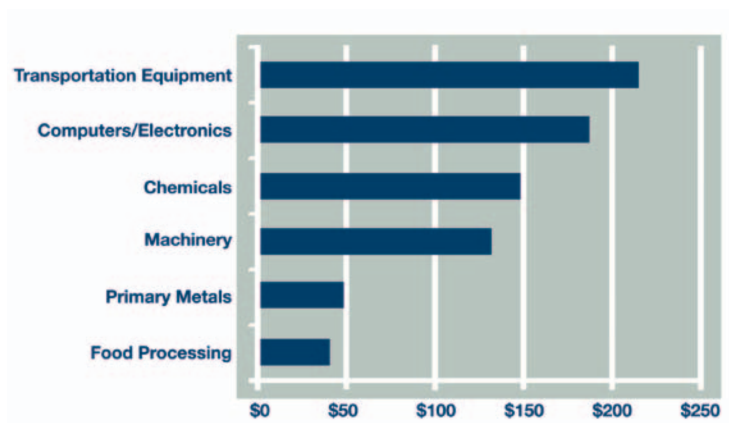
However, the trade deficit is a cause of concern and impacts every citizen through the relationship between prices, inflation, and the strength of the dollar compared to other currencies. This also underscores the need for a strong domestic manufacturing base.

MANUFACTURING EXPORTS AND TRADE BALANCE, 2000-2007 ($ IN BILLIONS)



Source: U.S. International Trade Commission Trade Dataweb

LEADING SECTORS IN MANUFACTURED PRODUCT EXPORTS, 2007 ($ IN BILLIONS)



Source: U.S. International Trade Commission Trade Dataweb

Geographic Profile Of Manufacturing Sector

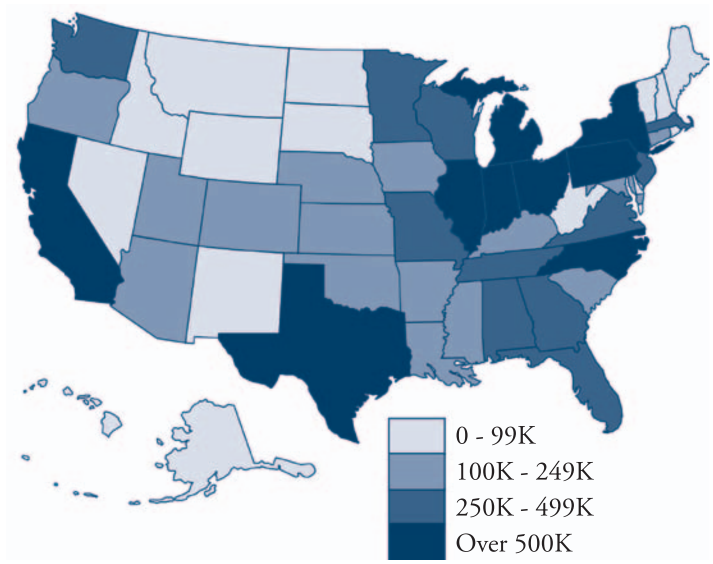
As might be expected, the most populous states, including California, Texas, Ohio, and Pennsylvania, also had the highest amount of total manufacturing jobs.

One characteristic of energy-intensive industries is their choice of location in the Nation. In many instances, they are located near their material suppliers. For example, petroleum refineries are often located on shipping routes used by oil producers. Wood mills and pulp and paper mills are typically sited near large timber resources in the Northwest and Southeast. In other instances, they are located close to their customers. For example, metal casters are located near auto and farm or construction equipment assembly plants in the Midwest. And in other cases, they are located where it is the most economical for them to produce their products, such as aluminum smelters near inexpensive hydroelectric power in the Tennessee Valley and the Northwest.

Firms in these industries tend to be located in rural areas and are often important sources of income and employment. Not only do these industries supply jobs directly, but they also create jobs through the multiplier effect. The end result is that for certain states, energy-intensive industries can represent up to about twice the average contribution to GDP as the national average. In fact, energy-intensive industries are underrepresented in many of the more populous states.

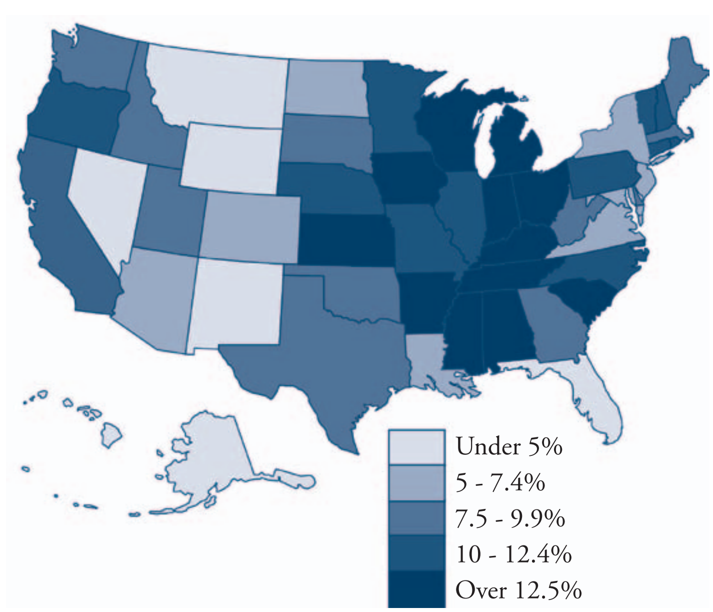
This market profile report highlights these energy-intensive manufacturing industries.

MANUFACTURING: EMPLOYMENT BY STATE, 2006



Source: Annual Survey of Manufactures 2006, U.S. Census Bureau

MANUFACTURING: PERCENT OF NON-FARM EMPLOYMENT BY STATE, 2006



Source: Annual Survey of Manufactures 2006, U.S. Census Bureau and Bureau of Labor Statistics

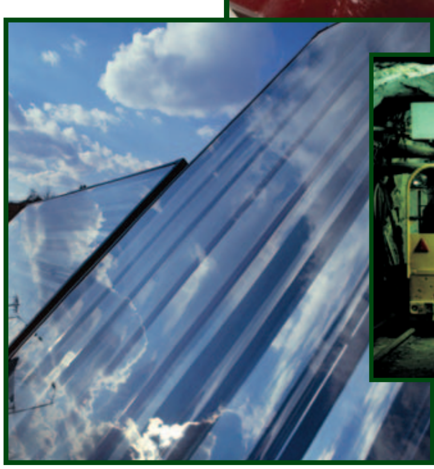
SUBSECTOR MARKETS

The industrial sector is composed of many distinct subsectors. While there are interrelationships among the subsectors, each subsector has its own unique aspects. This report highlights the most energy-intensive industrial subsectors. Information presented for each subsector include: salient economic statistics, energy consumption and trends, environmental data, investment statistics and financial trends, geographic concentration, subsector significance and status, and supply chain and stakeholders.

Profiles are included for the following industrial market sectors:

- Aluminum
- Cement
- Chemicals
- Fabricated Metals
- Food & Beverage Manufacturing
- Forest Products
- Glass
- Information Technology
- Iron & Steel
- Metal Casting
- Mining
- Petroleum Products
- Transportation Equipment

One particular note of caution in the subsector market profiles is a difference in reporting methodology for energy consumption data, which are presented on an end-use basis (excluding off-site electricity generation and transmission losses); and estimated carbon emissions, which include emissions from off-site electricity losses.



MARKET PROFILE: ALUMINUM

Overview

Establishments: 590

- 15 primary aluminum smelters (several smelters currently idled or curtailed)
- Nearly 100 large secondary aluminum facilities
- Several hundred facilities for manufacturing final products from semi-finished shapes

Employees: 62,716

Production: 4.29 million tons

- 2.86 million tons (primary aluminum)
- 1.43 million tons (secondary aluminum)

Value of Shipments/Revenues:
$40.80 billion

Trade Balance:

- Dollar Value: -$7.89 billion
- Imports for consumption: 4,950 thousand tons
- Exports: 3,190 thousand tons
- Net import reliance as a percentage of apparent consumption: 26%

Investments

Capital Expenditures: $0.77 billion

R&D Expenditures: N/A

Energy and Environment

Energy Use: 0.351 Quadrillion Btu

Estimated Carbon Emissions:

- Energy-related: 48 $MMTCO_2$
- Process-related: 4 $MMTCO_2$

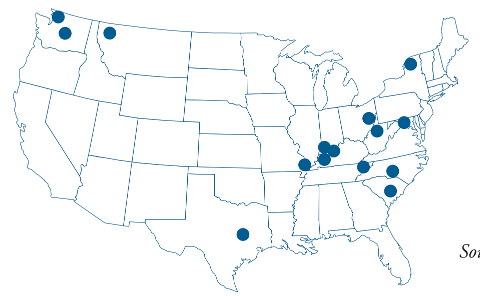
Emissions of Criteria Air Pollutants:
14,200 thousand tons

Purchased Energy Costs for Heat and Power: $2.68 billion

Pollution Control Costs: $0.37 billion

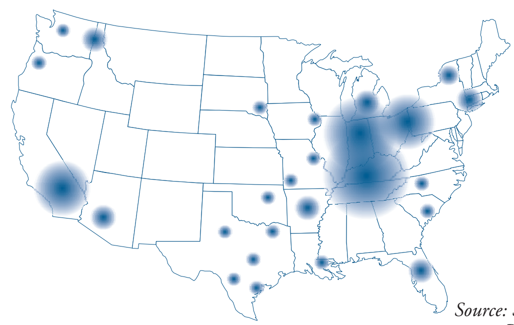
GEOGRAPHIC CONCENTRATION
NAICS Codes Covered: 3313

Primary Aluminum Smelters



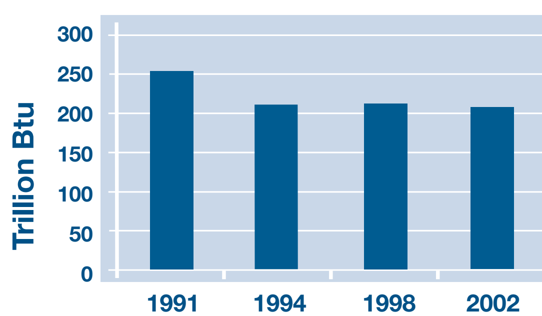
Source: 2007 Minerals Yearbook, U.S. Geological Survey

Large Secondary Aluminum Facilities



Source: Scrap Metals Supplement, Recycling Today Magazine, 2005 and 2009

Trend in Fuel Use for Primary Aluminum 1991-2002



Source: EIA MECS reports

SIGNIFICANCE OF THE U.S. ALUMINUM INDUSTRY

- 16% of global supply and 9% global market share
- Fourth-largest producer of primary aluminum (after China, Russia, and Canada)
- Adds nearly $40 billion to the American economy annually in products and exports
- Has a $3.5 billion total payroll

Status of the Aluminum Industry

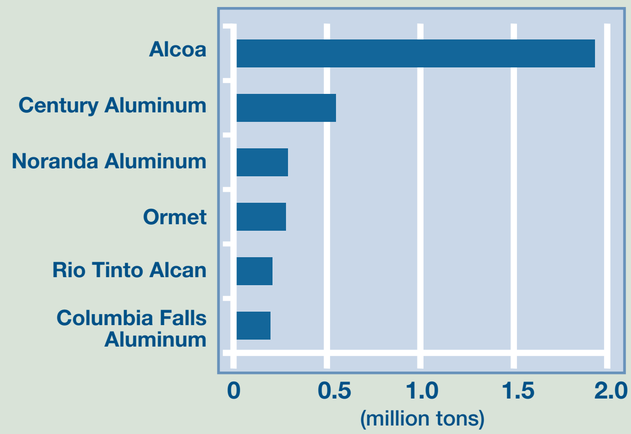
In 2007, domestic primary aluminum production was at its highest level in four years because of higher global demand and the restarting of several U.S. smelters after new power contracts were negotiated. During this period, surging metal prices, supply shortages and huge returns on investment made the global aluminum market highly profitable as well as speculative. In 2008, however, the situation changed. The global financial crisis led to a significant drop in demand and aluminum prices slid downward throughout 2008. International markets are expected to remain lethargic through 2009 and many producers are expected to cut production even further.

The number of U.S. smelters has declined from 32 in 1980 to 15 today. Some industry sources predict that by 2020, only three to six primary production facilities will be operating in the United States. This scenario assumes that large, multinational companies will shift electricity-intensive primary production outside the United States to lower energy costs. Other analysts predict that domestic primary aluminum capacity will disappear over the next 10 to 15 years because aluminum companies will not be able to purchase electricity at a rate that will allow them to compete in a global market.

Energy is the foremost issue facing the industry today. Energy costs represent approximately 28% of total production costs for primary aluminum and 4% for secondary (scrap-based) aluminum, for an overall industry average of 8%. Currently, the secondary aluminum industry recovers approximately 54% of the aluminum containers produced in this country.

In the past decade, the aluminum industry has benefitted from growth in the aerospace and consumer electronics industries and increased lightweighting of vehicles. While the demand for good quality aluminum is rising in the United States, the cost structure – particularly energy prices – is a barrier to increased domestic production.

Leading Primary Aluminum Producers, U.S. Capacity, 2008



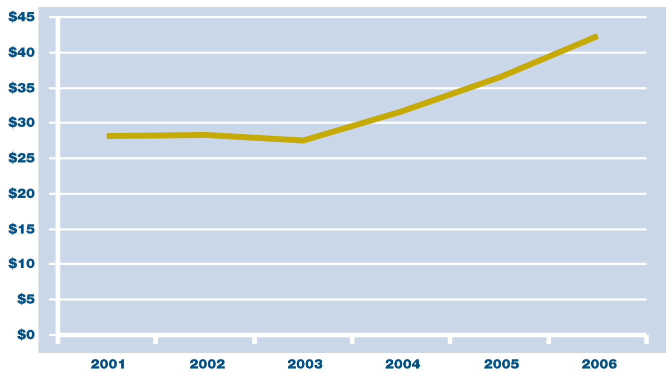
Source: various aluminum company press releases

ENERGY ASSESSMENT HELPS KAISER ALUMINUM SAVE ENERGY AND IMPROVE PRODUCTIVITY

A DOE Save Energy Now assessment was performed at Kaiser Aluminum's extrusion plant in Sherman, Texas. Using DOE's Process Heating Assessment and Survey Tool (PHAST) software, plant employees and a qualified industry expert identified significant energy savings opportunities in the melting furnaces. Plant staff wasted no time moving forward. First, they adjusted burner controls on a main reverberatory melting furnace to lower excess oxygen levels. They also made some repairs to the furnace's door sill and jamb to reduce heat losses. Through these simple changes, the plant achieved annual savings of 45 billion Btu and reduced the furnace's energy intensity by 11%. With project costs of $28,000 and energy cost savings of $360,000, the simple payback was under 1 month.

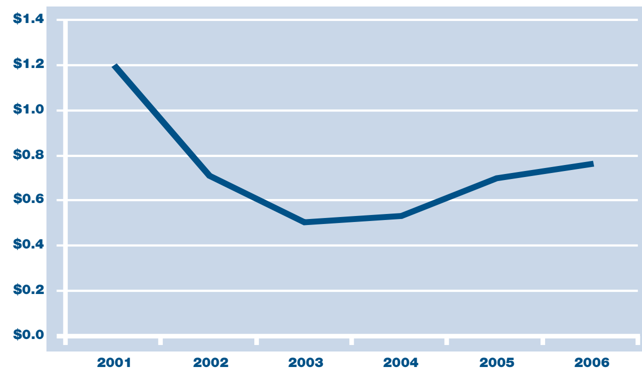
FINANCIAL TRENDS: ALUMINUM

Nominal Value of Shipments Trend for U.S. Aluminum Industry ($ in Billions)



Source: Annual Survey of Manufactures, various years

Nominal Capital Expenditures Trend for U.S. Aluminum Industry ($ in Billions)



Source: Annual Survey of Manufactures, various years

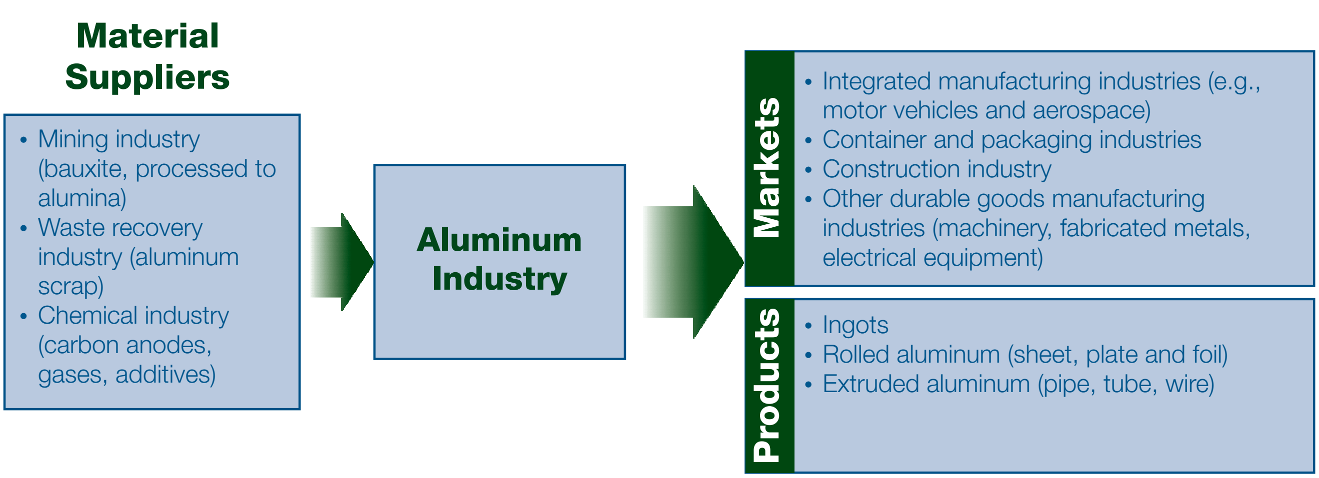
ALUMINUM MANUFACTURERS AND STAKEHOLDERS
(Select Examples)

Manufacturers
- Alcoa
- Aleris International
- Century Aluminum
- Hydro Aluminum
- Kaiser Aluminum
- Logan Aluminum
- Noranda Aluminum
- Rio Tinto Alcan

Suppliers and Vendors
- Air Products
- Ebner Furnaces
- Gillespie & Powers
- Sherwin Alumina
- Vesuvius

Organizations
- SECAT
- The Aluminum Association
- The Minerals, Metals & Materials Society

SUPPLY CHAIN



MARKET PROFILE: CEMENT

Overview

Establishments: 247

Employees: 17,171

Production: 98.2 million tons

Value of Shipments/Revenues: $10.76 billion

Trade Balance:

- -$1.19 billion
- Imports for consumption: 22.2 million metric tons
- Exports: 1.6 million metric tons (< 2% total U.S. production)
- Net import reliance as a percentage of apparent consumption: 18%

Investments

Capital Expenditures: $0.96 billion

R&D Expenditures: N/A

Energy and Environment

Energy Use: 0.410 Quadrillion Btu

Estimated Carbon Emissions:

- Energy-related: 39 $MMTCO_2$
- Process-related: 43 $MMTCO_2$

Emissions of Criteria Air Pollutants: 612,800 tons

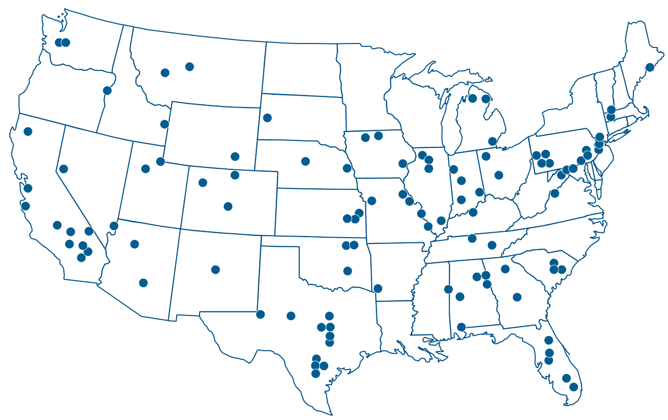
Purchased Energy Costs for Heat and Power: $1.61 billion

Pollution Control Costs: $0.33 billion

GEOGRAPHIC CONCENTRATION

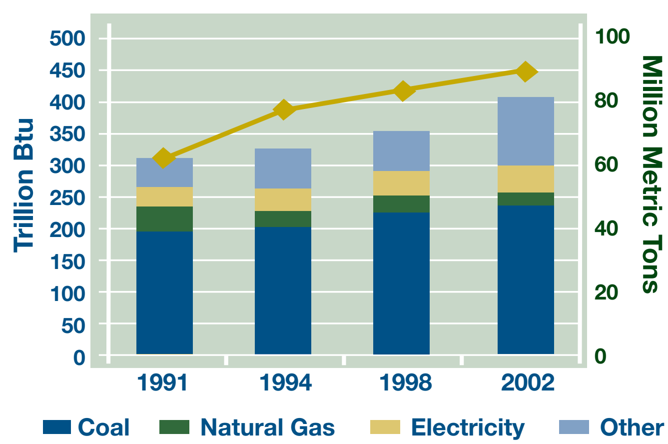
NAICS Codes Covered: 32731

Location of U.S. Cement Plants



Source: Energy and Emission Reduction Opportunities for the Cement Industry, DOE

Trend In Energy Use & Production For The Cement Industry, 1991-2002



Source: Various EIA MECS reports and Minerals Yearbooks, U.S. Geological Survey

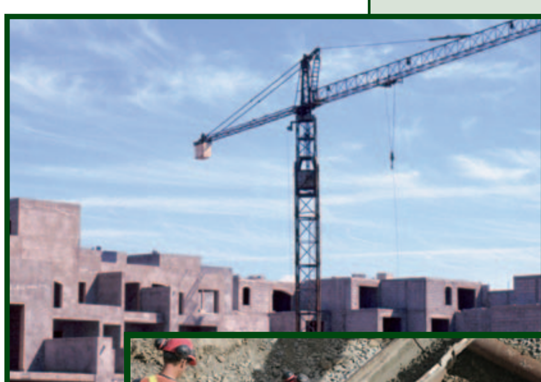
SIGNIFICANCE OF THE U.S. CEMENT INDUSTRY

- Responsible for 4% of global cement production behind only China and India
- Directly contributes over 17,000 jobs to the U.S. economy in addition to the hundreds of thousands of jobs involved in construction and infrastructure development

Status of the Cement Industry

U.S. cement production is widely dispersed with operations spread across 37 states. Approximately 50% of domestic production is concentrated in six states – Texas, California, Pennsylvania, Missouri, Michigan, and Alabama. Foreign companies own roughly 80% of U.S. cement capacity with Swiss, Mexican, Italian, and French companies all representing large industry players. The largest cement company produces over 12% of the industry total while collectively the top five companies produce over 50% of U.S. production.

Despite strong capacity utilization rates at domestic plants, the U.S. still imported approximately 18% of its cement. Five major countries – China, Canada, Columbia, Mexico, and the Republic of Korea – account for over 80% of these imports. This heavy reliance on imports to meet U.S. cement demand has subjected the industry to the volatility of global economic conditions. Record commodity prices and the corresponding record dry bulk shipping rates throughout 2007 and the first half of 2008 left importers exposed to inflated costs difficult to pass on in an industry that competes primarily on price. As a result, the U.S. cement industry is exploring capacity expansion. By 2012, an additional 25 million metric tons of new capacity is expected to come on line.



Employment in the U.S. cement industry has declined approximately 20% since 1985, reflecting industry-wide efforts to adopt more efficient automated production processes. These efforts proved largely successful as the average kiln today produces nearly 74% more cement than its predecessor did 20 years ago. Many of the efficiency gains have been captured by focusing new capital investments on plants that use dry kilns to manufacture cement versus those that use the more energy-intensive wet kiln process. As a result, the number of wet kilns has steadily declined and today roughly 85% of cement production in the United States is manufactured in dry process kilns.

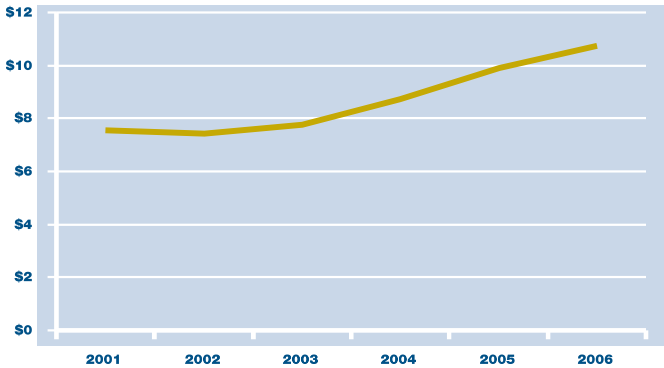
FLUIDIZED-BED KILNS AN ENERGY-SAVING OPPORTUNITY FOR CEMENT

DOE supported the development of large pilot-scale fluidized-bed kilns (200 metric tons/day) that have been developed and have demonstrated significant energy savings. The capital costs of fluidized-bed systems are estimated around 88% of the capital costs of a modern cement facility and operating costs equivalent to 75% of a modern cement facility's operating costs. They have smaller carbon footprints, and their superior combustion characteristics enable the use of lower-grade, lower-cost coal.

The recent collapse in the housing market, and the tight credit environment has lowered demand for cement and concrete in the United States. Housing permits and starts fell to record lows in the latter half of 2008. Nonresidential buildings and public sector construction, also impacted by the recession, have still helped spur demand, thanks in part to $244 billion in transportation infrastructure spending as part of the SAFETEA-LU bill passed in 2005. However, recent industry surveys suggest across-the-board declines in cement demand.

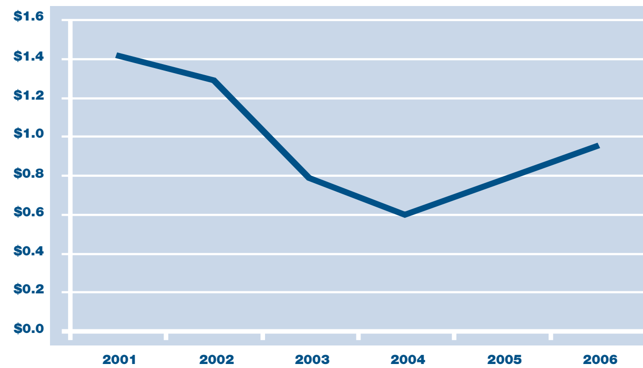
FINANCIAL TRENDS: CEMENT

Nominal Value of Shipments Trend for U.S. Cement Industry ($ in Billions)



Source: Annual Survey of Manufactures, various years

Nominal Capital Expenditures Trend for U.S. Cement Industry ($ in Billions)



Source: Annual Survey of Manufactures, various years

CEMENT MANUFACTURERS AND STAKEHOLDERS
(Select Examples)

Manufacturers

- Ash Grove Cement
- Buzzi Unicem USA
- CEMEX
- Holcim (US)
- Lafarge North America
- Lehigh Cement
- Monarch Cement
- Texas Industries

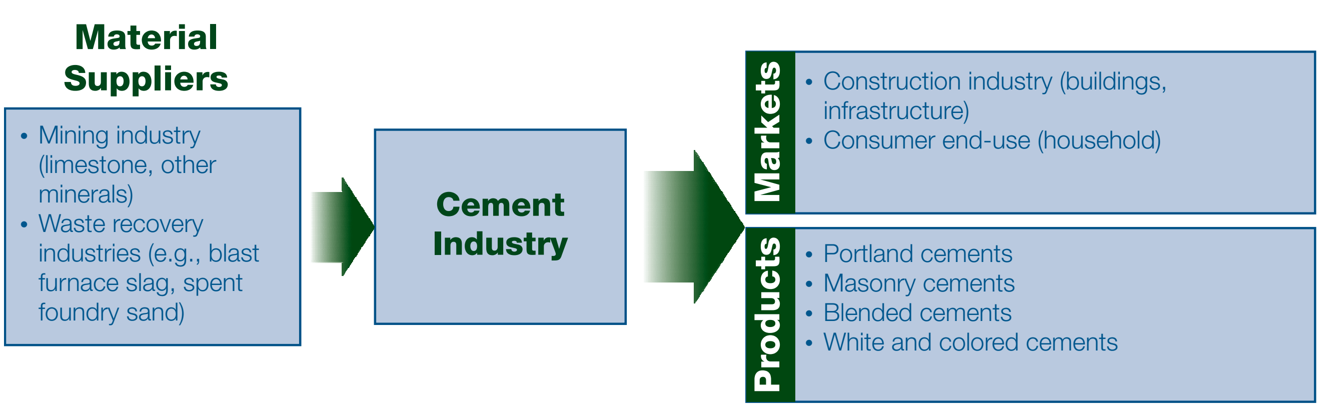
Suppliers and Vendors

- F.L.Smidth
- Fives FCB
- KHD Humboldt Wedag International
- Polysius

Organizations

- American Concrete Institute
- Cement Kiln Recycling Coalition
- Portland Cement Association
- World Business Council for Sustainable Development (Cement Sustainability Initiative)

SUPPLY CHAIN



MARKET PROFILE: CHEMICALS

Overview

Establishments: 13,476

- 18% basic chemical manufacturing
- 7% resin, synthetic rubber, fibers, & filaments
- 7% pesticide, fertilizer, & other agricultural
- 14% pharmaceutical & medicine
- 15% paint, coating, & adhesive
- 18% soap, cleaning compound
- 22% other chemical

Employees: 748,464

Production: 1,230 million tons

Value of Shipments/Revenues:
$657.08 billion

Trade Balance:

- $1.95 billion
- Imports account for 23% of U.S. demand

Investments

Capital Expenditures: $17.66 billion

R&D Expenditures: $16.12 billion

Energy and Environment

Energy Use: 6.465 Quadrillion Btu

Estimated Carbon Emissions:

- Energy-related: 311 $MMTCO_2$
- Process-related: 5 $MMTCO_2$

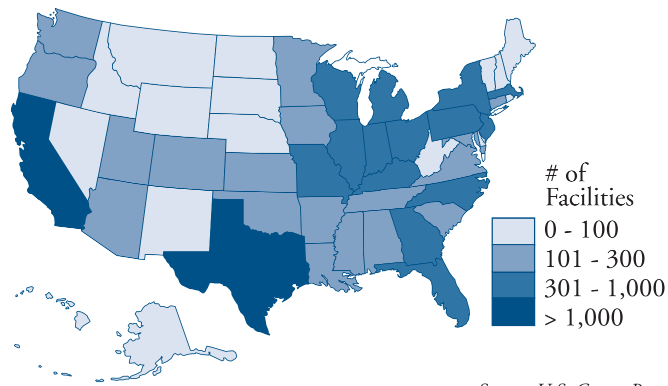
Emissions of Criteria Air Pollutants:
1,536,700 tons

Purchased Energy Costs for Heat and Power: $21.97 billion

Pollution Control Costs: $6.49 billion

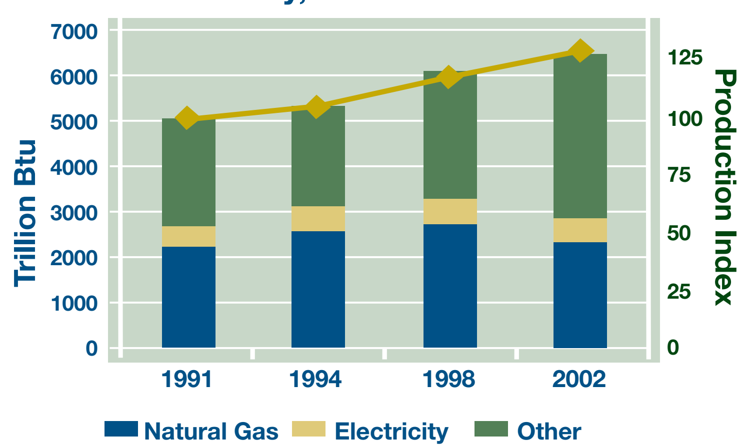
GEOGRAPHIC CONCENTRATION

NAICS Codes Covered: 325



Source: U.S. Census Bureau

Trend in Energy Use and Production for the Chemical Industry, 1991-2002



Source: Various EIA MECS reports and Federal Reserve Board (G.17 Industrial Production and Capacity Utilization)

SIGNIFICANCE OF THE U.S. CHEMICAL INDUSTRY

- World's largest chemicals producer with 21% of total world chemical output
- Second highest value of shipments (after transportation equipment)
- Largest manufacturing consumer of natural gas, accounting for 8% of all U.S. natural gas consumption
- Largest U.S. manufacturing employer, with an estimated 4% of all workers supporting the manufacturing of chemicals, either directly or through suppliers
- Annual payroll exceeding $45 billion

Status of the Chemical Industry

The U.S. chemical industry is maturing, and many segments of the industry experienced little or no growth during the 1990s. U.S. chemical companies are positioning themselves as global science and technology-based companies as they evolve to a more knowledge-intensive, value-added focus. Restructuring, joint ventures, acquisitions to secure new technology platforms, supply chain integration, and investment in overseas capacity are all steps being taken to optimize business portfolios in the more competitive global marketplace.

Capacity utilization steadily declined during the 1990s as added capacity came on-line, eventually reaching a 20-year low of 71% in 2001. With the exception of the 2005 hurricanes, the general capacity utilization trend has been upward since 2003.

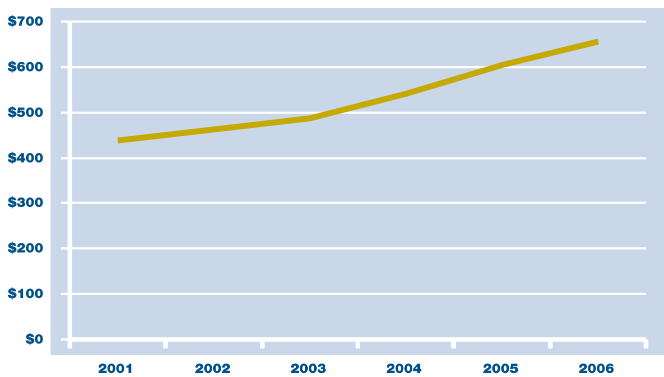
Industry analysis indicates that profitability has weakened in chemical manufacturing since 1997. Operating rates declined as increasing natural gas prices squeezed margins. Trade performance began to improve in 2006 and 2007 with the fast-paced growth in the global economy during this time. Tightening global supply/demand balances and a reduction in the value of the U.S. dollar led to accelerated U.S. chemical exports. Petrochemicals and pharmaceuticals were the biggest contributors in the export market at 64% of total exports in 2007.

QUICK-PAYBACK FERTILIZER PLANT STEAM SYSTEM OPTIMIZATION CUTS FUEL COSTS

The J.R. Simplot company's Don Plant in Pocatello, Idaho received a DOE Save Energy Now assessment in 2006 to help operators identify ways to reduce energy use in its steam system. Plant personnel began implementing some of the recommendations as soon as the assessment concluded. They optimized boiler operation to reduce steam venting, improved condensate recovery, repaired steam traps, and fixed steam leaks. As a result, the plant realized total annual cost savings of $335,000 and energy savings of more than 75,000 MMBtu. With project costs of approximately $180,000, the plant achieved a simple payback of approximately 6.5 months.

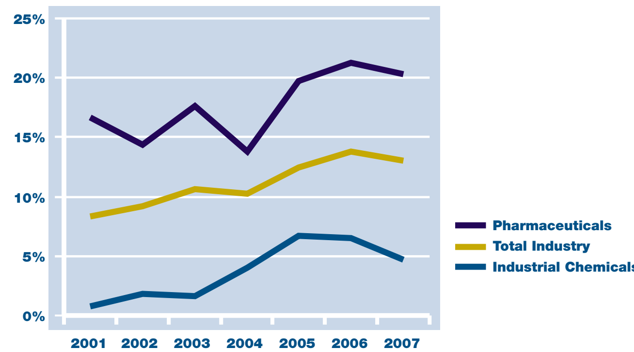
FINANCIAL TRENDS: CHEMICAL

Nominal Value of Shipments Trend for U.S. Chemical Industry ($ in Billions)



Source: Annual Survey of Manufactures, various years

Profit Trends for U.S. Chemical Industry (After-Tax)



Source: Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations, various editions

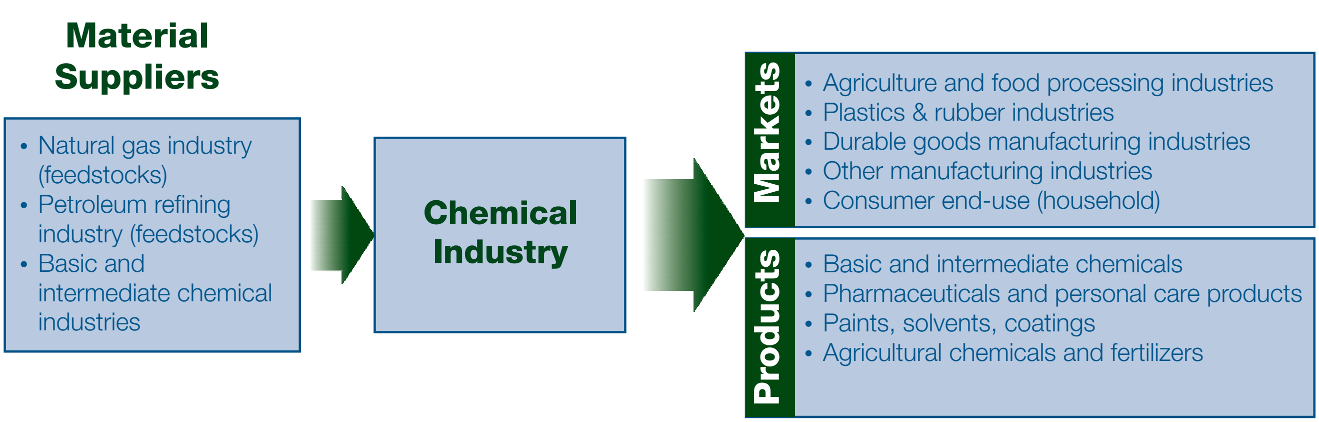
CHEMICAL MANUFACTURERS AND STAKEHOLDERS
(Select Examples)

Manufacturers
- Air Products and Chemicals
- BASF
- Celanese
- Dow Chemical
- DuPont
- Eastman Chemical
- ExxonMobil
- FMC
- Lyondell Chemical
- Merck
- Pfizer
- Praxair

Suppliers and Vendors
- AspenTech
- Bechtel
- Chem Systems
- Emerson
- Foster Wheeler
- Fluor
- Jacobs
- Shaw Group

Organizations
- American Chemical Society
- American Chemistry Council
- American Institute of Chemical Engineers
- Council for Chemical Research
- Pharmaceutical Research and Manufacturers of America
- Synthetic Organic Chemical Manufacturers Association

SUPPLY CHAIN



MARKET PROFILE: FABRICATED METALS

Overview

Establishments: 62,384

- Forging and stamping: 3,262
- Cutlery and hand tool manufacturing: 1,690
- Architectural and structural metals manufacturing: 12,437
- Boiler, tank, and shipping container manufacturing: 1,846
- Hardware manufacturing: 1,011
- Spring and wire product manufacturing: 1,828
- Machine shops, turned product, and screw, nut, & bolt manufacturing: 27,393
- Coating, engraving, heat treating, and allied activities: 6,355
- Other fabricated metal product manufacturing: 6,562

Employees: 1,491,836

Value of Shipments/Revenues: $317.21 billion

Trade Balance: -$18.18 billion

Investments

Capital Expenditures: $8.34 billion

R&D Expenditures: $1.43 billion

Energy and Environment

Energy Use: 0.388 Quadrillion Btu

Estimated Carbon Emissions: 44 $MMTCO_2$

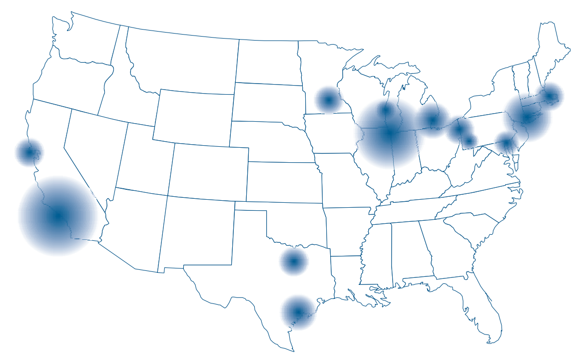
Emissions of Criteria Air Pollutants: 82,800 tons

Purchased Energy Costs for Heat and Power:

$5.2 billion

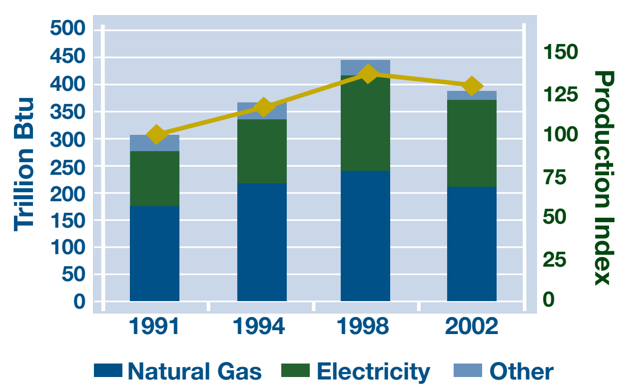
Pollution Control Costs: $0.365 billion

GEOGRAPHIC CONCENTRATION
NAICS Codes Covered: 332



Source: U.S. Census Bureau

Trend In Energy Use And Production For The Fabricated Metals Industry, 1991-2002



Source: Various EIA MECS reports and Federal Reserve Board (G.17 Industrial Production and Capacity Utilization)

SIGNIFICANCE OF THE U.S. FABRICATED METAL PRODUCTS INDUSTRY

- Generates 1.5 million jobs, representing more than 11% of the U.S. manufacturing sector's employment
- Accounts for 9% of the U.S. manufacturing value added and 1% of the total U.S. GDP

Status of the Fabricated Metals Industry

The fabricated metal products industry is highly fragmented. Because of the diverse manufacturing processes involved, most companies make only a limited range of products. For example, the largest 50 companies only account for 20% of the total market. Larger market share concentrations can be found in some specialty products such as metal cans, cutlery, boilers, and springs.

Sales are directly linked to economic growth because the demand for products depends on the needs of other industrial companies. Technical expertise and efficient manufacturing operations greatly affect the profitability of individual companies. Smaller companies can effectively compete in this industry because of the specialized nature and use of their products.

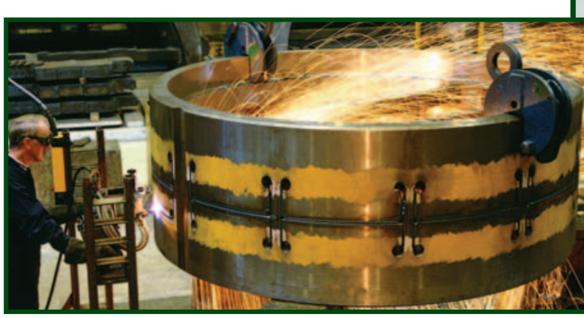
ENHANCEMENT OF ALUMINUM ALLOY FORGINGS

The forging process creates parts that are stronger than those manufactured by any other metalworking process. Unfortunately, the grain growth in the material prior to forging can be significant, which subsequently affects the fatigue properties of the final part. DOE supported the development of a novel infrared technology that uses tungsten-halogen lamps as the heating source for the heat flux to preheat aluminum billets prior to forging into various shapes. The technology can produce in higher-quality forgings, with longer fatigue life, finer grain size, and less energy consumption.

Historically, labor productivity has made large gains, but the fabricated metal products industry still remains fairly labor-intensive, with average annual revenues per worker averaging $150,000. Energy costs are not a significant share of the industry's capital expenditures and represent only 2.6% of direct production costs. However, with increasing prices for raw metals and natural gas, fabricated metal products have been following an inflationary trend. To offset the rising energy prices, some plants save energy costs by producing in long runs rather than in several short runs.

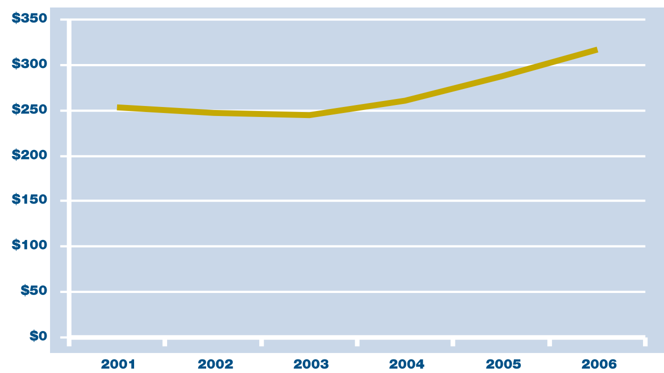
From 2003 to 2007, sales of open die and seamless ring forgings in North America increased by an average of 23% per year. In that same period, sales of open die forgings grew at an average of 10% per year. In 2007, forging sales across all types increased by an average of 14%.

The Agie Charmilles Machining Business Activity Index suggests an increase in activity for the machining subsector for 2006-2007. However, data for 2008 suggests a sharp decline in activity in the second quarter and an increase in the third quarter to levels comparable with the third quarter of 2006.



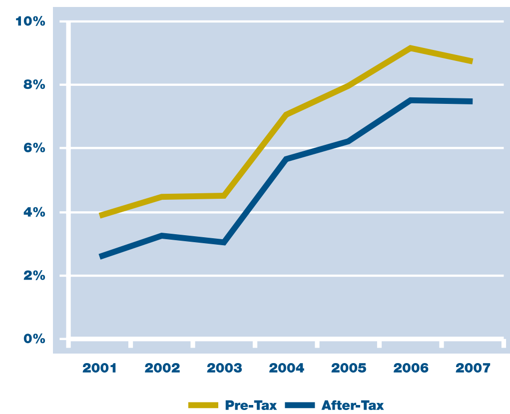
FINANCIAL TRENDS: FABRICATED METALS

Nominal Value of Shipments Trend for U.S. Fabricated Metals Industry ($ in Billions)



Source: Annual Survey of Manufactures, various years

Profit Trends for U.S. Fabricated Metals Industry



Source: Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations, various editions

FABRICATED METAL MANUFACTURERS AND STAKEHOLDERS
(Select Examples)

Manufacturers

- Ball
- Crane
- Crown Holdings
- Encore Wire
- General Cable
- Harsco
- Illinois Tool Works
- Silgan Holdings
- Superior Essex
- Timken
- Titanium Metals
- Wolverine Tube

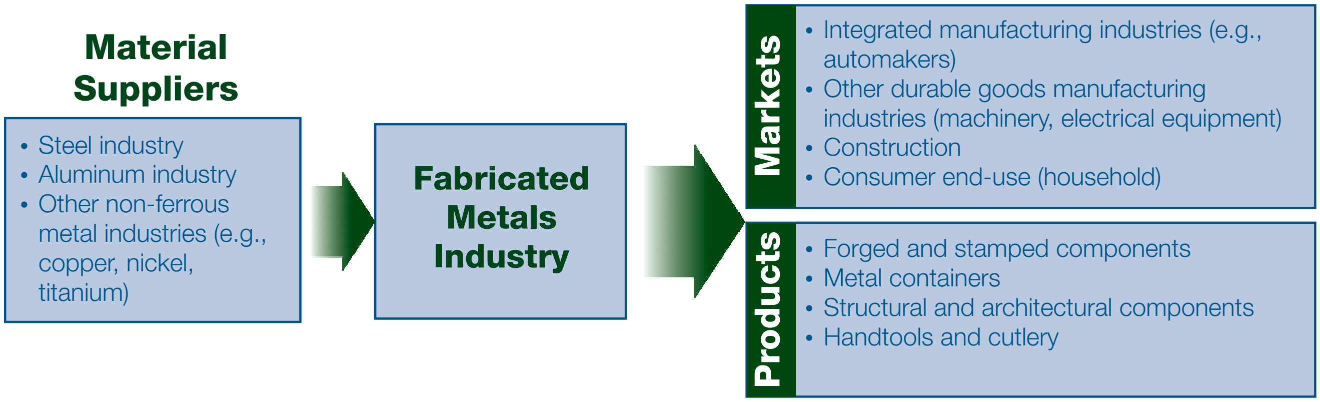
Suppliers and Vendors

- Ajax Tocco Magnethermic
- Almex USA
- Bodycote
- Ebner Furnaces
- Inductotherm

Organizations

- ASM Heat Treating Society
- American Welding Society
- Center for Heat Treating Excellence
- Forging Industry Association
- Metal Treating Institute
- Original Equipment Suppliers Association

SUPPLY CHAIN



MARKET PROFILE: FOOD & BEVERAGE MANUFACTURING

Overview

Establishments:

Approximately 30,940

- 27,915 food establishments
- 3,025 beverage and tobacco establishments

Employees: 1,560,836

Value of Shipments/Revenues:

$661 billion

Trade Balance:

- Food manufacturing: $4.60 billion
- Beverage and tobacco manufacturing: -$12.13 billion

Investments

Capital Expenditures: $15.95 billion

R&D Expenditures: $2.72 billion

(food manufacturing only)

Energy and Environment

Energy Use:

1.228 Quadrillion Btu

Estimated Carbon Emissions:

94.7 $MMTCO_2$

(food manufacturing only)

Emissions of Criteria Air Pollutants: 473,400 tons

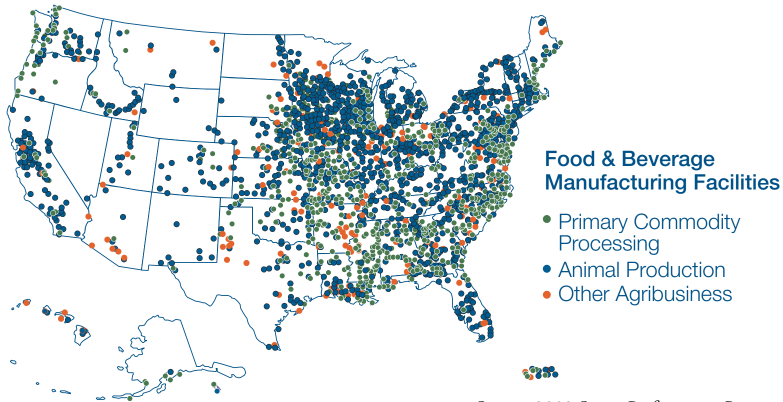
Purchased Energy Costs for Heat and Power: $11.06 billion

Pollution Control Costs:

$2.38 billion

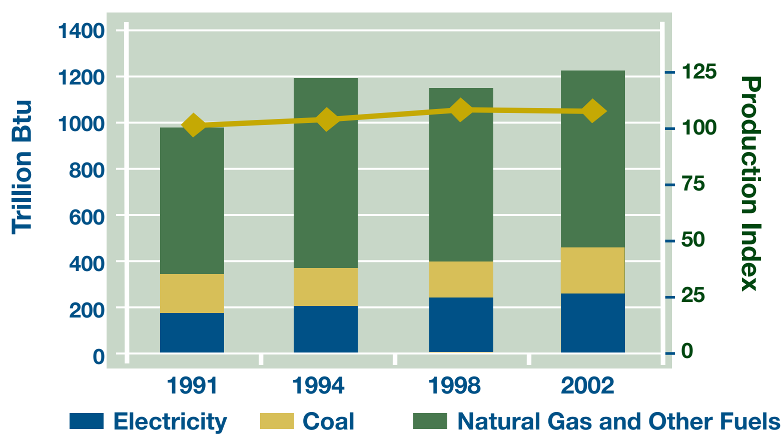
GEOGRAPHIC CONCENTRATION

NAICS Codes Covered: 311, 312



Source: 2008 Sector Performance Report, EPA

Trend In Energy Use And Production For The Food/Beverage Industry, 1991-2002



Source: Various EIA MECS reports and Federal Reserve Board (G.17 Industrial Production and Capacity Utilization)

SIGNIFICANCE OF THE U.S. FOOD AND BEVERAGE MANUFACTURING INDUSTRY

- American consumers spent $1.164 trillion on food sales in 2007.
- Domestic producers generate more than 1.5 million jobs
- Food manufacturing productivity has increased by around 30% since 1987, while beverage and tobacco manufacturing has increased by 21% over the same time period

Status of the Food & Beverage Manufacturing Industry

The food and beverage industry is highly competitive and globally integrated. Increasing globalization of agriculture markets and companies has increased trade for food and beverage products. In 2007, U.S. exports amounted to about $44 billion, while imports totaled $51 billion. A growing world population, rapidly growing middle classes in developing countries such as China and India, shifts in consumer dietary preferences, and escalating energy prices resulted in basic global food commodity prices rising by 220% between the start of 2002 and early 2008. However, the U.S. food and beverage industry is not immune from the global financial crisis, as commodity prices have dropped along with reduced demand for certain products. Nonetheless, the industry is expected to record positive growth trends over the long term.

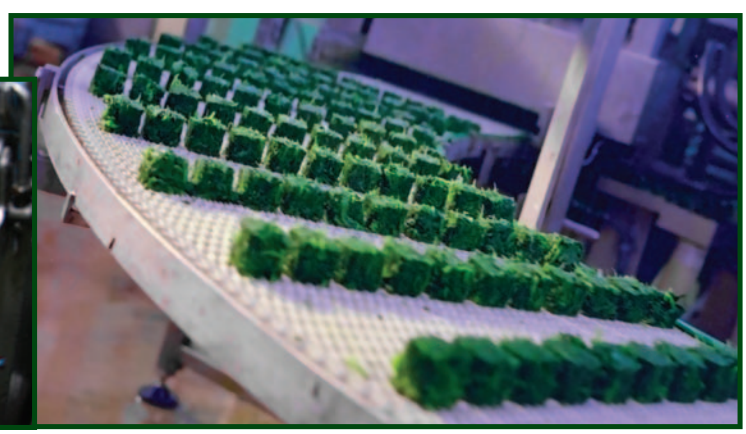
Capital expenditures in the food processing industry have exhibited continued growth; between 1982 and 2002, annual capital investment increased 3.4 times, from $3.7 billion to $12.5 billion. Within the industry, the subgroups with the highest rates of capital investments over the past five years are seafood processing (8.2%) and dairy products (8.1%). On the other hand, capital investment in the grain and oilseed milling industry decreased by nearly 30% over the past five years.

The aggregate performance of the food processing industry is better than most other U.S. manufacturers based on profitability, capacity utilization, capital expansion, and investment. The result of this capital expansion and investment is evident. Over the past 20 years, the food production industry has increased domestic output by 37%, while increasing employment by only 2%. The beverage and tobacco industry increased domestic output by 5% and decreased employment by 20% over the same time period.

ENERGY EFFICIENT FOOD BLANCHING

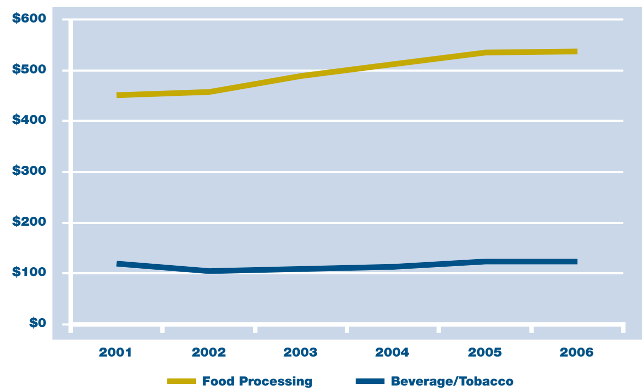
Key Technology Inc. has commercialized a new process for recirculating and reusing steam. The blancher innovation, developed with DOE support, uses 70% less energy than conventional blanchers, The technology also eliminates process wastewater, improves product quality, and increases productivity. Over 60 units of the blanching system are in use across the U.S. food processing industry.

While many external factors influence the overall performance of the industry, the outlook for individual companies that can control costs and respond to emerging market opportunities will be significantly enhanced. The cost of energy represents a small fraction of the total cost of processing foods, 4 - 5% on average. In general, the food processing industry treats energy like water and other utilities – extremely essential, but not a top concern. However, high natural gas prices are of great importance in the agricultural sector because natural gas is used to produce nitrogen fertilizers.



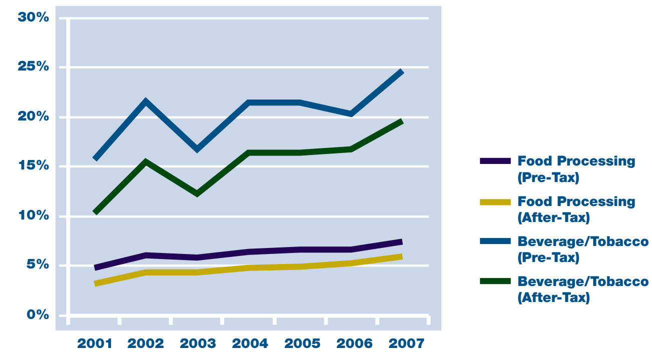
FINANCIAL TRENDS: FOOD & BEVERAGE MANUFACTURING

Nominal Value of Shipments Trend for U.S. Food and Beverage Industry ($ in Billions)



Source: Annual Survey of Manufactures, various years

Profit Trends for U.S. Food and Beverage Industry



Source: Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations, various editions

FOOD AND BEVERAGE MANUFACTURERS AND STAKEHOLDERS
(Select Examples)

Manufacturers

- Archer Daniels Midland
- Cargill
- Coca-Cola
- ConAgra Foods
- General Mills
- H.J. Heinz
- J.R. Simplot
- Kellogg
- Kraft Foods
- Molson Coors Brewing
- PepsiCo/FritoLay
- Sara Lee
- Smithfield Foods
- Tyson Foods

Suppliers and Vendors

- Alfa Laval
- Fluor
- Jacobs Engineering
- Linde
- United Industries Group

Organizations

- Center for Byproducts Utilization
- Food Processing Machinery and Supplies Association
- Grocery Manufacturers Association
- Northwest Food Processors Association
- National Food Processors Association
- Process Equipment Manufacturers Association
- Renewable Fuels Association
- The Food Processors Institute

SUPPLY CHAIN

Material Suppliers

- Agriculture industry (produce, grains, livestock)
- Chemical industry
- Container and packaging industry

Food and Beverage Industry

Markets

- Consumer end-use (household)
- Food service industry
- Agriculture industry
- Petroleum refining industry

Products

- Packaged foods
- Beverages
- Animal feed/food
- Ethanol
- Tobacco

MARKET PROFILE: FOREST PRODUCTS

Overview

Establishments: 22,722
- 5,520 pulp and paper manufacturing sites
- 17,202 wood products manufacturing sites

Employees: 949,585

Production:
- 89.8 million tons of paper products
- 57.7 million tons of pulp

Value of Shipments/Revenues:
$281.43 billion

Trade Balance:
- $16.55 billion

Investments

Capital Expenditures: $11.21 billion

R&D Expenditures: $2.79 billion

Energy and Environment

Energy Use: 2.740 Quadrillion Btu

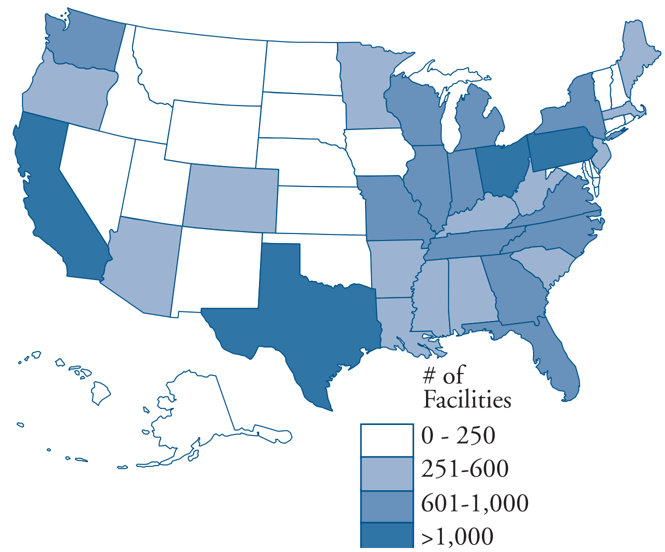
Estimated Carbon Emissions:
102.4 $MMTCO_2$ (Paper industry only)

Emissions of Criteria Air Pollutants:
1,671,500 tons

Purchased Energy Costs for Heat and Power: $11.48 billion

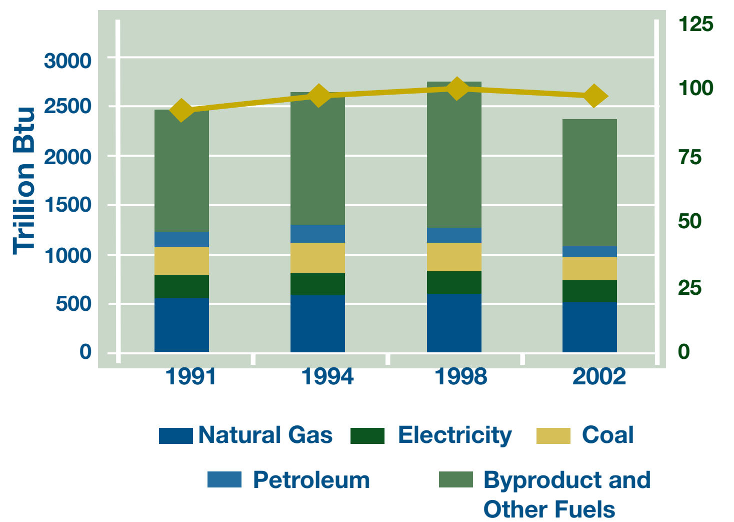
Pollution Control Costs: $3.07 billion

GEOGRAPHIC CONCENTRATION
NAICS Codes Covered: 321, 322



Source: U.S. Census Bureau

Trend In Fuel Use And Production For The Paper Industry, 1991-2002



Source: Various EIA MECS reports and American Forest and Paper Association

SIGNIFICANCE OF THE U.S. FOREST PRODUCTS INDUSTRY
- Supplies jobs in all 50 states
- Domestic paper and pulp production has grown to $151.5 billion in 2002, a 14% increase since 1992
- Wages in this sector increased 36% between 1992 and 2003

Status of the Forest Products Industry

The U.S. paper industry has traditionally been dependent on consumer demand and the overall health of the U.S. economy. A growing gross domestic product has typically correlated well with a commensurate expansion of shipments for paper. In the past several years, the industry continued to consolidate and restructure, and many pulp and paper mills have closed. The U.S. integrated pulp and paper mill population has declined to about 580 operating plants today, resulting in production and job losses.

The U.S. paper industry has been hampered by high natural gas prices, as natural gas accounts for 21% of its energy use. Between 2000 and 2005, the cost of fuels and purchased electricity increased by 26% for the pulp and paper industry. By 2006, purchased energy for heat and power represented 8.4% of total direct production costs. The rise in energy costs was a contributing factor to the closing of 232 mills and loss of 182,000 jobs since 2000.

Controlling the costs of purchased energy is important to the forest products industry. Typically, the largest energy intensity improvements occur when inefficient mills are replaced, rather than when companies improve energy efficiency within existing facilities. For example, a new state-of-the-art wood preparation facility in 1998 was only 87% as energy intensive as the average existing wood preparation plant. Process efficiency improvements have also contributed to long-term energy intensity reductions, along with increased capacity for cogeneration, also known as combined heat and power (CHP). Recent energy intensity reductions have resulted from the closure of inefficient mills. The industry has also sought to control energy costs by increasing the utilization of waste streams and installing variable speed motors and more energy-efficient lighting.

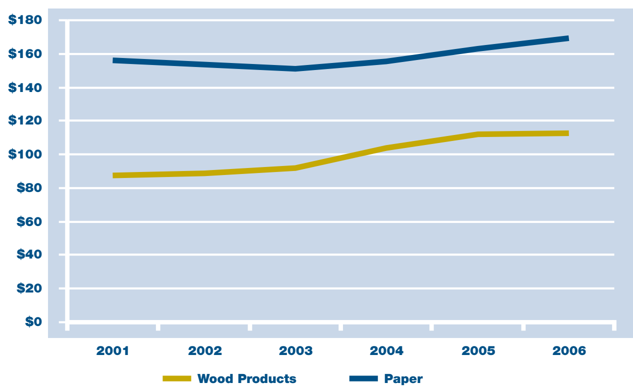
The industry continues to research advanced technologies for reducing the energy intensity of paper production, including advanced drying technologies. Black liquor gasification has been under development for many years, and small commercial-sized units are being demonstrated today with certain pulping processes. According to the American Forest & Paper Association, full implementation of black liquor and biomass gasification programs could make the forest products industry a net exporter of renewable electricity.

ANNUAL ENERGY SAVINGS EXCEED $1 MILLION AT BOISE INC. ST. HELENS PAPER

In 2006, Boise Inc. participated in a DOE Save Energy Now assessment at its pulp and paper mill in St. Helens, Oregon. The goal of the assessment was to evaluate and identify natural gas savings opportunities in the mill's steam system. A DOE Energy Expert trained the mill's employees to use DOE's steam system software tools to identify energy savings opportunities. After the assessment, the mill's personnel identified and implemented a project that significantly reduced energy use of a process in their steam system. As a result, the mill achieved total savings of $1 million in annual energy costs and 154,000 MMBtu in fuel. With total implementation costs of $31,000, the mill achieved a simple payback of less than one month. Additionally, the mill's implementation results were shared with other Boise Inc. paper mills in the United States.

FINANCIAL TRENDS: FOREST PRODUCTS

Nominal Value of Shipments Trend for U.S. Forest Products Industry ($ in Billions)



Source: Annual Survey of Manufactures, various years

Profit Trends for U.S. Forest Products Industry (After-Tax)

Source: Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations, various editions

FOREST PRODUCTS MANUFACTURERS AND STAKEHOLDERS
(Select Examples)

Manufacturers

- Boise Cascade
- Champion Enterprises
- Domtar
- Graphic Packaging Holding
- International Paper
- Kimberly-Clark
- Koch Industries
- Louisiana-Pacific
- MeadWestvaco
- Packaging Corp. of America
- Plum Creek Timber
- Rayonier
- Rock-Tenn
- Smurfit-Stone Container
- Sonoco Products
- Temple-Inland
- Universal Forest Products
- Weyerhaeuser

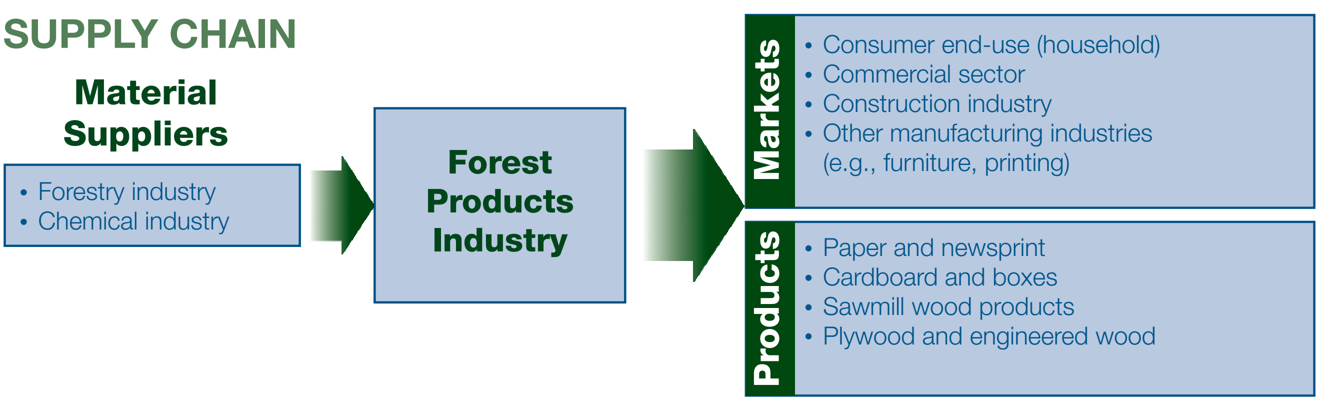
Suppliers and Vendors

- Eka Chemicals
- Jacobs Engineering
- Kadant
- Metso Paper
- Voith Paper

Organizations

- American Fiberboard Association
- American Forest and Paper Association
- Hardwood Manufacturers Association
- Institute of Paper Science and Technology
- National Council for Air and Stream Improvement
- North American Packaging Association
- Process Equipment Manufacturers Association
- Technical Association of the Pulp and Paper Industry

SUPPLY CHAIN



MARKET PROFILE: GLASS

Overview

Establishments:
Approximately 2,572 total establishments
- 35 flat glass plants
- 50 container glass plants
- 50 fiberglass plants

Employees: 119,708

Production: 18-20 million tons annually
- 9.5 million tons container glass
- 5.5 million tons flat glass
- 3 million tons fiberglass

Value of Shipments/Revenues:
$30.14 billion

Trade Balance:
-$1.01 billion

Investments

Capital Expenditures: $1.68 billion

R&D Expenditures: N/A

Energy and Environment

Energy Use: 0.253 Quadrillion Btu

Estimated Carbon Emissions:
20.9 $MMTCO_2$

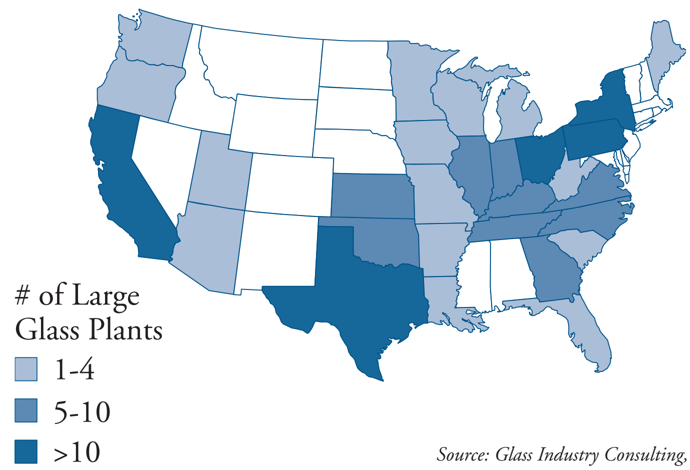
Emissions of Criteria Air Pollutants:
216,000 tons

Purchased Energy Costs for Heat and Power: $2.55 billion

Pollution Control Costs: $0.15 billion

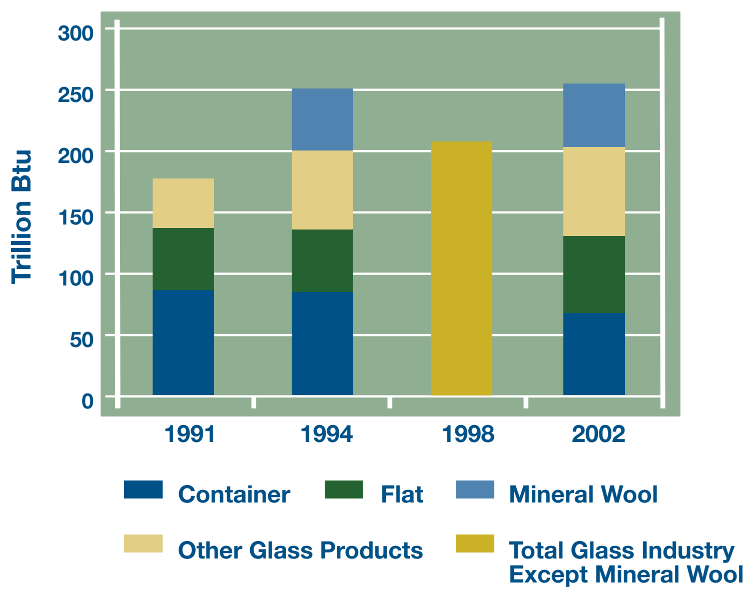
GEOGRAPHIC CONCENTRATION
NAICS Codes Covered: 3272, 327993

Number of Major Glass Plants



Source: Glass Industry Consulting, Inc.

Trend in Energy Use for Glass Industry Segments, 1991-2002



Source: Various EIA MECS reports

SIGNIFICANCE OF THE U.S. GLASS INDUSTRY
- Around 15% of world glass production
- Second-largest producer (behind China)
- 2.5% annual improvement in productivity between 1987 and 2006
- 7.4% increase in production between 2002 & 2007

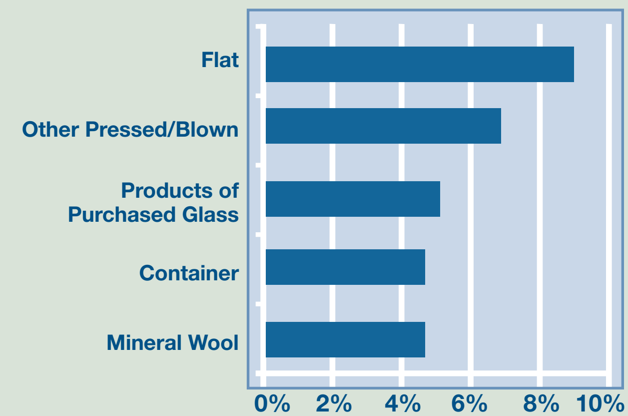
Status of the Glass Industry

The U.S. glass industry continues to be challenged by competition from both imported products and other materials as well as high natural gas prices. Of the major sectors, insulation fiberglass and flat glass had fared the best over the past few years due to strong demand for buildings and automobiles. However, recent weakness in these end-use markets has impacted glass production in the flat and fiberglass sectors. The container glass sector also continues to lose market share in many product segments, and the television glass sector has been shuttered. Several companies in the industry have been negatively impacted by asbestos litigation over the past decades.

On average, energy costs represented approximately 14% of direct production costs in 2006, but vary significantly by sector. Capital expenditures for glass and glass product production are also relatively high, particularly for the flat glass sector.

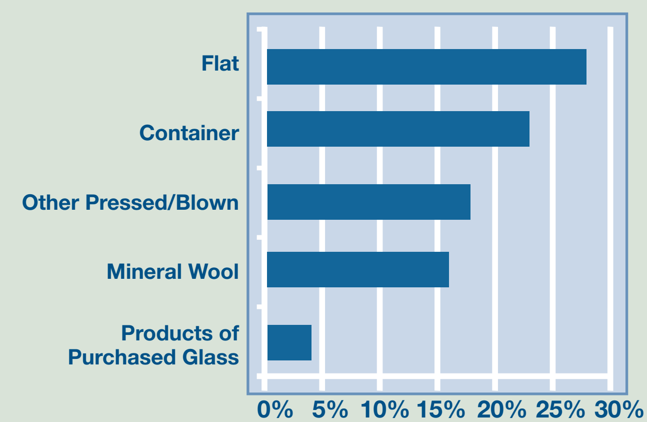
About 30% of the glass industry has converted to oxy-fuel firing technology since the early 1990s. While oxy-fuel firing significantly reduced the amount of fuel required, the expense of purchased oxygen is a major inhibitor in further conversions. More recently with higher costs for natural gas, electric melting has been more attractive, particularly for fiber production. Research efforts, though limited, continue to make glass melting more efficient and rapid, although advanced refining techniques may be required to successfully implement major advances in melting technology.

Capital Expenditures as a Percent of Shipments, 2006

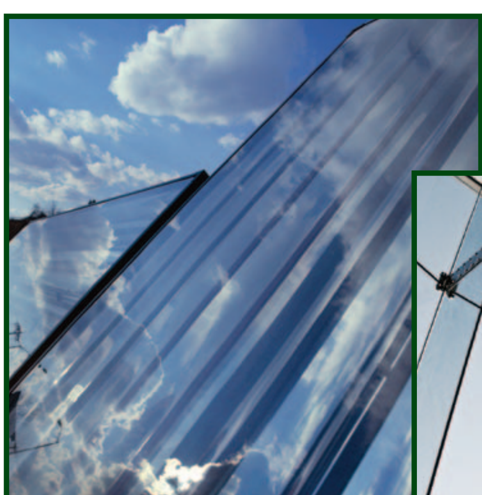


Source: Annual Survey of Manufactures, 2006

Estimated Energy Share of Direct Production Costs by Glass Sector, 2006

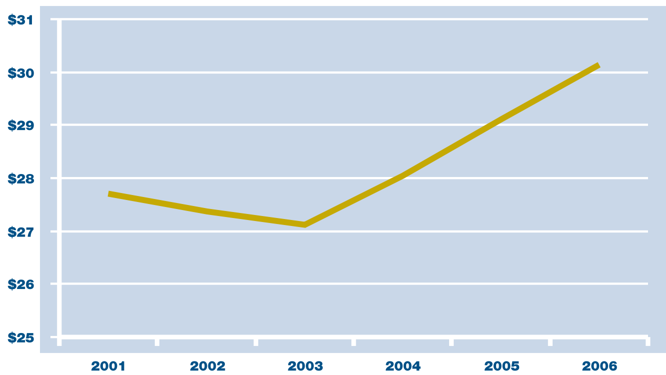


Source: Annual Survey of Manufactures, 2006



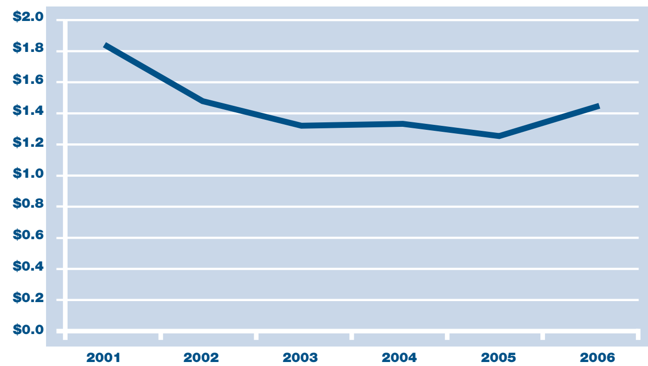
FINANCIAL TRENDS: GLASS

Nominal Value of Shipments Trend for U.S. Glass Industry ($ in Billions)



Source: Annual Survey of Manufactures, various years

Nominal Capital Expenditures Trend for U.S. Glass Industry ($ in Billions)



Source: Annual Survey of Manufactures, various years

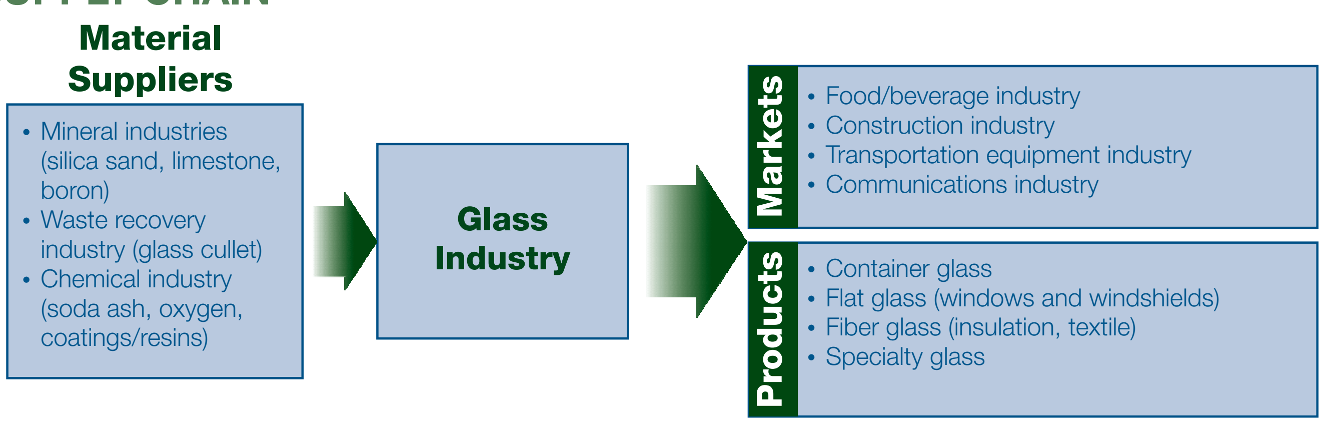
GLASS MANUFACTURERS AND STAKEHOLDERS
(Select Examples)

Manufacturers
- AFG
- Cardinal Glass
- Corning
- Guardian Industries
- Libbey
- Johns Manville
- Osram-Sylvania
- Owens-Illinois
- Owens Corning
- PPG Industries
- Saint-Gobain
- Schott North America

Suppliers and Vendors
- Air Liquide
- BOC
- Eclipse Combustion
- RHI Monofrax
- Siemens Energy & Automation
- U.S. Silica
- Toledo Engineering

Organizations
- American Ceramic Society
- Glass Association of North America
- Glass Manufacturing Industry Council
- Glass Packaging Institute
- National Glass Association
- North American Insulation Manufacturers Association

SUPPLY CHAIN



MARKET PROFILE: INFORMATION TECHNOLOGY

Overview

Facilities: 15,910, about 25% located in California

Employees: 1,002,087

Value of Shipments/Revenues: $391 billion

Trade Balance:

- $125 billion trade deficit
- Exports worth $188 billion USD to 227 countries
- Imports valued at $312.9 billion USD from 203 countries

Investments

Capital Expenditures: $14.78 billion

R&D Expenditures: $56.77 billion

Energy and Environment

Energy Use: 0.201 Quadrillion Btu

Estimated Carbon Emissions: 29 $MMTCO_2$

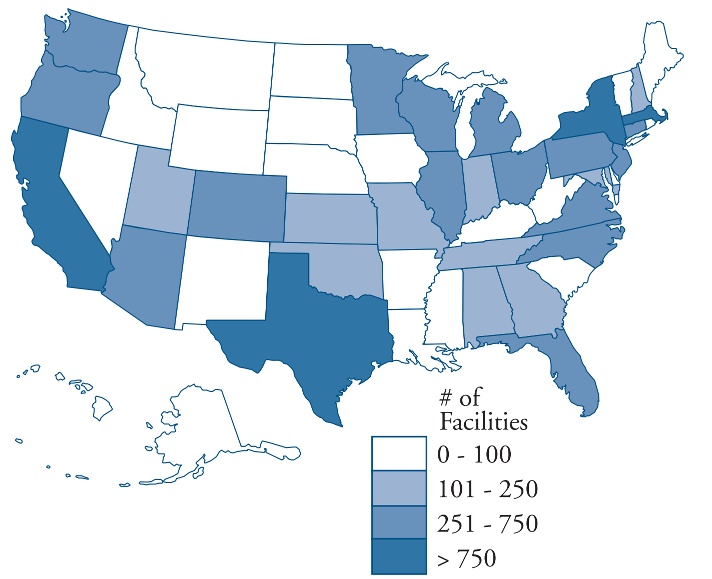
Emissions of Criteria Air Pollutants: N/A

Purchased Energy Costs for Heat and Power: $2.82 billion

Pollution Control Costs: $0.78 billion

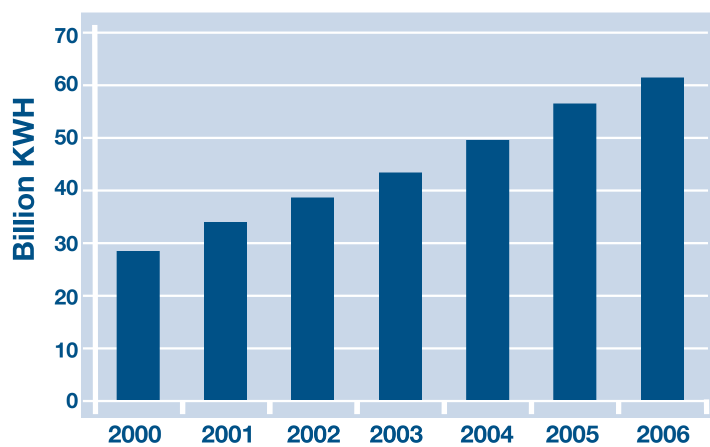
GEOGRAPHIC CONCENTRATION

NAICS Codes Covered: 334



Source: U.S. Census Bureau

Trend in Data Center Electricity Use, 2000-2006



Source: Report to Congress on Server and Data Center Energy Efficiency, EPA

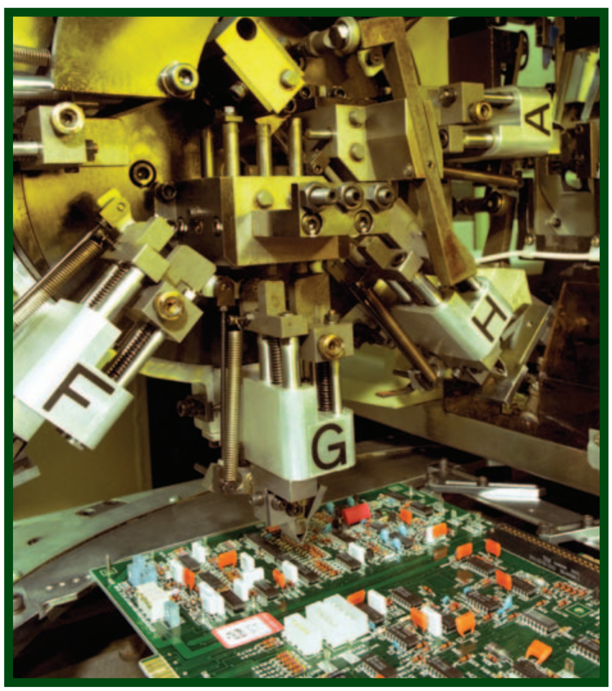
SIGNIFICANCE OF THE COMPUTER, ELECTRONICS, AND ELECTRICAL APPLIANCE INDUSTRY

- Employs over 1 million people
- Adds nearly $400 billion to the American economy annually in products and exports
- Pays $61 billion in annual total payroll

Status of the Information Technology Industry

The frenetic pace of innovation in the Computer and Electronics industry requires constant innovation in newer and faster products and applications to remain competitive ground. As a result, R&D spending in the Computer and Electronics industry is comparatively high, accounting for roughly 23% of the $247.7 billion in industrial R&D spending in 2006. High R&D spending, coupled with a fragmented industry that manufactures products that incorporate or are incorporated into a diverse array of goods, has led to the development of specialized electronics centers, such as Silicon Valley.

Globalization significantly impacts the computer and electronics industry. Today, it is not uncommon for foreign companies to operate in the United States while U.S. companies open development centers overseas. The intensity of foreign competition from Asia and Europe has decimated some domestic consumer electronics producers. As a result, U.S. manufacturers tend to concentrate on computers, microchips, and other high-end products. In 2004, China overtook the United States to become the leading exporter of information technology products. Pressures from foreign imports and from domestic manufacturers moving overseas will likely continue into the future.



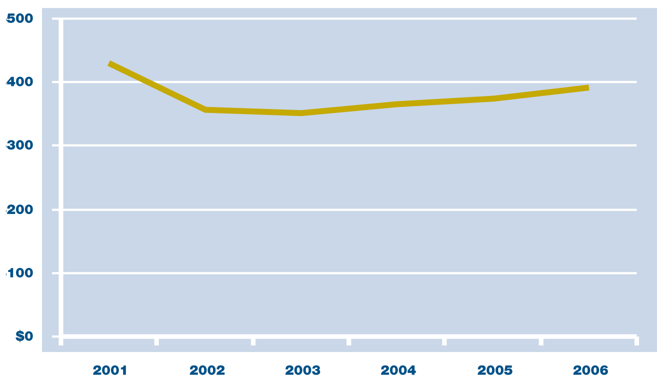
Employment declined in this industry 25.6% from 1.7 million in 1997 to 1.26 million in 2002 and has shed an additional 250 thousand jobs since 2002, dropping the industry to roughly 1 million jobs as of 2006. Between 2006 and 2016, employment is projected to further decline by 12%. The industry continues to stand out by adding almost $231 billion in value. In the future, sales of military electronics and electromedical equipment are expected to remain strong while opportunities in artificial intelligence, digital technology, and nanotechnology will help provide new growth for companies and researchers on the cutting edge of technological development.

The industry continues to face pressure over maintaining involvement in product life cycles as increased consumption of goods has led to a corollary increase in electronics waste. In many cases, this waste has been "outsourced" to third world and emerging economies where it can pose both health and environmental hazards to workers who break down parts to scavenge any valuable component pieces or precious metals.

Steadily rising demand for data processing and storage is continuing to stimulate rapid growth in the U.S. data center industry. This increasing demand has been driven by a number of factors including on-line financial services and trading, the move towards digitization of medical records, the use of satellite navigation and electronic shipment tracking, and the general growth in internet communication and global commerce.

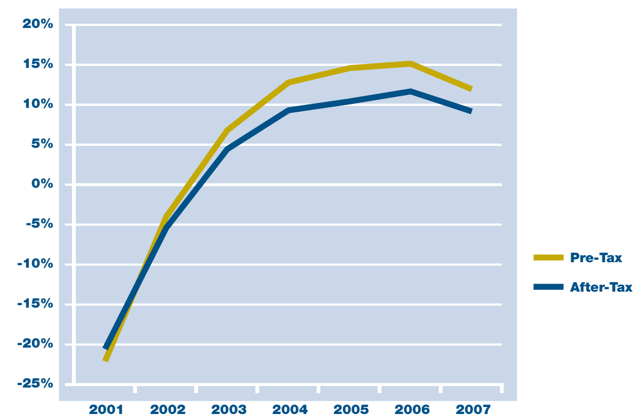
FINANCIAL TRENDS: INFORMATION TECHNOLOGY

Nominal Value of Shipments Trend for U.S. Computers & Electronics Industry ($ in Billions)



Source: Annual Survey of Manufactures, various years

Profit Trends for U.S. Computers & Electronics Industry



Source: Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations, various editions

COMPUTER AND ELECTRONICS MANUFACTURERS AND STAKEHOLDERS (Select Examples)

Manufacturers and Users

- Advanced Micro Devices
- Apple Computer
- AT&T
- Cisco Systems
- Dell
- Google
- Hewlett-Packard
- IBM
- Intel
- Microsoft
- Motorola
- Sun Microsystems
- Texas Instruments
- Time Warner
- Verizon
- Yahoo

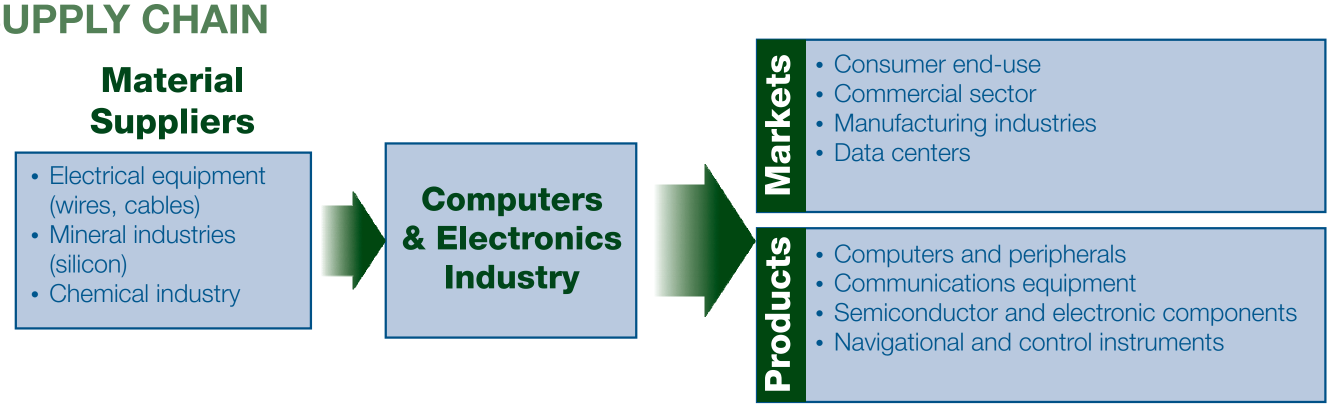
Suppliers and Vendors

- Advanced Semiconductor Engineering
- Applied Materials
- CH2M HILL
- KLA-Tencor
- Lam Research
- Varian Semiconductor Equipment

Organizations

- National Cable and Telecommunications Association
- Semiconductor Industry Association
- The Green Grid
- United States Telecom Association

SUPPLY CHAIN



MARKET PROFILE: IRON & STEEL

Overview

Facilities: Approximately 700

- 16 integrated steel mills
- 98 electric arc furnace mills (mini-mills)
- Hundreds of facilities for manufacturing final products from semi-finished shapes

Employees: 127,000

Production: 108.1 million tons

- 45.3 million tons in integrated mills
- 62.8 million tons in EAF facilities

Value of Shipments/Revenues:

$112.92 billion

Trade Balance:

- \- $21.90 billion
- Imports accounted for 21.8% of apparent U.S. supply in 2007
- Exports represented 10.5% of total net shipments in 2007

Investments

Capital Expenditures: $2.23 billion

R&D Expenditures: N/A

Energy and Environment

Energy Use: 1.457 Quadrillion Btu

Estimated Carbon Emissions:

- Energy-related: 126 $MMTCO_2$
- Process-related: 1.4 $MMTCO_2$

Emissions of Criteria Air Pollutants:

1,000,300 tons

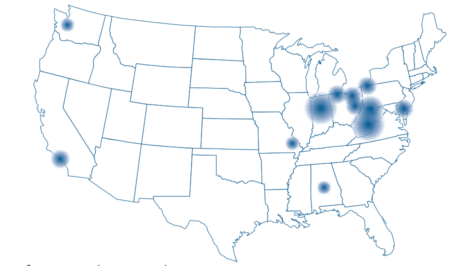
Purchased Energy Costs for Heat and Power:

$6.69 billion

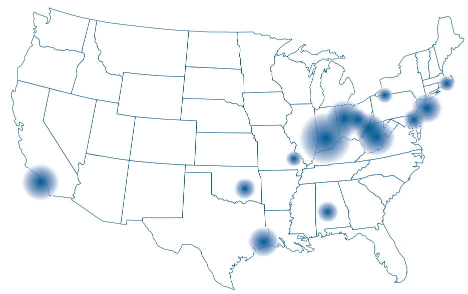
Pollution Control Costs: $1.53 billion

GEOGRAPHIC CONCENTRATION
NAICS Codes Covered: 3311, 3312

Iron and Steel Mills (3311)

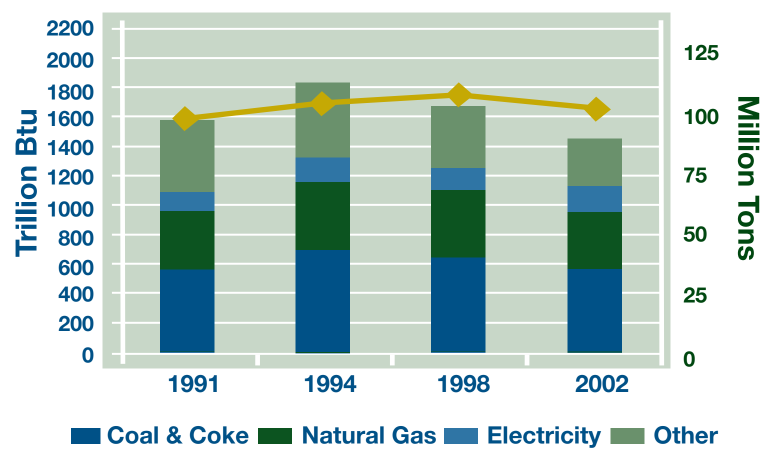


Steel Products (3312)



Source: U.S. Census Bureau

Trend in Fuel Use and Production by Steel Mills, 1991-2002



Source: Various EIA MECS reports and American Iron and Steel Institute

SIGNIFICANCE OF THE U.S. IRON AND STEEL INDUSTRY

- 7.3% of world steel production
- Third-largest steel-producing sector (after China & Japan)
- Steel's contribution to the American economy is estimated at $350 billion annually.
- Domestic producers support more than 1.2 million jobs.
- Productivity has more than tripled since the early 1980's.

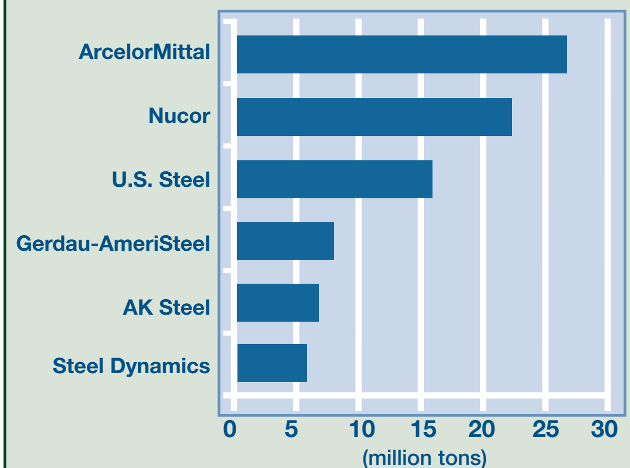
Status of the Iron & Steel Industry

The U.S. steel industry, as well as the world steel industry, stalled in the second half of 2008 because of the global economic crisis. Weak demand, rising stockpiles, slowdowns in the housing and other end-use industries contribute to an unfavorable forecast for 2009. Until this year, the U.S. steel industry had performed well in the 2000s, continuing to consolidate and restructure. Demand, capacity, and prices had all risen substantially from the last downturn in the late 1990s. As of the end of 2007, the industry's capacity utilization was 92%, higher than the 10-year average of 87%. However, prices and production began falling in the second half of the year, with the Chinese steel industry declining the most.

The U.S. iron and steel industry is subject to rising energy prices. On average, energy costs represent approximately 20% of the price of steel (AISI 2008). The electric arc furnace (EAF) segment of the industry focuses heavily on electricity prices and availability. EAF producers are also concerned about cost pressures from increased scrap prices, as well as tight scrap supplies. Some EAF mills have invested in on-site alternative iron making production units to produce direct reduced iron (DRI) to supplement purchased scrap. However, many of these closed in the early 2000s because of rising natural gas prices. In 2006, the industry consumed about 1.65 million tons of DRI.

While the domestic industry has experienced incremental growth, steelmaking processes themselves have transformed at a faster pace. In 2007, average yield was 92.3%, up from 89.5% in 2000 and 83.5% in 1990, reflecting a dramatic increase in operating efficiency.

Leading Steel Producers, North American Production, 2007



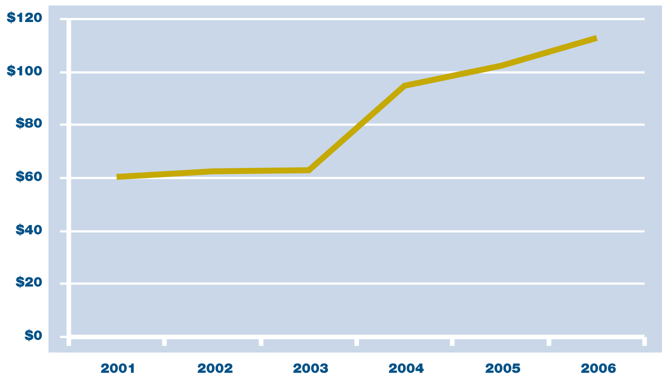
Source: various steel company press releases

MESABI NUGGET IRON MAKING PROCESS

Mesabi Nugget LLC has commercialized a new process for making high-purity iron from low-quality iron ore. The new one-step process uses 30% less energy than traditional iron making. A $235 million facility is currently being constructed in Hoyt Lakes, Minnesota.

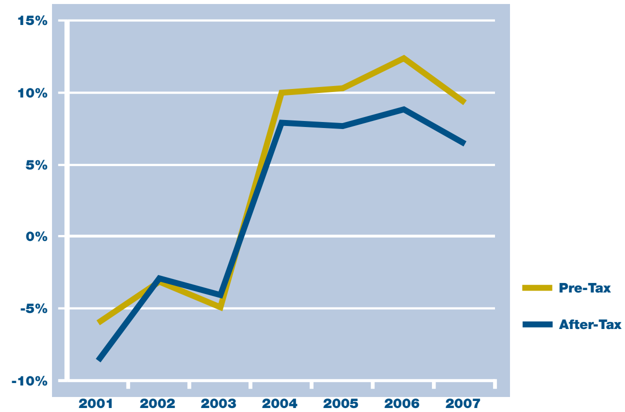
FINANCIAL TRENDS: IRON & STEEL

Nominal Value of Shipments Trend for U.S. Iron & Steel Industry ($ in Billions)



Source: Annual Survey of Manufactures, various years

Profit Trends for U.S. Iron & Steel Industry



Source: Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations, various editions

IRON AND STEEL MANUFACTURERS AND STAKEHOLDERS
(Select Examples)

Manufacturers

- AK Steel
- Arcelor Mittal
- Commercial Metals
- Gerdau Ameristeel
- Nucor Steel
- Republic Engineered Products
- Steel Dynamics
- Schnitzer Steel Industries
- U.S. Steel

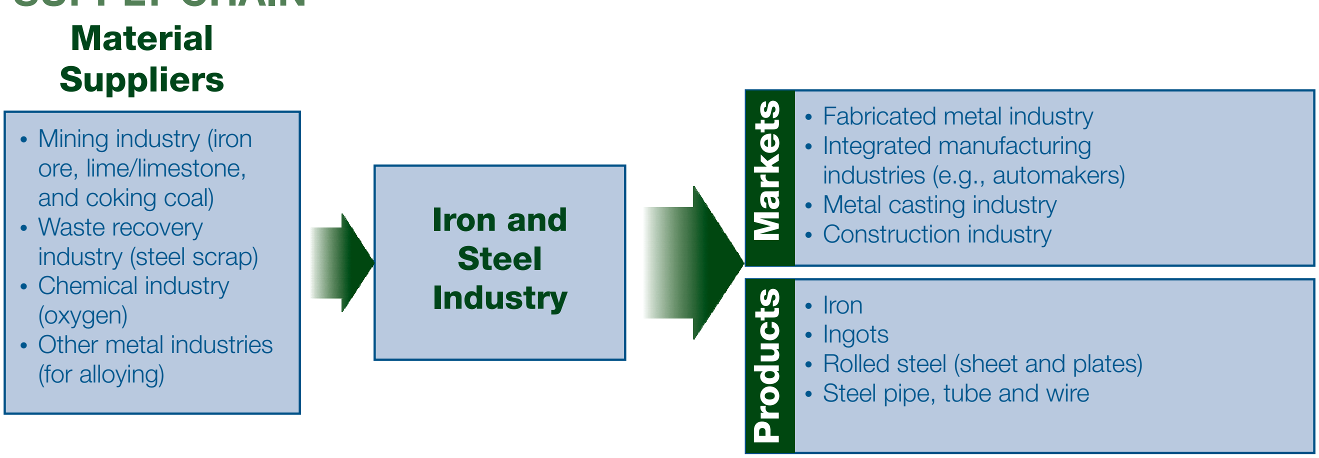
Suppliers and Vendors

- CH2MHILL
- Danieli
- Hauck Manufacturing
- North American Refractories
- Midrex Technologies
- Paul Wurth
- Praxair
- Siemens Energy & Automation
- SMS
- Vesuvius

Organizations

- American Iron and Steel Institute
- Association for Iron & Steel Technology
- Specialty Steel Industry of North America
- Steel Manufacturers Association
- Steel Recycling Institute

SUPPLY CHAIN



MARKET PROFILE: METAL CASTING

Overview

Establishments: 2,170
- 700+ Ferrous
- 1400+ Nonferrous

Employees: 163,000

Production: 12.5 million tons
- 8.4 million tons of iron castings
- 1.4 million tons of steel castings
- 2.0 million tons of aluminum castings
- 0.7 million tons of other metal castings

Value of Shipments/Revenues:
$33.46 billion

Trade Balance:
- \- $0.07 billion
- Imports accounted for about 23% of apparent U.S. supply
- Exports represented about 13% of total net shipments

Investments

Capital Expenditures: $1.22 billion

R&D Expenditures: N/A

Energy and Environment

Energy Use: 0.157 Quadrillion Btu

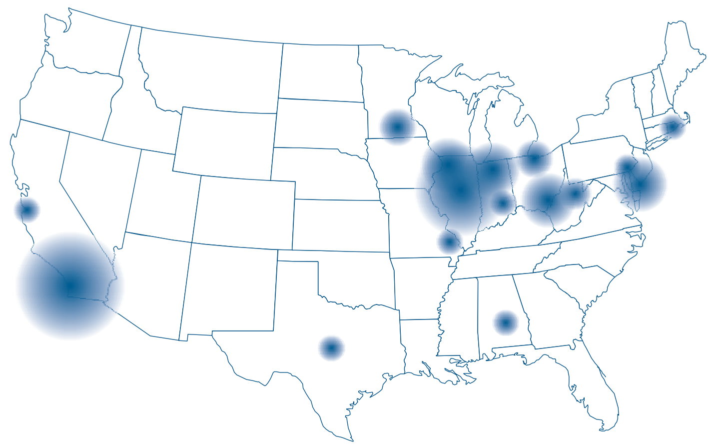
Estimated Carbon Emissions:
17.9 MMTCO$_2$

Emissions of Criteria Air Pollutants:
81,000 tons

Purchased Energy Costs for Heat and Power: $1.68 billion

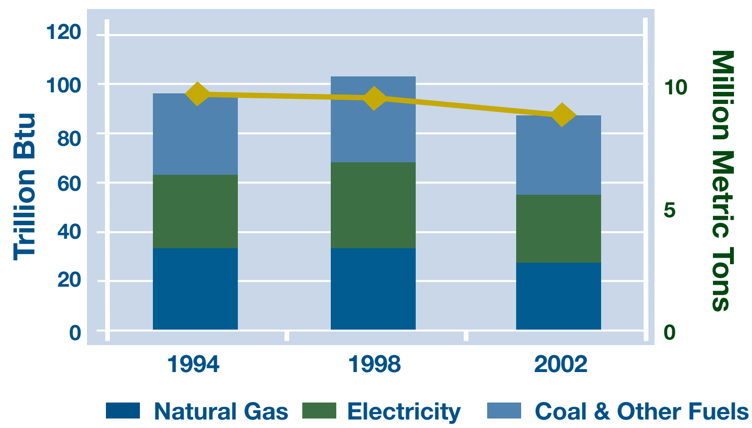
Pollution Control Costs:
$0.54 billion

GEOGRAPHIC CONCENTRATION
NAICS Codes Covered: 3315



Source: U.S. Census Bureau

Trend in Energy Use and Production for Iron Castings, 1994-2002



Source: various EIA MECS reports and Censuses of World Casting Production

SIGNIFICANCE OF THE U.S. METAL CASTING INDUSTRY
- 90% of manufactured durable goods contain one or more metal castings
- Provides $7 billion in wages
- Second-largest casting industry (after China)
- Uses 90+% recycled metals in ferrous casting facilities

Status of the Metal Casting Industry

The casting industry has experienced back-to-back years of declining sales and profits. Many casting suppliers have been forced to close or "mothball" facilities. Many market sectors are expected to consume castings in peak quantities in the coming years, although others will decline due to technological and material change. Markets for metal castings are increasingly competitive and casting customers are placing greater emphasis on high-quality, competitively priced castings. There is increasing demand for lighter-weight, high-strength ferrous and nonferrous cast metal components and castings that meet demanding design specifications.

Cast iron products represent about two-thirds of total casting shipments, followed by aluminum and steel castings, with other nonferrous alloys (e.g,. copper-based, zinc, magnesium) produced in much smaller quantities. Light metals continue to replace iron castings in motor vehicle applications, causing the closure and reduction in production capacity of many iron casting operations. The largest market for castings is in the production of automotives and light trucks (about 31% of shipments); the sharp downturn in the auto industry in 2008 has had a significant impact on the casting industry.

Most metal casting shops are small, independently owned facilities that perform on a contract basis, though some "captive" foundries are part of larger manufacturing operations. Of the approximate 2,500 metal casting facilities located throughout the 50 states, 80% employ fewer than 100 people, 14% employ between 100 and 250 people, and only 6% employ more than 250.

Overall U.S. metal casting industry capacity utilization was between 75 and 80% in 2008. Energy represents 7.3% of production costs.

ENERGY-SAVING MELTING AND REVERT REDUCTION TECHNOLOGY (E-SMARRT)

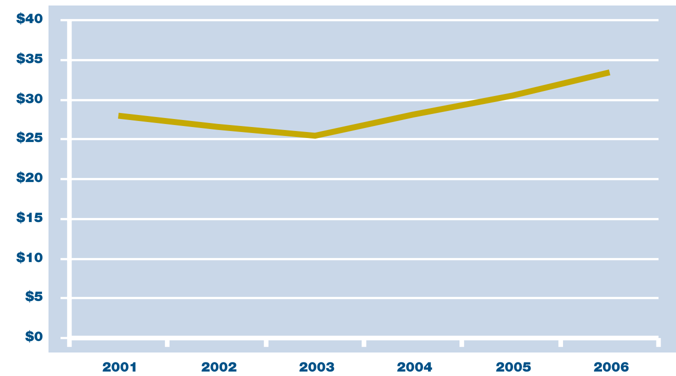
The E-SMARRT program is developing "easy-to-implement" technologies to improve energy efficiency and reduce carbon emissions in the metal casting industry, including:

- Advanced melting technology
- Innovative casting processes for yield improvement/revert reduction
- Instrumentation and control improvement
- Material properties for casting or tooling design improvement

Led by the Advanced Technology Institute and supported by DOE, the project team consists of leading metal casting industry associations and their membership, along with 13 foremost metal casting R&D organizations. As of 2008, there were 93 E-SMARRT Industry Cost Share Partners working on nearly 30 tasks.

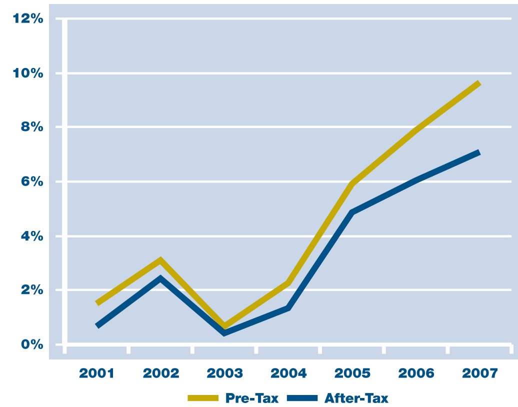
FINANCIAL TRENDS: METAL CASTING

Nominal Value of Shipments Trend for U.S. Metal Casting Industry ($ in Billions)



Source: Annual Survey of Manufactures, various years

Profit Trends for U.S. Metal Casting Industry



Source: Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations, various editions

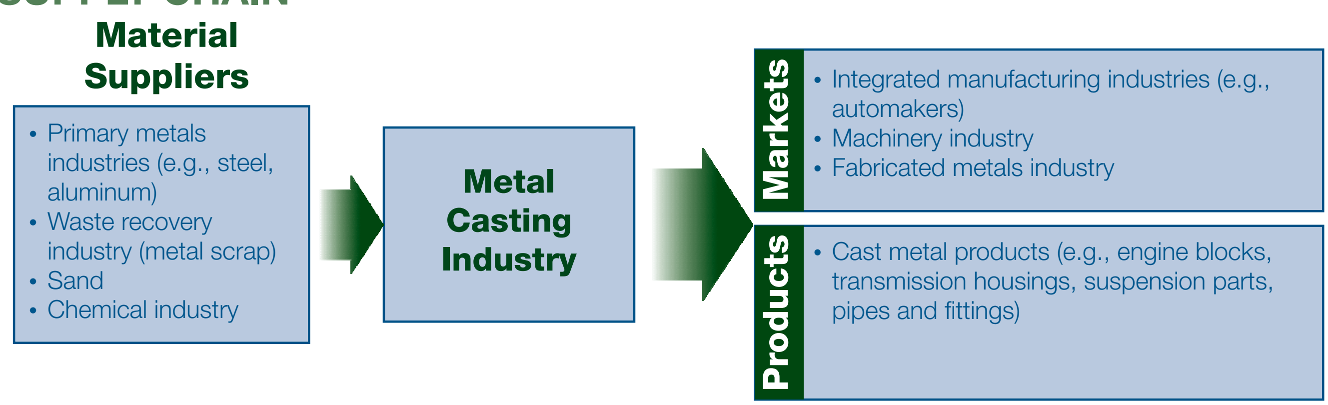
METAL CASTING MANUFACTURERS AND STAKEHOLDERS
(Select Examples)

Manufacturers
- Atchison Casting
- Deere & Co.
- Doehler-Jarvis
- General Motors
- Heick Die Casting
- Mercury Marine
- Precision Castparts
- Superior Aluminum Casting
- Waupaca Foundry

Suppliers and Vendors
- Ajax Tocco Magnethermic
- Carpenter Brothers
- DISA Industries
- Foseco Metallurgical
- Hunter Automated Machinery
- Inductotherm
- Simpson Technologies
- Unimin
- U.S. Silica
- Vulcan Engineering
- Wheelabrator Group

Organizations
- American Foundry Society
- American Society for Metals International
- Cast Metals Coalition
- Cast Metals Institute
- Casting Industry Suppliers Association
- North American Die Casting Association
- Steel Founder's Society of America

SUPPLY CHAIN



MARKET PROFILE: MINING

Overview

Facilities:

- 1,438 coal mines
  (612 underground, 812 surface)
- 108 metal mines
- 12,756 industrial mineral mines

Employees:

219,000 (excludes oil and gas)

Production:

- Coal: 1,162.8 million tons
- Metals: 59.4 million tons
- Industrial minerals:
  3,128.9 million tons

Value of Shipments/Revenues:

$78.65 billion
(excludes oil and gas)

Trade Balance:

$5.63 billion

Investments

Capital Expenditures:

$4.19 billion
(excludes oil and gas, 2002)

R&D Expenditures: N/A

Energy and Environment

Estimated Energy Use:

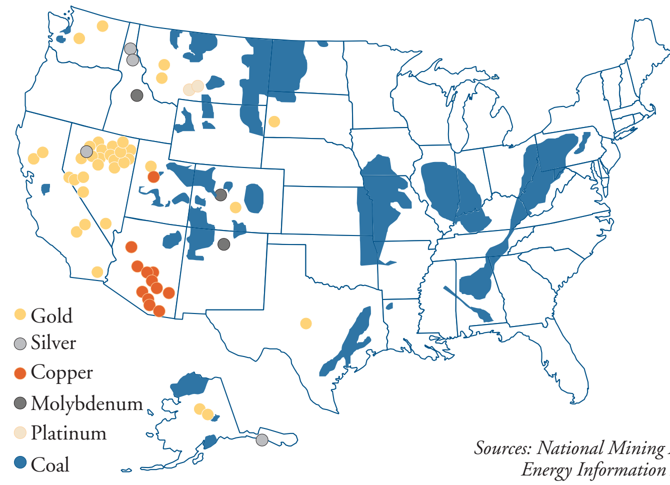
0.551 Quadrillion Btu

Estimated Carbon Emissions: 55 $MMTCO_2$

Emissions of Criteria Air Pollutants: 219,100 tons

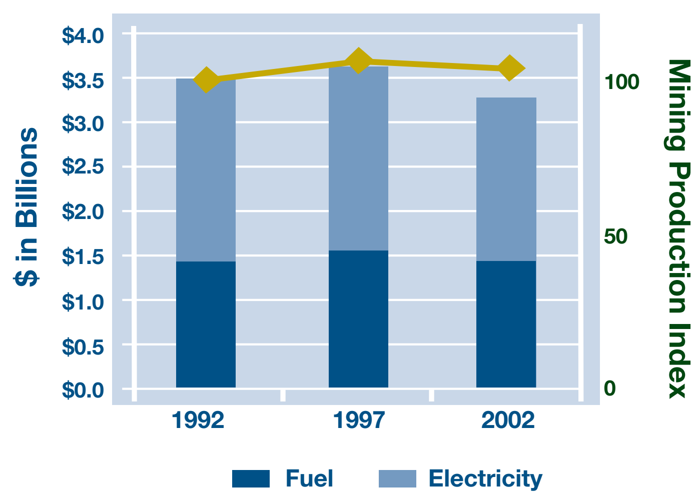
Purchased Energy Costs for Heat and Power:
$3.296 billion (2002)

GEOGRAPHIC CONCENTRATION
NAICS Codes Covered: 212



Sources: National Mining Association and Energy Information Administration

Trend in Nominal Purchased Energy Costs and Production for the Mining Industry, 1992-2002



Source: Various Census of Mining reports and Federal Reserve Board (G.17 Industrial Production and Capacity Utilization)

SIGNIFICANCE OF THE U.S. MINING INDUSTRY

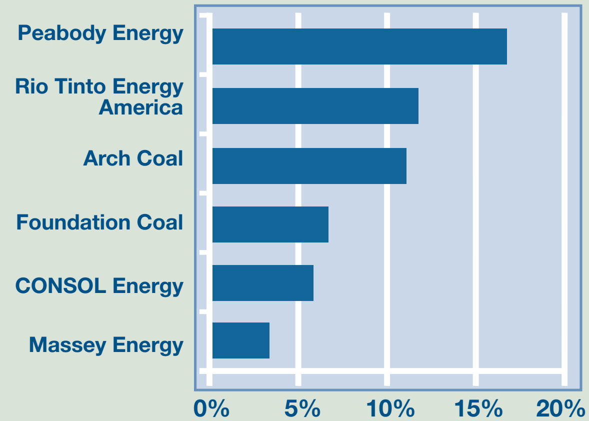
- World's 2nd leading producer of coal at 1.1 billion tons in 2006, nearly 17% of world production
- World's leading producer of lead, soda ash, and phosphate rock and the second largest producer of gold and copper
- Directly employs over 200,000 workers and indirectly supports an additional 1.6 million jobs in manufacturing, engineering and environmental and geological consulting
- Industry productivity has nearly doubled since the mid-1980s

Status of the Mining Industry

The U.S. and world mining industries stalled in the second half of 2008 due to recession in the United States, Europe, and Japan and the accompanying deterioration of the Chinese and other developing economies. Weakened demand for raw materials, slumping commodity prices, growing base metal stockpiles, and slowdowns in the housing and other end-use industries all contribute to a continuing poor market outlook in 2009. Over the past decade, the rapid development of China, India and other developing economies had provided a surge in demand for raw materials such as coal, metals, and industrial minerals. However, the recent global economic crisis has given the industry an extremely rapid and severe demand shock that has reverberated throughout the entire mining industry.

The mining industry is very capital and energy intensive. In 2002, the mining industry spent $3.3 billion or 21% of its total cost of supplies on energy (not including labor). The energy-intensive nature of mining is evident by the recovery ratio of the various materials being mined. Coal, with an average recovery ratio of 82%, requires the mining of 1.2 tons of material in order to recover 1 ton of coal. Industrial minerals have an average recovery ratio of 90%, while metals have an average recovery ratio of 4.5%. Thus, in order to recover 1 ton of metal, 22 tons of material will need to be mined.

Leading Coal Producers, Share of U.S. Production, 2007



Source: EIA Annual Coal Report, 2007

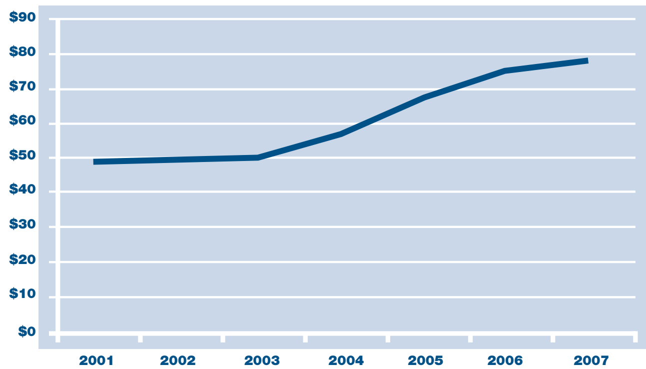
RIM™ RADIO-IMAGING METHOD: IMAGING AHEAD OF MINING

The RIM Radio-Imaging Method uses wireless synchronization between a transmitter and remote imaging receiver to produce images of coal seams for precise identification of cleaner, more complex coal beds. This method can find geological hazards through longwall mapping and also enables detection and mapping of old mine voids and the prediction of coal and ore thickness and trends. This technology was a 2004 R&D 100 Award Winner and was developed with DOE support.

Minerals are mined either underground or through surface methods like open-pit mining. Approximately 69% of coal and 97% of nonfuel minerals are extracted through surface mining methods. Both mining methods go through a process involving three general stages. The first stage is extraction, which includes activities such as blasting and drilling in order to loosen and remove material from the mine. The second stage is materials handling, which involves the transportation of ore and waste away from the mine to the mill or disposal area. The third stage, beneficiation & processing, takes place at the processing plant. This stage recovers the valuable portion of the mined material and produces the final marketable product.

FINANCIAL TRENDS: MINING

Nominal Value of Shipments Trend for U.S. Mining Industry ($ in Billions)



Source: Bureau of Economic Analysis, Gross-Domestic-Product-by-Industry Accounts

Profit Trends for U.S. Mining Industry

Source: Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations, various editions

MINERAL PRODUCERS AND STAKEHOLDERS
(Select Examples)

Producers
- Arch Coal
- CONSOL Energy
- Freeport-McMoRan
- Massey Energy
- Newmont Mining
- Peabody Energy
- Rio Tinto

Suppliers and Vendors
- Bucyrus International
- Caterpillar
- Ingersoll-Rand
- Joy Global
- Terex

Organizations
- Association of Equipment Manufacturers
- Industrial Minerals Association
- National Mining Association
- National Stone, Sand, and Gravel Association
- Northwest Mining Association

SUPPLY CHAIN

Material Suppliers
- Machinery industry
- Transportation equipment industry
- Chemical industry (explosives, blasting agents, acids)

Mining Industry

Markets
- Utilities
- Primary metals industry
- Non-metallic minerals industry (glass, cement, lime)
- Construction industry

Products
- Coal
- Industrial metal ores (iron, copper)
- Precious metals (gold, silver)
- Industrial minerals (potash, borates)
- Crushed rock and stone

MARKET PROFILE: PETROLEUM PRODUCTS

Overview

Establishments:

- 2262 total establishments
- 150 petroleum refineries (4 idle) in 2008

Employees: 101,009

Production: 6,568 million barrels of finished petroleum products (refineries and blenders), including:

- 3.1 billion barrels of finished motor gasoline
- 1.5 billion barrels of distillate fuel oil
- 0.5 billion barrels of jet fuel

Value of Shipments/Revenues:
$546.81 billion

Trade Balance:

- -$46.15 billion
- Crude oil feed input: approximately 66% imported (3.7 billion barrels net import)
- Finished petroleum product: approximately 7% imported (607 million barrels) and 9% exported (455 million barrels)

Investments

Capital Expenditures: $11.83 billion

R&D Expenditures: $1.43 billion

Energy and Environment

Energy Use: 6.799 Quadrillion Btu (includes crude oil feed)

Estimated Carbon Emissions:
304.8 $MMTCO_2$

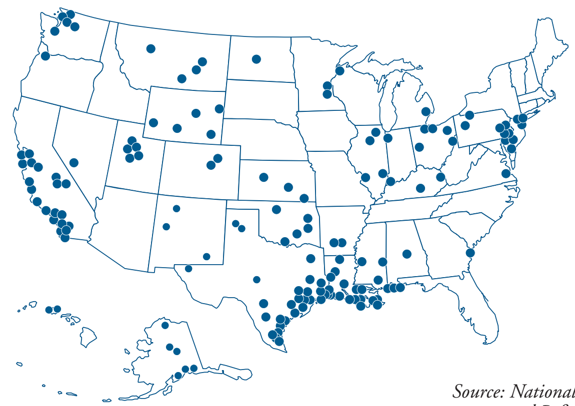
Emissions of Criteria Air Pollutants:
138,000 tons

Purchased Energy Costs for Heat and Power: $12.23 billion

Pollution Control Costs: $4.27 billion

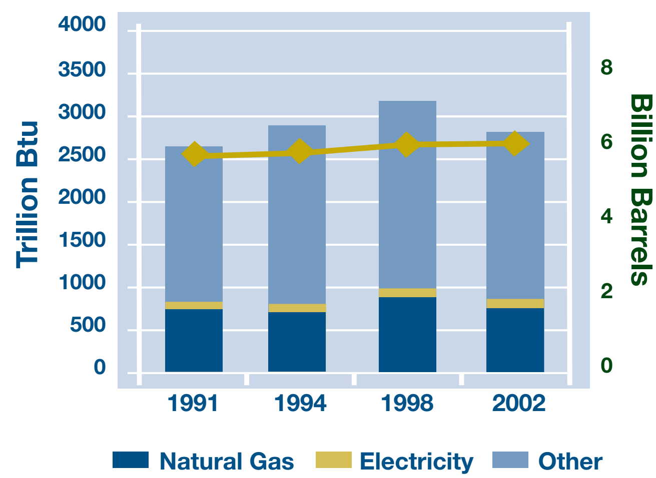
GEOGRAPHIC CONCENTRATION
NAICS Codes Covered: 324

Location of U.S. Refineries



Source: National Petrochemical and Refiners Association

Trend in Fuel Use and Petroleum Product Production for the Refining Industry, 1991-2002



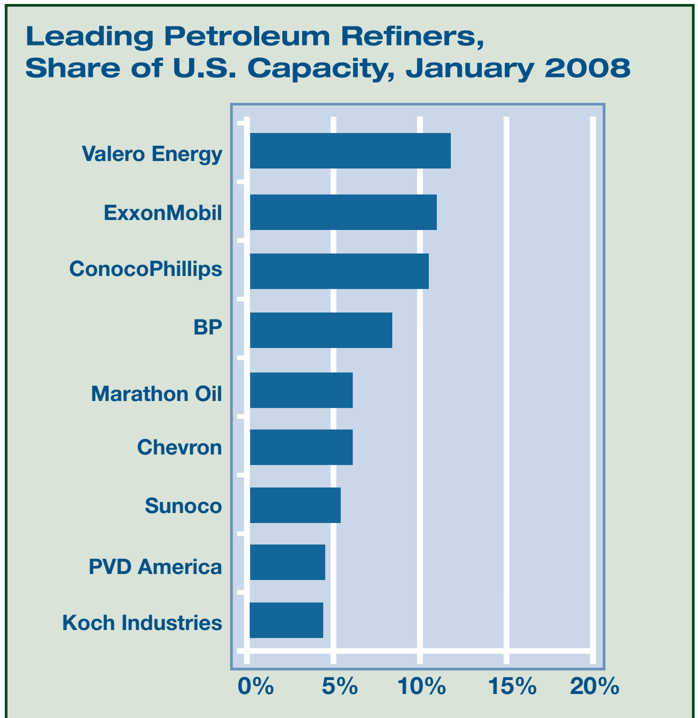
Source: Various EIA MECS reports and EIA Petroleum Supply Annual reports

SIGNIFICANCE OF THE U.S. PETROLEUM REFINING INDUSTRY

- Largest producer of refined petroleum products in the world with 22% of total world refinery output
- Highest capital intensity (capital invested) per employee
- Largest manufacturing energy consumer (fuel and feedstock)
- Largest producer of energy by-product fuels (primarily waste gas), which then provides 68% of the industry's fuel energy use

Status of the Petroleum Products Industry

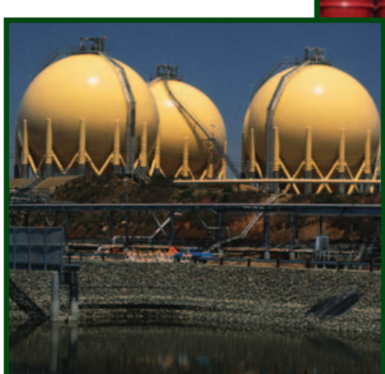
The net production of finished petroleum refinery products in the U.S. has climbed steadily from less than 5 billion barrels in the early 1980s to over 6.6 billion barrels in 2007. When measured in terms of output per hour, the industry's productivity increased by 3.8% annually between 1987 and 2006.



Source: EIA Petroleum Refinery Report 2008, based on crude oil distillation capacity

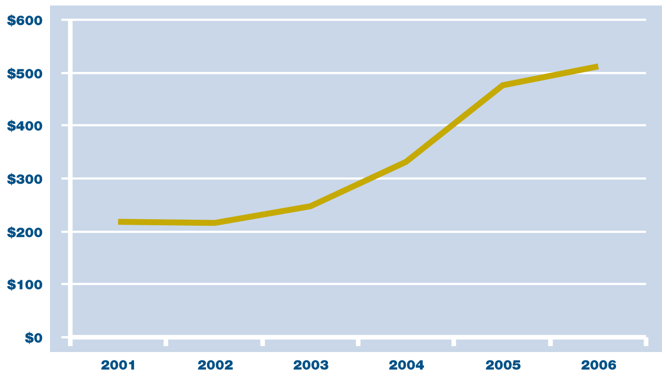
The refining industry capacity utilization rate is often the highest among all manufacturing sectors in the United States. Petroleum refining capacity utilization reached record highs in the late 1990s, peaking at a rate of almost 100% in 1997 before returning to a more sustainable level of 88.5% in 2007. Although no new domestic refineries have been built since the 1970s, existing facilities increased capacity by using equipment capable of processing the increasingly heavy crude oil slate. This increased the concentration of productive capacity in the East, West, and Gulf Coast regions and provided greater access to major shipping routes. But as evidenced in the past several years, Gulf Coast refineries are highly vulnerable to hurricane damage and significant production outages, exacerbating product supply constraints in some localities.

Petroleum refining is a complex industry, both from business and technology perspectives. Compared to other manufacturing sectors in the United States, petroleum refining invests more capital per employee than any other industry. The capital-intensive nature of this industry is reflected in the high value of purchased materials, energy, and equipment, along with advanced technology innovation. Other industry challenges include the recent price volatilities for crude oil and gasoline. Government mandates for removing the gasoline additive MTBE and increasing biofuel/ethanol blending have also impacted refinery operations and limited refining capacity expansion plans.



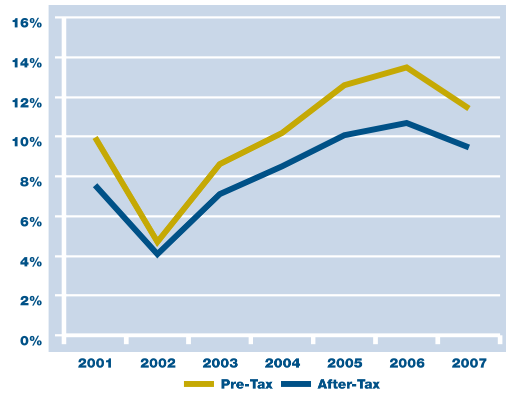
FINANCIAL TRENDS: PETROLEUM PRODUCTS

Nominal Value of Shipments Trend for U.S. Petroleum Products Industry ($ in Billions)



Source: Annual Survey of Manufactures, various years

Profit Trends for U.S. Petroleum Products Industry



Source: Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations, various editions

PETROLEUM PRODUCT MANUFACTURERS AND STAKEHOLDERS
(Select Examples)

Manufacturers
- BP
- Chevron
- ConocoPhillips
- ExxonMobil
- Koch Industries
- Marathon Oil
- Royal Dutch Shell
- Sunoco
- Tesoro
- Valero Energy
- Western Refining

Suppliers and Vendors
- AspenTech
- Bechtel
- Fluor
- Honeywell
- Jacobs
- KBC
- Nalco
- UOP

Organizations
- American Institute of Chemical Engineers
- American Petroleum Institute
- National Petrochemical & Refiners Association
- National Petroleum Council

SUPPLY CHAIN

Material Suppliers
- Oil & gas extraction industry
- Chemical industry

Petroleum Products Industry

Markets
- Consumer end-use (household, transportation)
- Transportation sector (trains, airplanes, shipping)
- Industrial sector (manufacturing, mining, agriculture, construction)
- Commercial sector

Products
- Fuels (gasoline, diesel, distillate oil, LPG)
- Refined petroleum feedstocks for chemical production
- Asphalt

MARKET PROFILE: TRANSPORTATION EQUIPMENT

Overview

Establishments: 12,639

- Motor vehicle manufacturing: 374
- Motor vehicle body and trailer manufacturing: 2,151
- Motor vehicle parts manufacturing: 5,728
- Aerospace product and parts manufacturing: 1,583
- Railroad rolling stock manufacturing: 202
- Ship and boat building: 1,768
- Other transportation equipment manufacturing: 833
- Motor vehicle manufacturing accounts for less than 3% of the sector's establishments, but represents 40% of the sector's value of shipments

Employees: 1,525,036

Production:

- Automotive (2006): 11.26 million vehicles (4.37 million cars and 6.89 million SUVs, vans, and light trucks)
- Aerospace (2005):
  - 4,096 civil aircrafts (2,853 general aviation, 947 helicopters, 296 transports)
  - 559 military aircrafts

Value of Shipments: $699.03 billion

Trade Balance: -$62.79 billion

Investments

Capital Expenditures: $15.18 billion

R&D Expenditures: $30.01 billion

Energy and Environment

Energy Use: 0.427 Quadrillion Btu

Estimated Carbon Emissions: 50 $MMTCO_2$

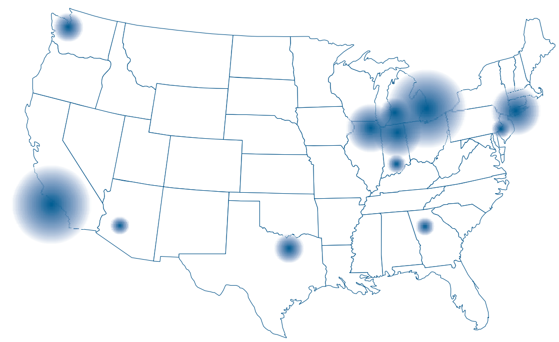
Emissions of Criteria Air Pollutants: 134,000 tons

Purchased Energy Costs for Heat and Power: $4.82 billion

Pollution Control Costs: $1.58 billion

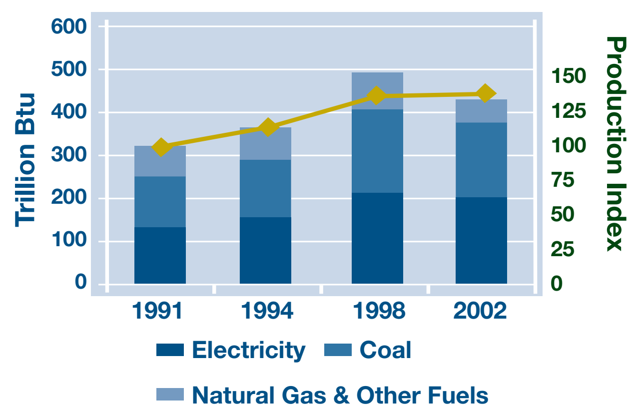
GEOGRAPHIC CONCENTRATION

NAICS Codes Covered: 336



Source: U.S. Census Bureau

Trend in Energy Use and Production for the Transportation Equipment Industry, 1991-2002



Source: Various EIA MECS reports and Federal Reserve Board (G.17 Industrial Production and Capacity Utilization)

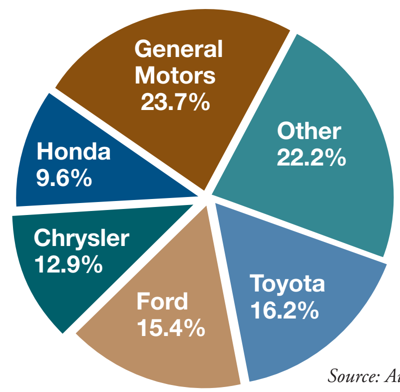
SIGNIFICANCE OF THE TRANSPORTATION EQUIPMENT INDUSTRY

- Generates 1.5 million jobs, representing more than 11% of the U.S. manufacturing sector's employment
- Accounts for 12% of the U.S. manufacturing value added and 1.4% of the total U.S. GDP

Status of the Transportation Equipment Industry

The transportation equipment manufacturing industry boasts one of the nation's highest production levels. Energy costs represent about 1% of the production output by a vehicle assembly plant. However, transportation equipment manufacturing plants actively seek cost reduction opportunities because of the increasingly competitive environment within the industry.

Market Share for U.S. Light-Duty Vehicle Sales, 2007



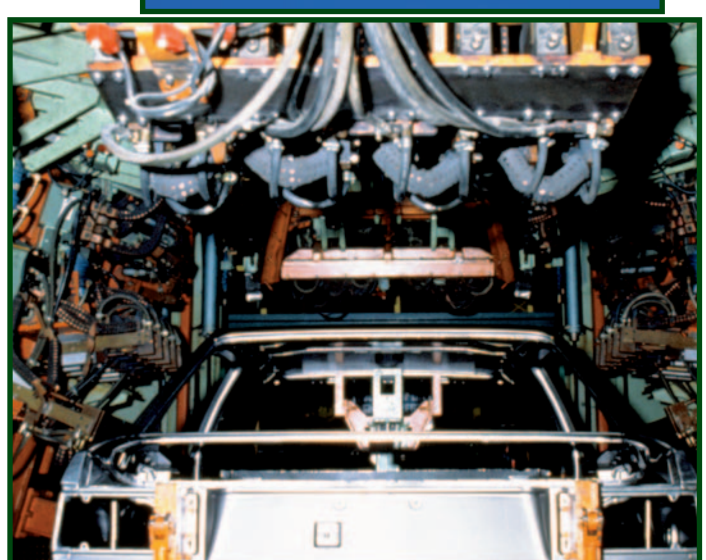
Source: Autodata Corp.

Automotive Manufacturing Industry

The U.S. automotive sector is a highly competitive market, and U.S. automakers continuously face increasing competition from international car makers. In the last decade, U.S. automakers implemented a series of operational changes in response to increasing international competition. These changes include the adoption of improved process technologies, a shift to new products with higher value-added per hour worked, increased features and quality in existing products, a shift within the industry to more efficient producers, and process efficiency improvements from changes in product mix. In addition, the U.S. automotive industry is strongly regulated. These regulations include those affecting fuel economy, safety, and environmental emissions.

In 2007, the U.S. accounted for 15% of the world's total production share of cars and commercial vehicles. When prices for raw materials and energy increase, transportation equipment manufacturers encounter pressure on operating margins. High fuel prices also influence consumer behavior, which has impacted the automotive industry, in particular. In response to high gasoline prices, customers purchased fewer large, energy-consuming automobiles, such as sport utility vehicles (SUV).

In 2008, U.S. automakers accounted for 48% of domestic sales, down from 51% in 2007. The automotive industry began facing financial troubles, stemming from the global financial crisis and credit crunch. U.S. automotive manufacturers began seeking government assistance for short- to medium-term funding and to prevent bankruptcy. As of November 2008, total car sales, year-to-date (YTD), decreased by more than 8% while total SUV sales dropped by more than 34% over the previous year.

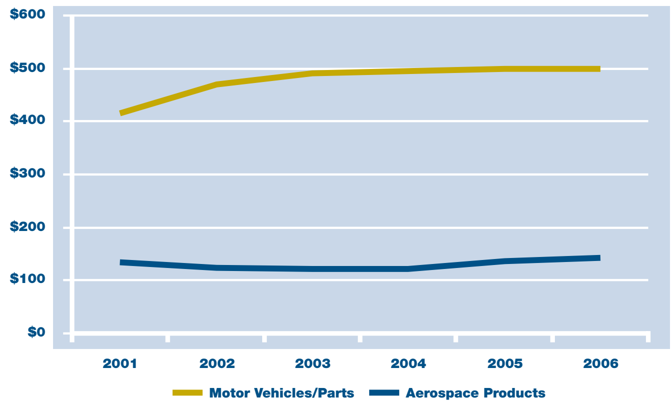


Aerospace Industry

Despite the current economic downturn, the U.S. aerospace industry remains financially healthy. Aerospace industry sales for civilian, military, and space applications grew 2.1% to $204 billion in 2008. Civil aircraft sales grew by $400 million. Missile, military aircraft, and space products also experienced growth in 2008.

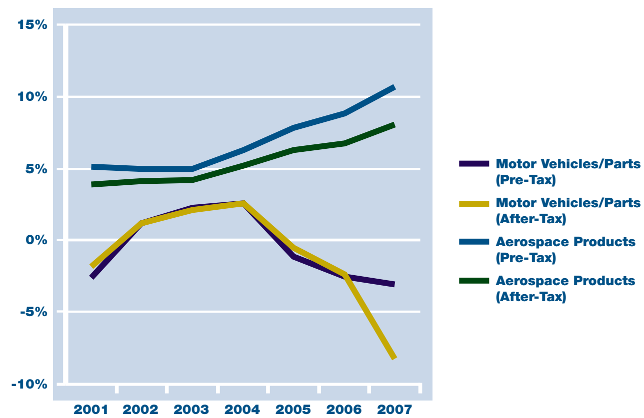
FINANCIAL TRENDS: TRANSPORTATION EQUIPMENT

Nominal Value of Shipments Trend for U.S. Transportation Equipment Industry ($ in Billions)



Source: Annual Survey of Manufactures, various years

Profit Trends for U.S. Transportation Industry



Source: Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations, various editions

TRANSPORTATION EQUIPMENT MANUFACTURERS AND STAKEHOLDERS (Select Examples)

Manufacturers

- Boeing
- Chrysler
- Ford Motor
- General Dynamics
- General Motors
- Honda Motor
- Lockheed Martin
- Paccar
- Raytheon
- Toyota Motor
- Trinity Industries
- United Technologies

Suppliers

- Alcoa
- Allegheny Technologies
- Cummins
- Dana
- Delphi
- Dow Chemical
- DuPont Automotive
- Eaton
- Goodyear Tire & Rubber
- Johnson Controls
- Lear
- Magna International
- PPG Industries
- Titanium Metals
- TRW Automotive Holdings
- U.S. Steel
- Visteon

Organizations

- Aerospace Industries Association
- Alliance of Automobile Manufacturers
- Association of International Automobile Manufacturers
- Center for Automotive Research
- Original Equipment Suppliers Association
- SAE International
- U.S. Council for Automotive Research

SUPPLY CHAIN

Material Suppliers

- Primary and fabricated metal industries
- Plastic and rubber industries
- Electronics industry
- Glass industry
- Chemical industry

Transportation Equipment Industry

Markets

- Consumer end-use
- Aerospace industry
- Military sector
- Construction and mining industries
- Maritime and shipping industries

Products

- Motor vehicle parts
- Passenger vehicles
- Aerospace products and parts
- Off-highway construction and mining equipment
- Ships and boats

DOE ACTIVITIES IN THE INDUSTRIAL SECTOR

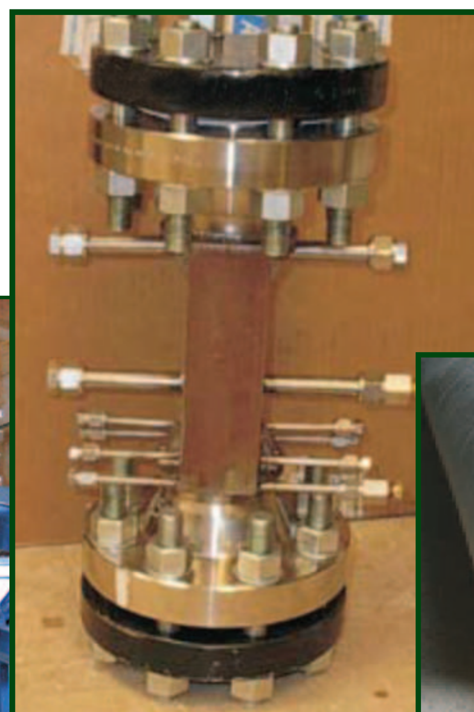
Manufacturers are typically risk-averse and need to see proof of a technology's performance in a specific industrial application before they will consider adopting it. The U.S. Department of Energy (DOE) Industrial Technologies Program (ITP) instills confidence in potential buyers by conducting late-stage R&D, demonstrating cross-cutting technologies in specific industrial applications, and verifying technology claims.

Examples of technologies supported by ITP that are expected to enter the commercial market and expand markets are described on the following pages. These technologies have been developed and demonstrated in cooperation with industry to address critical needs in the manufacturing sector. This section describes the opportunity, benefits, and the markets for these technologies.

The DOE Industrial Technologies Program (ITP) brings together top talent from all sectors to solve some of the toughest challenges facing industry. ITP collaborates with cost-share partners to accelerate the development of energy-saving technologies. Many of these technologies are in use across industry, increasing productivity and reducing emissions nationwide.

ITP's track record includes:

- 48 R&D 100 awards between 1991 and 2008.
- Over 100 technologies available today.
- More than 150 patents between 1994 and 2007.



MESABI NUGGET ITMK3 TECHNOLOGY

The Opportunity

An increasing percentage of U.S. steel production is made by electric arc furnace (EAF) based "mini-mills". EAFs traditionally use steel scrap salvaged from derelict autos, machine shop waste and defunct skyscraper framework. EAFs have traditionally produced the crudest type of steel, such as "rebar" the steel rods used to reinforce concrete construction. To improve product quality to produce a higher revenue product, mini-mill operators use higher quality scrap and solidified pig iron, a high quality iron produced by the blast furnaces used by the traditional integrated steel industry. ITP and its partners – Mesabi Nugget LLC, Steel Dynamics, and the State of Minnesota – have successfully demonstrated the use of a cost-effective new process for producing blast furnace-quality iron from low-quality iron ore.

The Technology

The one-step Mesabi Nugget iron making process is based on Kobe Steel's ITmk3 technology. The process combines reduction and melting into a single step using a rotary hearth furnace. Over a two-year period, the pilot plant funded by ITP and its partners demonstrated that low-grade iron ore and low-volatility coal can be converted into 97% pure iron nuggets that are equivalent to pig iron in terms of quality and performance.

CONSTRUCTION OF A 500,000 MT/YR PLANT IS UNDERWAY IN MINNESOTA.

Uniqueness and Competitive Advantage

The ITmk3 process is the only commercial direct reduced iron (DRI) process that produces iron of pig iron quality with no undesirable tramp elements. Relative to the blast furnace, the Mesabi Nugget ITmk3 process produces the same quality product although as a solid rather than a liquid. This solid product is more desirable for electric arc furnace applications, which are limited with respect to the percentage of liquid "hot metal" that can be used.

Markets

The key customers for the iron nuggets produced in the new process are the growing number of electric arc-furnace-based minimills. The basic oxygen furnaces used at integrated mills, as well as iron foundries, represent secondary markets for the nuggets. Iron ore producers are the entities that will actually install the process in order to serve their steel mill customers. Two additional installations now planned are by iron ore producers, although it is likely they will not move ahead until the commercial-scale operation of the ITmk3 process has been verified.

Benefits

The ITmk3 process uses about 30% less energy than the traditional blast furnace route for producing iron. The process uses readily available raw materials, including low-grade taconite ore. It is expected to produce iron nuggets for about half the cost of purchasing pig iron on the open market. When the process is combined with EAF steelmaking, it produces fewer GHG emissions than the coke/blast furnace/BOF route. Other benefits include easier handling and shipping as a bulk commodity, and no generation of slag by-products.

Technology Status

The Mesabi Nugget technology has been tested at the pilot scale by Mesabi Nugget LLC and has been found to be both technically and economically viable. Steel Dynamics, in partnership with Kobe Steel, is currently constructing a $235 million commercial-scale, 500,000 metric ton/year facility near Hoyt Lakes, Minnesota. Operation of this installation, which will begin upon completion of construction in late 2009, is expected to establish commercial-scale viability.

Barriers to Market Entry and Keys to Success

The largest barrier to adoption of the Mesabi Nugget process is the lack of validated performance data from a commercial-scale plant. Participation by DOE in the pilot plant test served as a catalyst for other organizations to join in sponsoring the pilot runs. This resulted in interest from both commercial organizations and the state of Minnesota, which invested in the pilot demonstration and is now providing some debt financing for the first commercial plant. The most critical issues to be demonstrated are the cost and product quality achieved in the full-scale production facility.

ISOTHERMAL MELTING PROCESS

The Opportunity

Effective, efficient application of energy has long been a priority of the aluminum industry. All phases of aluminum melting provide major opportunities for energy savings because traditional gas-fired combustion furnaces operate at low efficiencies (~30%). To address this opportunity, Apogee Technology, Inc. has developed the Isothermal Melting Process (ITM®), an advanced, high-performance aluminum melting process with dramatically reduced energy consumption and melt loss, no in-plant emissions, and a small footprint. Apogee's partners on the project include General Motors, Aleris International, and Alcoa.

The Technology

The Isothermal Melting Process (ITM) is a radically new concept that has demonstrated potential to revolutionize the aluminum industry's melting capabilities. In ITM, an aluminum melt pool moves from a pumping bay to a heating bay, where high-intensity electric heaters heat the pool just enough for it to melt solid metal being added to the pool. The pool then moves through charging and treatment bays that provide compact areas to control alloying and purifying. The key breakthrough in ITM is the development of durable heaters that provide high-intensity heat (5 to 10 times that of traditional commercial heaters) via electrical conduction.

Uniqueness and Competitive Advantage

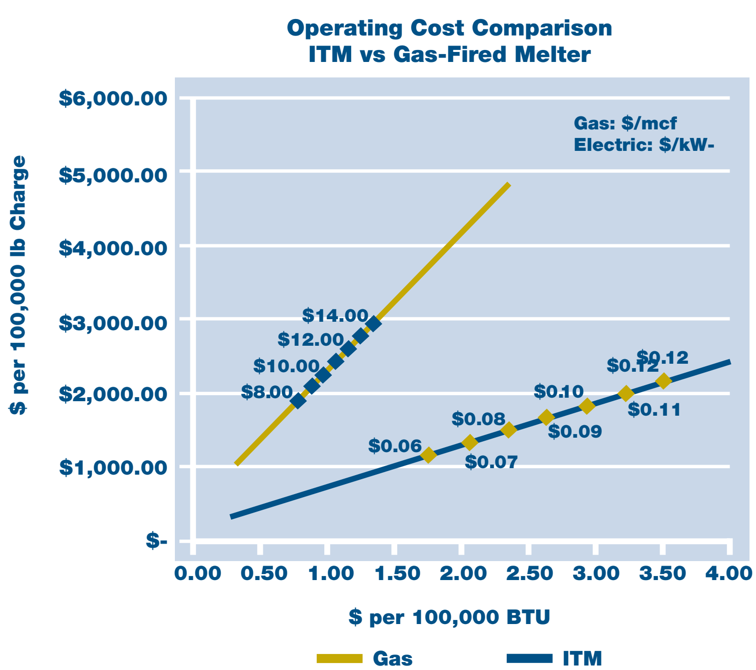
The very distinctive advantage of the ITM's heating method is that the conversion process occurs at essentially 100% energy efficiency. Electric resistance energy conversion is not unique to the ITM® process, however. While other electricity-based aluminum heating methods exist, they are limited either by comparatively low conversion efficiency or reduced heat flux. High-rate and thermally efficient electrical resistance melting had not been achieved in the aluminum industry prior to the emergence of ITM®.

Markets

ITM can be applied in every segment of the aluminum industry, including the melting of imported primary aluminum ingots and scrap metal for secondary aluminum production. The technology can also be used to increase efficiency in the copper, glass, steel, and other molten metal industries.

Benefits

The ITM process operates at a specific melting energy requirement of 552 Btu/lb Al, compared to an industry average or more than 1,800 Btu/lb Al). The melt loss using this closed-loop technology is less than 1% versus the industry average of 2- 3%, and it requires one-third the floor space of a conventional aluminum melter. Additional benefits include the system's portability and contribution to enhanced safety and industrial hygiene. The capital investment required is on par with that of conventional melters and metal holders. The cost savings of using ITM are illustrated in the figure.



Technology Status

- Gen 1 ITM® (2 units) successfully operated for 1½ and 4½ years; long-term sustainability under evaluation.
- 7,000 lb/hr GEN 2 ITM® under construction – complete 2010.
- GEN 3 ITM® in design/component evaluation phase.
- Plan for construction (3) 2,200 – 5,000 lb/hr ITM® units in 2009.
- 27 related U.S. and foreign patents.

Barriers to Market Entry and Keys to Success

Barriers to the adoption of ITM technology include:

- Pushback on new technologies from the conservative metal industries.
- The high consequences of failure.
- Limited expansion of production facilities in a slow economy.

The government's role in getting ITM to market includes cost-sharing R&D, supporting critical technology demonstrations, helping link developers with potential markets, validating technical performance, and promoting the technology through its outreach activities. Keys to the technology succeeding include favorable economics and equipment sustainability.

MICROCHANNEL REACTOR FOR ON-SITE HYDROGEN PEROXIDE PRODUCTION

The Opportunity

Hydrogen peroxide (H_2O_2) is one of the most versatile and environmentally compatible oxidizing agents in use today. Currently, concentrated H_2O_2 is produced at large facilities and must be transported to an end-use facility, where it is diluted prior to storage and use (most commercial applications of this chemical require concentrations far below 70%). An innovative new technology being developed by Stevens Institute of Technology and FMC Corporation gives end-users the capability for on-site, on-demand H_2O_2 generation to reduce transportation, storage, and concentration dilution energy use and costs.

The Technology

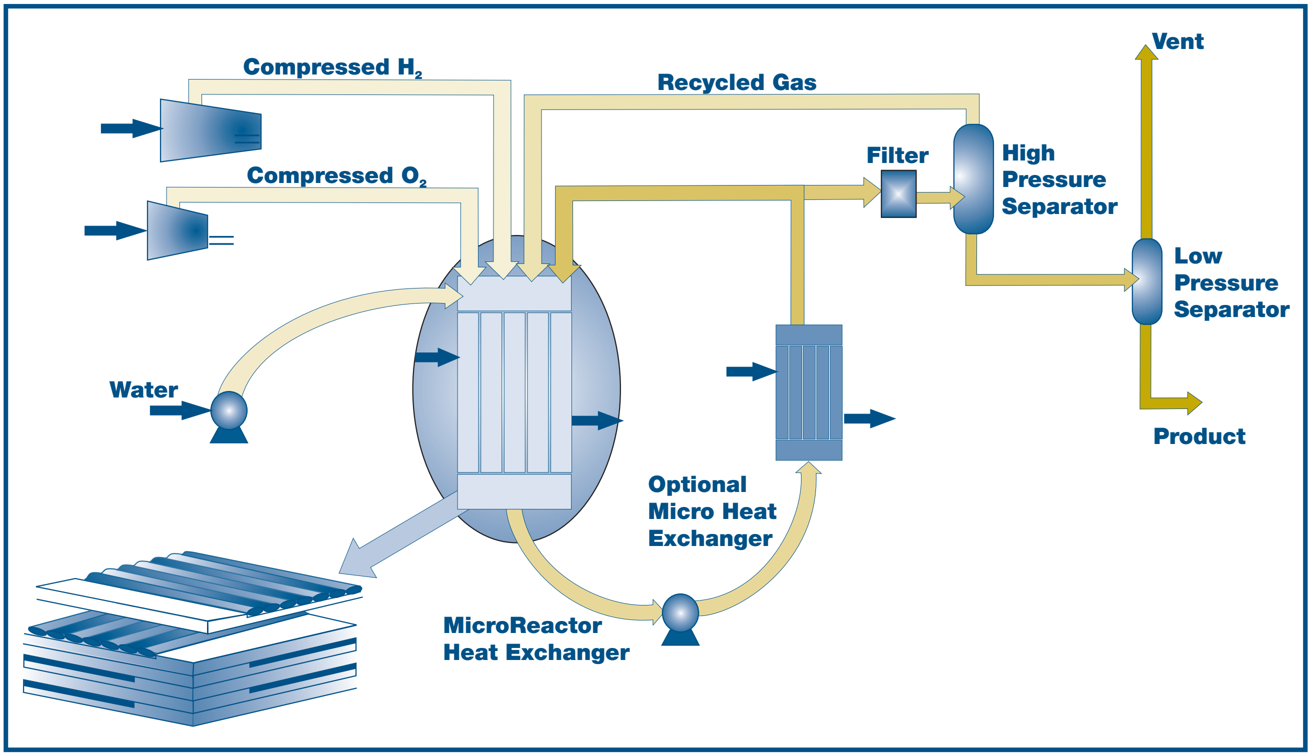
The "microchannel" reactor can produce hydrogen peroxide on-site at any concentration demanded by the user's application. In this reactor, chemical reactions take place in the confinement of hundreds of microchannels, allowing continuous flow operation. Catalysts are packed into the microchannels to increase reaction rates, which are also enhanced by the reactor's extremely high surface-to-volume ratios.

Uniqueness and Competitive Advantage

Combining hydrogen and oxygen in conventional reactor systems is not feasible because the mixture becomes flammable and even explosive. This factor, plus other operating issues related to corrosion and contamination, makes it highly unlikely that on-site, on-demand H_2O_2 production using conventional technology will ever be economically feasible. The microchannel technology will be the first skid-mounted, portable reactor to be marketed to the chemical industry. It will be capable of producing 1-1.5 wt % concentrations of hydrogen peroxide at rates of 1-10 kg/hour.

Markets

Hydrogen peroxide is one of today's most widely used chemicals, with applications ranging from agriculture to industrial processes like pulp and paper and synthesis of oxychemicals to water purification to health care. Current demand for H_2O_2 is around 1 billion lbs/year. In addition, the production of propylene - a high commodity chemical used for a variety of applications - represents a potentially significant new market for point-of-use H_2O_2 production.



Benefits

Use of the microchannel reactor could potentially save 5 trillion Btu/year of steam and 3 trillion Btu/year in electricity in the production of H_2O_2 alone. These savings translate to an approximate 30% reduction in overall production and transportation costs for the $1 billion H_2O_2 industry. Other benefits include unit portability and enhanced safety and productivity.

Technology Status

A pilot unit has been used to produce over 1 wt % H_2O_2, which is applicable for biocides and wastewater treatment. FMC has also been able to produce more than 2 wt % H_2O_2 in a single channel reactor and is currently undergoing process optimization of the pilot unit to achieve 5 wt % H_2O_2 concentrations. Engineering design optimization of a skid-mounted device will be completed in 2009.

A limited survey of potential customers has indicated significant industry interest in the technology. Therefore, Stevens and FMC will continue activities leading to commercialization after completion of the ITP-funded project. FMC is planning to install the technology in a new medium-size H_2O_2 plant in New Jersey.

Barriers to Market Entry and Keys to Success

Barriers to the adoption of microchannel reaction technology include:

- Technical issues related to catalysts, gas composition, and scale-up.
- Customer reluctance to implementing on-site production technology.
- Initial up-front costs.
- Competing technologies.

AEROGEL THERMAL INSULATION TECHNOLOGY

The Opportunity

In the United State alone, thermal losses in industrial steam distribution systems account for more than 1% of total domestic energy consumption. Conventional steam pipe insulation products, typically produced from mineral wool, fiberglass, calcium silicate, perlite, and various foams, are only moderately effective in their insulating capacity. They also suffer long-term physical degradation due to the extreme heat (up to 650°C or 1200°F) and high humidity environments they are subjected to under routine service conditions. Areas of damaged insulation increase energy losses and can be points for corrosion initiation. To reduce energy losses and decrease overall operating costs, heavy industry users of steam have sought alternative pipe insulation solutions. ITP and its partners—Aspen Aerogels—have successfully demonstrated the use of silica aerogels as a superior pipe insulation material with the added benefit of significantly improved performance in harsh service environments.

The Technology

Silica aerogels consist of a three-dimensional, intertwined cluster of silica solids and nanopores filled with air. Because of the large volume of air within their structure (more than 90%), they are extremely low-density solid materials with very high surface areas (~200m^2/cm^2) and very low thermal conductivities. This makes them superb thermal insulators for a variety of applications. In addition, these materials are also highly hydrophobic, robust, and possess good flexibility and conformability. ITP funding helped develop aerogels that can withstand temperatures up to 725°F (385°C) and their deployment into a broad spectrum of industries. Current ITP funding supports the enhancement of these materials to meet the steam-distribution industry standard of 1200°F (650°C) while also being applicable to more geometrically complex piping systems.

Uniqueness and Competitive Advantage

In insulation applications, the extremely low thermal conductivity property of the silica aerogel significantly reduces the amount of material required to achieve the same or even better energy savings as compared to conventional insulation materials. In addition, the aerogel's robust properties and hydrophobic nature allow it to withstand extreme environments where other materials systems would routinely fail.

Markets

The key customers for the silica aerogels are the hydrocarbon-processing and compressed-gases industries since they rely heavily on steam to drive processing. Other markets for the aerogel material include pipe-in-pipe (PiP) and pre-insulated cryogenic piping industries. Other uses could include non-pipe components in industrial processing such as furnace covers, coker panels, hot duct works and other high-temperature applications.

Field demonstration activities: installation of aerogels onto a variety of in-service hydrocarbon-processing equipment

Benefits

Because of the aerogel's extremely low thermal conductivity, its use in pipe-insulation applications reduces energy losses and would require 50% - 80% less material when compared to other insulation types for identical performance. The saved space can be used for additional piping or other requirements. The hydrophobic nature of the aerogel resists moisture incursion and water vapor penetration onto pipe surfaces, thereby eliminating incidences of surface corrosion. These materials maintain their integrity in harsh environments. The existing blanket aerogel form factor provides for easy low-cost installation onto pipes and enables additional energy efficiencies by integrating insulation into areas that were previously not possible. The use of aerogels for insulation applications provide for savings in capital, installation, and operating costs.

Technology Status

Silica aerogels are currently being optimized for their manufacturability - increasing yield and minimizing production costs - while delivering the appropriate material properties for industrial steam pipe applications. Concurrently, these insulation materials are under going industry acceptance studies which include: 1) educating the end user on the performance and savings that can be realized with Aerogel Based Pipe Insulation (ABPI); and 2) application-specific testing to quantify material performance improvements and/or acceptability for the intended use conditions. In depth material testing and actual field demonstrations are also on-going.

Barriers to Market Entry and Keys to Success

The largest barriers to adoption of the silica aerogels in industrial steam distribution systems are cost-effectiveness and the need for ample independent verification of the product's capabilities. Continued DOE funding and successes in parallel markets have generated interest from the hydrocarbon-processing industry. Qualification against a variety of industry testing standards (ASTM and ISO), independent head-to-head tests (aerogels vs. existing insulations materials), and successful field demonstrations will bolster the acceptance of aerogels for commercial use. Materials and processes for producing aerogels will be scrutinized to ensure cost-effective commercial-scale deliveries. Existing blanket-style production of the aerogels can easily meet current piping form factors; the flexibility of the aerogel material ensures that other pipe geometries can also be accommodated.

LOW-COST TITANIUM PRODUCTION TECHNOLOGY

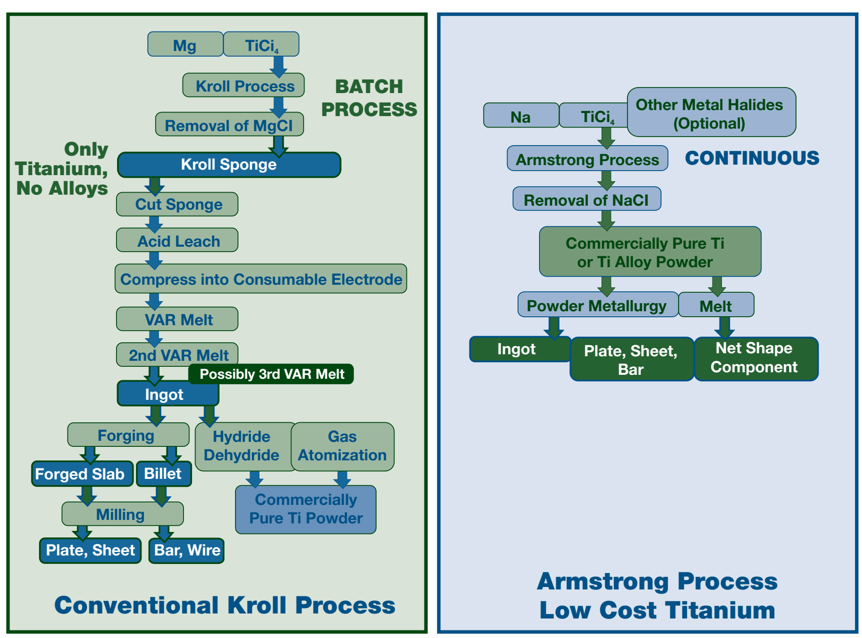
The Opportunity

Titanium (Ti) and titanium alloys' high strength to density ratio allows for the fabrication of thinner and lighter components, thereby saving energy without sacrificing performance. Additionally, Ti's resistance to environmental/corrosion attack allows for its use in numerous harsh operating conditions. However, Ti's high costs and limited availability - attributed to the lengthy, energy intensive, and dated Kroll production process - constrain its use. In the Kroll process, multiple steps are required to arrive at commercial grade Ti ingots. After post-processing, powder consolidation, and part machining, scrap rates can range between 50-90%. Alloying of Ti is not possible until the latter stages of the process, adding costly extra steps and consuming more energy in an already prolonged method. As such, prices ranging from \$35-\$50/lb for Ti plates and \$50-150/lb for Ti powders are not uncommon. If a simpler, less energy consuming, and lower cost production method were available, Ti would see expanded use. While many alternative production approaches are under development, International Titanium Powder (ITiP) has successfully demonstrated the Armstrong Process, a shorter, less expensive method for producing Ti powders and Ti alloy powders in a continuous fashion.

The Technology

In the Armstrong Process (AP), titanium tetrachloride vapor ($TiCl_4$) is injected into a continuous stream of molten sodium (Na). A reaction occurs between the $TiCl_4$ and the sodium producing titanium powder and NaCl. With simple modifications of the process and additional reactor vessels, Ti alloy compositions can be made (such as Ti-6Al-4V powder, the work-horse of titanium applications). These powders are then consolidated into parts using various technologies such as vacuum hot pressing, extrusion, or melt processing.

Uniqueness and Competitive Advantage



The current Kroll batch process involves the reduction of $TiCl_4$ in a retort at elevated temperatures; this reduction process can take several days. After the reduction, the Kroll process creates a titanium metal sponge which requires further processing to arrive at production-grade Ti. The AP has the advantage of delivering Ti and Ti-alloy powders with fewer processing steps, thereby using 40-50% less energy compared to the Kroll method. The AP method is continuous and operates at relatively low temperatures. The AP eliminates the need for an intermediary sponge step and directly delivers high purity Ti powders suitable for metallurgical processes. The Ti scrap rate from this new process is dramatically reduced as well – to as low as 10%. Finally, the cost of these Ti powders is between $10-30/lb, enabling wider industrial and commercial use.

Markets

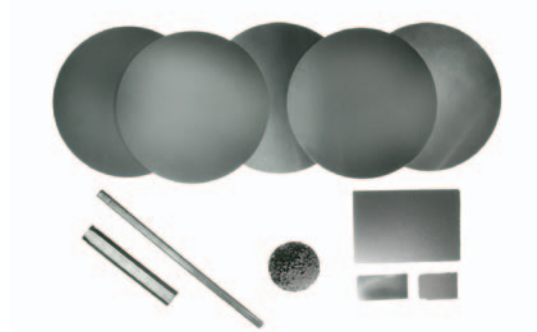
The chemical, energy/petroleum, aerospace, automobile, medical/biomedical, military, and other industries would benefit from the use of low cost Ti in their product portfolio. Example opportunity areas include: chemical applications, armor and other defense components, sporting gear, bio/medical equipment, automotive and aerospace components to name a few. Titanium consumption for military applications is expected to double over the course of the next 10 years.

Benefits

With the AP, fewer steps for producing Ti will reduce its costs to customers and improve lead times by up to 80%. This will translate to further penetration of existing markets and use in completely new applications. Ti's high strength-to-weight ratio and superior chemical properties will lead to lighter, more robust, and more reliable products. As a result, products using Ti will use less energy and emit fewer pollutants over its service life.

Technology Status

AP Ti powders are available in limited commercial quantities for research and development. These powders are produced on ITiP's prototype reactor. ITiP is currently building a full scale production plant that will annually produce between 2 to 4 million pounds of titanium. Plans exist to build an Armstrong plant to produce up to 50 million pounds of titanium per year. However, high demand also exists for fully developing solid state consolidation technologies that could directly deliver titanium products. DOE-ITP is currently supporting the development of manufacturing technology to process new titanium powders into fully consolidated near net shape components for industrial applications.



Armstrong Derived Titanium Powder with Solid State Consolidated Plates, Bars, and Sheet.

Barriers to Market Entry and Keys to Success

A variety of barriers exist to the unfettered use of AP Ti powders. For instance, defect-free processing techniques with the AP require optimization. After this, strategies for successful powder manufacturing scale-up can be implemented. Solid state powder consolidation technologies need attention in order to ensure delivery of mass-produced parts. A battery of material qualification tests (mechanical, electrical, chemical) need to be performed to ensure short and long term reliability. Market barriers also include the resistance to use AP Ti in commercial and military applications because of their unproven capabilities under extremely demanding conditions. However, the demand for Ti in military applications is only expected to increase and the stringent standards in these applications will fully scrutinize AP Ti and help facilitate commercial acceptance.

COMBINED HEAT AND POWER

The Opportunity

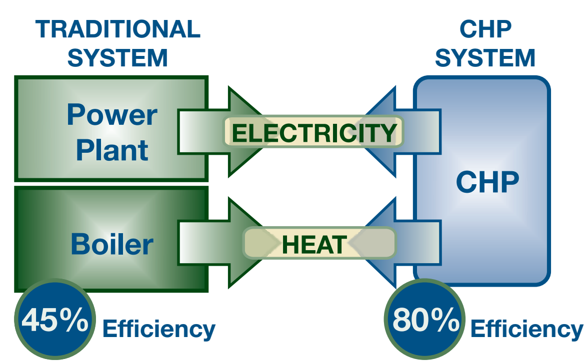
By providing onsite power generation, waste heat recovery, and system integration, combined heat and power (CHP) offers a realistic, near-term solution for exceptional energy efficiency and emission reduction. The great majority of U.S. electric generation does not make use of the waste heat. As a result, the average efficiency of utility generation has remained at roughly 34% since the 1960s. New and improved CHP technologies can expand current markets and open new opportunities. Specific opportunities lie with component technologies that facilitate new applications for advanced turbines, advanced reciprocating engine systems, microturbines, and thermally activated technologies as well as integrated energy systems that provide "plug and play" capability for new markets at commercial and small industrial facilities

The Technology

CHP, also known as cogeneration, is the concurrent production and use of electricity or mechanical power and useful thermal energy from a single fuel source. CHP includes a suite of technologies that can use a variety of fuels to generate electricity or power at the point of use, allowing normally lost heat to be recovered to provide needed heating or cooling. Using CHP today, the United States already avoids more than 1.9 Quadrillion British thermal units (Quads) of fuel consumption and annual CO_2 emissions equivalent to removing more than 45 million cars from the road.

Uniqueness and Competitive Advantage

CHP Process Flow Diagram



A CHP system recovers the heat normally lost in electricity generation for use in cooling, heating, dehumidification, and other processes. Compared to separate generation of electricity and heat, combined heat and power systems can operate at greater than 80% efficiency and provide many benefits, including:

- **Energy efficiency:** CHP systems recycle waste energy and use it for heating and cooling while enhancing fuel utilization efficiency.
- **Emission reduction:** CHP technologies decrease pollutant and GHG emissions and can use clean, renewable fuels to provide electrical and thermal energy.
- **Energy reliability and quality:** CHP can operate in parallel with the grid to enhance power reliability and support operations, or supply onsite generating capacity.
- **Energy security:** CHP systems can operate independently of the grid to sustain critical services such as health care, communications, and public safety after disasters.
- **Economic development:** CHP systems directly relieve grid congestion, reduce or eliminate power purchases, and avoid construction of new power plants.

Markets

CHP can use a variety of fuels to provide reliable electricity, mechanical power, or thermal energy for industrial plants, universities, hospitals, or commercial buildings. Unlike wind and solar generating technologies, CHP can operate 24 hours a day in any climate or location in the United States. The heat and power is produced at or near the site of consumption and therefore does not face transmission and delivery (T&D) constraints. CHP is typically located at sites already zoned for commercial or industrial activities. CHP can be used in a wide variety of applications including large and small industrial facilities, commercial buildings, multi-family and single-family housing, institutional facilities and campuses, and district energy systems.

Benefits

If the United States were to achieve 20% of generating capacity from CHP by 2030, benefits would include:

- A 60% reduction of the projected increase in carbon dioxide (CO_2) emissions by 2030 – the equivalent of removing 154 million cars from the road;
- Fuel savings of 5.3 quadrillion Btu annually - the equivalent of nearly half the total energy currently consumed by US households;
- Economically viable application throughout the nation in large and small industrial facilities, commercial buildings, multi-family and single-family housing, institutional facilities and campuses; and
- The creation of 1 million new highly-skilled, competitive "green-collar" jobs through 2030 and $234 billion in new investments throughout the United States.

Technology Status

CHP systems at more than 3,300 sites across the nation today deliver 85 gigawatts of power—about

9% of U.S. electricity generating capacity. Combined heat and power is not a new technology. More than 100 years ago, CHP systems were common onsite electricity generators in industrial applications. Using CHP today, the United States already avoids more than 1.9 Quadrillion British thermal units (Quads) of fuel consumption and 248 million metric tons of carbon dioxide (CO2) emissions annually compared to traditional separate production of electricity and thermal energy.

Barriers to Market Entry and Keys to Success

Despite its proven benefits, a number of hurdles must be overcome to realize the full potential of CHP in the marketplace. Regulatory, policy, and institutional barriers persist, in spite of successes at the state and regional level, and recent federal legislation boosting tax credits for CHP. For example, electric rate structures linking utility revenues and returns to the number of kilowatt-hours sold act as a disincentive for utilities to encourage customer-owned onsite generation. In addition, CHP technology applications are impeded by interconnection issues, sundry technical barriers, and environmental permitting regulations that focus on heat input and do not recognize the higher overall efficiency improvements offered by CHP. However, the development of more efficient CHP components such as advanced turbines, reciprocating engines, and thermally activated technologies, as well as integrated energy systems for new markets at commercial and small industrial facilities will enable this proven technology to fully realize its full potential.

POLICIES, INCENTIVES, AND MARKET DRIVERS

RESEARCH AND DEVELOPMENT

Industry continues to be underinvested in R&D, particularly energy-related efforts. Many energy-intensive industries are severely constrained in their ability to invest in R&D due to their low profit margins and inability to fully appropriate the resulting benefits to their companies. In recent years, R&D investments in the energy-intensive industries have not kept pace with the rest of the economy. In fact, the energy-intensive industries have the lowest R&D investment rate in the entire industrial sector, with R&D spending at a rate of only 1% of sales. This compares with an average of R&D spending of ~4% of sales for all of industry.

Energy-intensive manufacturers are often unable to invest in energy-related process R&D without government assistance. Companies in these industries are unable to accept the costs and risks associated with undertaking the complex, capital-intensive activities needed to develop the next generation of process technologies. These technologies are seen as too expensive and risky, and unlikely to provide adequate long-term return to the firm, potentially resulting in lost production.

As a result of perceived risks, most manufacturers favor R&D investments that incrementally improve existing technology platforms. While this "optimize and extend" strategy carries less risk and produces near-term returns, it also prevents companies from investing in the very technologies that can help ensure their long-term competitive advantage.

Development of radically new industrial technologies requires significant investment in fundamental sciences, technology development, engineering, and demonstration. Such resource requirements are beyond the reach of even the largest companies—and often entire industries—without government facilitation and support. The government has a clear role in supporting research and development that can accelerate technology concepts to the point at which they can attract private investment for commercial development.

TECHNOLOGY ADOPTION

U.S. industrial companies have a large opportunity to profitably implement energy-efficient technology and processes, but a number of market barriers prevent them from doing so. Key barriers include:

- Responsibility for decisions related to energy efficiency delegated to line managers.
- Incomplete information on a technology's applications and benefits.
- Lack of incentives to drive energy efficiency.
- Competition for capital with other company projects.

Energy-efficient technologies often compete with less-efficient alternatives for market share. "First cost" is often the primary factor considered in these decisions rather than life-cycle cost, which leads to the installation of technology that not only is less energy-efficient but ends up costing more over the life of the equipment.

Furthermore, energy-intensive industries remain conservative where the risk is significant and the savings associated with installing a new technology are not guaranteed. Companies are reluctant to be the first adopter of a new technology, even one with demonstrated and validated performance. The cost of lost production due to plant shutdowns can far outweigh minor cost savings. Other potential risks include negative effects on product quality, unexpected process impacts, and higher-than-expected initial and/or operational costs. Because of these factors, government has an appropriate role to help demonstrate and cost-share the first application of emerging energy and carbon reduction technologies.

Another appropriate role for the government is to accelerate the uptake of proven technologies and practices by providing manufacturers with accurate, unbiased information on available solutions and with energy assessment tools that enable sound decision-making.

IMPROVING ENERGY EFFICIENCY OF THE INDUSTRIAL SECTOR

Improved energy efficiency is an important component to increasing national energy security, reducing the cost of energy, and combating climate change and environmental degradation. The McKinsey Global Institute estimates that "one hundred and seventy billion dollars a year invested in efforts to boost energy efficiency from now until 2020 could halve the projected growth in global energy demand…and deliver up to half of the emission abatement required to cap the long-term concentration of atmospheric greenhouse gases at 450 parts per million," the level researchers suggest is necessary to prevent a two degree centigrade increase in mean temperature. Meanwhile, the US Climate Action Partnership (USCAP), a coalition of NGOs and some of the most influential and energy intensive multinational corporations in the world, continues to actively call for the Federal government to develop and implement "stronger energy efficiency codes and standards for whole buildings and for equipment and appliances" in addition to financial and regulatory incentives. With industry comprising approximately one-third of national energy use, many of the statements highlighted above apply to industrial technology and processes.

Despite the estimated value of energy efficiency, only $1.8 billion of the $148.4 billion invested globally in sustainable energy investment in 2007 (up 60% from $92.6 billion in 2006) was dedicated to energy efficiency technology. While this represents a 78% increase over 2006 investment figures, it still weighs in at a paltry 1.2% of the total investment. Investors and market analysts contend that determining industrial energy efficiency financing is more challenging than investments in renewable energy because the cost-saving benefits are asymmetrical and frequently found in small, fragmented clumps not as readily identifiable as, for instance, a wind or concentrating solar generation site. In addition, many industrial efficiency upgrades are financed internally as part of larger capital budgeting activities.

FINANCIAL POLICIES TO ENCOURAGE INVESTMENT IN INDUSTRIAL ENERGY EFFICIENCY PROJECTS AND TECHNOLOGIES

Enhance Credit Terms through Federal Guarantees

Credit enhancement schemes can include any mechanism designed to help borrowers obtain access to favorable credit terms that they might otherwise obtain in the private lending markets. Such credit enhancement mechanisms most notably include loan guarantees and letters of credit. Loan guarantees for energy projects currently exist under the authority of the Department of Energy's Title XVII from the

Energy Policy Act of 2005 and the 2007 Energy and Water Development Appropriations Act. These guarantee programs support early commercial use of advanced energy technologies that avoid, reduce, or sequester greenhouse gas emissions and other air pollutants. The program currently has $42.5 billion in loan volume authority that can support renewable, energy efficiency, transmission, nuclear, and advanced fossil technologies.

Spur Investment by Offering Targeted Tax Credits
A number of tax credit vehicles are utilized by public agencies today including Production Tax Credits (PTC), Investment Tax Credits (ITC), and tax credits for research and development. PTCs, ITCs, and R&D credits are designed to catalyze investment by providing economic incentive to markets the government deems economically or politically vital. In operation, PTCs and ITCs reduce the amount of income payable by allowing deductions for a pre-determined production or investment activity. In addition, the EPAct 2005 established a tax deduction of $1.80/square foot for owners of new or existing buildings who install eligible technologies including but not limited to backpressure turbines, boilers, combustion turbines, reciprocating engines, heat recovery generators, and/or stirling engines.

Several states have recognized that allowing companies to deduct a portion of their investment in new, cleaner, and more efficient equipment could speed up turnover of existing capital stock. State tax credits include:

- **California Legislature AB 2553** - Establishes Air Quality Mitigation Zones for the purpose of creating jobs and reducing air pollution. Business incentives include a tax credit for qualifying equipment purchases.
- **California Legislature AB 1651** - Created a tax credit for certain qualified businesses that purchase or upgrade qualified environmental machinery and added provisions creating a tax credit for qualified capital equipment used to reduce greenhouse gas emissions
- **Assembly, No. 1283 (A1283), State of New Jersey, 212th Legislature** - Allows a credit for 20% of the costs of manufacturing equipment installed at a manufacturing facility in this State and improvements or additions that result in the renovation, modernization or expansion of a manufacturing facility in this State.

Engage Private Industry in Cost Sharing Partnerships
Public-private partnerships almost exclusively occur at the technology research phase of industrial efficiency development. Such partnerships spread the costs of R&D across industry players keen on developing new products or cost-saving processes and government agency's intent on achieving a broader policy agenda. This particular mechanism is employed heavily in ITP.

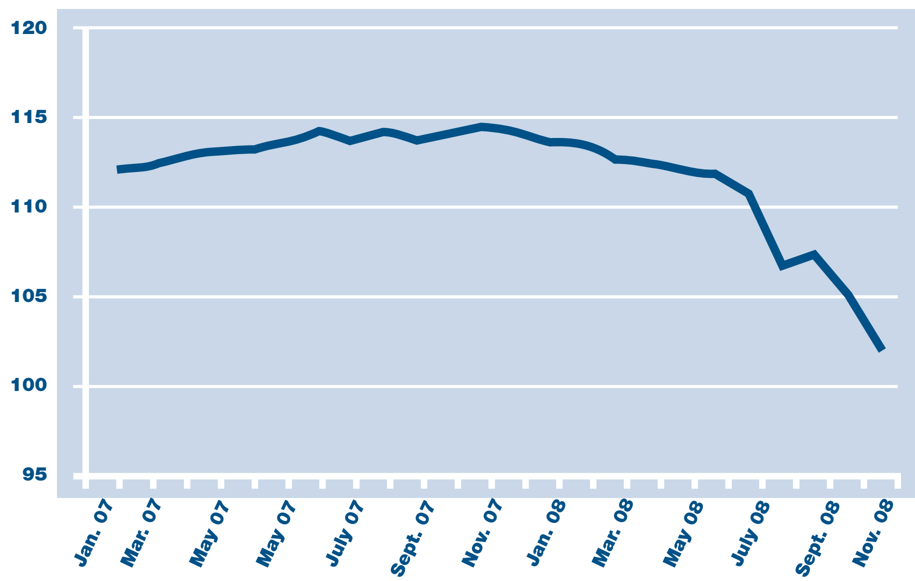
Administer Federal Grants and Direct Loans to Reduce Early Capital Costs
Federal grants are a form of financial aid that does not require repayment. The federal government offers grants to cover the partial or total cost of feasibility studies, technology demonstrations, or the purchase of new technologies. In some cases, cost sharing is required.

OUTLOOK FOR THE INDUSTRIAL SECTOR

The near-term outlook for the industrial sector and key manufacturing industries is very uncertain. The significant reduction in consumer and business demand for materials and products as a result of the credit crisis and current economic slowdown have radically changed expectations for industrial markets. Capacity utilization by U.S. manufacturers has fallen dramatically since early 2008, from 78.7% in December 2007 to 69.1% in December 2008, and has continued to fall in early 2009. The manufacturing production index, which peaked at a level of nearly 115 in November 2007 (2002 production level equivalent to 100 for the index), dropped to under 103 by December 2008. As an example of the drop in production, the U.S. steel industry shipped only half as much steel in January 2009 as it shipped in January 2008.

With so much slack capacity in not only U.S. manufacturing, but also globally, operating margins have shrunk dramatically. Capacity additions that were planned have been put on hold. Many firms have seen their credit ratings reduced, increasing borrowing costs. Anecdotal data from individual companies include significant planned reductions for capital expenditures to ensure sufficient cash reserves to survive the downturn. Two of the "Big Three" U.S. automakers have received capital infusions from the Federal government, and auto suppliers have also received government funds.

Manufacturing Production Index, 2007-2008 (2002 = 100)



Source: The Federal Reserve

Predicting when the U.S. economy will improve and U.S. manufacturers will begin expanding production is extremely difficult. Most surveys that project corporate expectations were conducted in the middle of 2008, before the economy significantly worsened. But even by then, weakness was clearly evident.

In Bank of America's 2009 CFO Outlook focused on manufacturing, only 20% of CFOs expected their company to expand capital expenditures in 2009, compared to 32% in the 2008 survey. On the opposite side, 40% expected to lower capital expenditures, up from 27% in 2008. A tightening in credit markets was evident, as 42% of CFOs forecast an increase in cost of capital, up from 26% in 2008. And 32% of CFOs reported lenders had restricted credit availability, up from 10% in 2008.

More recently, the broader Business Roundtable first quarter 2009 survey indicated two-thirds of leading American companies expect sales and capital spending to decrease during the subsequent six months. And the Manufacturers Alliance quarterly survey released in April 2009 indicated over three-quarters of senior executives believe the economic recovery, when it arrives, will be gradual and weak.

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Industrial Technologies Web Sites

U.S. Department of Energy Industrial Technologies Program (ITP)
www.eere.energy.gov/industry/

Alliance to Save Energy
ase.org/

American Council for an Energy-Efficient Economy
www.aceee.org/industry/index.htm

ITP Industrial Assessment Centers
www.iac.rutgers.edu/

ITP Save Energy Now
www.eere.energy.gov/industry/saveenergynow/

Lawrence Berkeley National Laboratory
industrial-energy.lbl.gov/

Oak Ridge National Laboratory
www.ornl.itp.govtools.us/

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