Energy Trends in Selected Manufacturing Sectors:

Opportunities and Challenges for Environmentally Preferable Energy Outcomes

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3.7 Metal Casting

3.7.1 Base Case Scenario

Situation Assessment

The metal casting industry (NAICS 3315) is a diverse industry that plays a critical role in U.S. manufacturing, as more than 90 percent of all manufactured goods in the United States contain cast metal components.[209]

There are approximately 2,300 metal casting facilities in the United States, including both ferrous and nonferrous (primarily aluminum) foundries and die casting facilities.[210] 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.[eeee] DOE data indicate that approximately 70 percent of sector energy use is by independent metal casting facilities and 30 percent is by captive foundries.[211] The industry is dominated by small "job-shop" businesses; 80 percent of metal casting facilities employ 100 people or less.[212] The sector is also varied due to differences in the metals being melted, alloying requirements, product specifications, casting processes used, capacity of operations, etc. Though metal casting facilities are found nationwide, ten states account for more than 80 percent of the industry's shipments: Ohio, Indiana, Wisconsin, Alabama, Michigan, Pennsylvania, Illinois, Tennessee, California, and Texas.[213]

The metal casting sector currently participates in EPA's Sector Strategies Program.

In recent years, the metal casting sector has experienced a downturn in part due to international competition and declines in the automobile industry. Out of all sectors considered in this analysis, the metal casting industry had the largest annual decrease in value added and value of shipments from 1997 to 2004 (see Table 44). At the same time, recent forecasts indicate an improved economic outlook for the sector in the future. By 2008 metal castings sales are projected to increase 15 percent from 2005 levels, and metal casting shipments are expected to be 8 percent higher than 2004 levels.[214] From 2003 to 2004,

Recent Sector Trends Informing the Base Case

Number of facilities: ↓
Value added and value of shipments: ↓
Energy intensity: ↓

Major fuel sources: Natural gas, purchased electricity

Current economic and energy consumption data are summarized in Table 44 on page 3-66.

Voluntary Commitments

The metal casting sector participates in DOE's Industries of the Future (IOF)/Industrial Technologies Program (ITP) as an "Energy Intensive Industry." ITP's goals for all energy intensive sectors include the following:

- Between 2002 and 2020, contribute to a 30 percent decrease in energy intensity.
- Between 2002 and 2010, commercialize more than 10 industrial energy efficiency technologies through research, development & demonstration (RD&D) partnerships.

The program has identified best practices for melting and other efficiency improvement opportunities in the sector that could result in energy savings and CO_2 emission reductions. Specific energy reduction techniques identified include the following:

- Replacing heel melting furnaces used for iron production with modern batch melters.
- Improving casting yield.
- Applying existing air/natural gas mixing methods to reduce ladle heating energy.

Industry participation in the program is managed by the Cast Metals Coalition, which in 1998 set measurable goals for 2020, including using 20 percent less energy to produce castings, compared to the sector's 1998 energy requirements of 320 trillion Btus. See http://www.eere.energy.gov/industry/metalcasting/ and http://cmc.aticorp.org/.

[eeee] According to the DOE analysis, *Theoretical/Best Practice Energy Use in Metalcasting Operations* (2004), energy data that rely on NAICS classifications (as do the sources used in this report) fail to capture energy use by colocated facilities.

the industry's value of shipments grew by more than 7 percent.[215] Growth in the production of light metals is expected to continue, in part due to transportation industry trends.

Profit margins in the industry are generally small and combined with the small average business size, suggest that companies have limited financial resources at their disposal, particularly for R&D initiatives that involve high costs, long investment horizons, and uncertain outcomes. At the same time, R&D is essential to maintaining the industry's position in an increasingly competitive global marketplace. DOE notes that casting processes must continually evolve to meet increasing demand for lighter-weight, higher-strength castings.[216] Thus, public/private R&D partnerships are essential to ensuring the long-term health and productivity of the industry. DOE's Industrial Technologies Program partners with the Cast Metals Coalition (representing 80 percent of the industry) and university researchers to develop transformational technologies that seek to reduce metal casting energy intensity (energy consumption per ton of production) by 20 percent by 2020.[217] Given the industry's limited financial resources, a recent DOE analysis suggests that the most promising technology advancements offer less capital-intensive energy-savings opportunities, such as retrofits aimed at increasing the efficiency of existing furnaces.[218]

The metal casting industry is heavily dependent on natural gas and purchased electricity, and growing interest in energy efficiency has been driven by the impacts of natural gas price volatility.[219] According to DOE, most of the sector's energy use (approximately 55 percent of total energy costs) can be attributed to the melting of metals, but moldmaking and coremaking also utilize significant amounts of energy. Being one of the most energy-intensive industries in the United States, reducing energy usage is a primary goal for the sector.[220]

The table below summarizes economic and energy consumption data presented in Chapter 2.

Table 44: Current economic and energy data for the metal casting industry

Economic Production Trends				
	Annual Change in Value Added 1997-2004	Annual Change in Value Added 2000-2004	Annual Change in Value of Shipments 1997-2004	Annual Change in Value of Shipments 2000-2004
	-3.2%	-5.4%	-2.4%	-3.7%
Energy Intensity in 2002				
	Energy Consumption per Dollar of Value Added (thousand Btu)	Energy Consumption per Dollar Value of Shipments (thousand Btu)	Energy Cost per Dollar of Value Added (share)	Energy Cost per Dollar Value of Shipments (share)
	10.3	5.6	8.0%	4.6%
Primary Fuel Inputs as Fraction of Total Energy Supply in 2002 (fuel use only)				
		Natural Gas	Net Electricity	Coke & Breeze
		49%	34%	15%
Fuel-Switching Potential in 2002: Natural Gas to Alternate Fuels				
		Switchable fraction of natural gas inputs		20%
		LPG	Fuel Oil	Electricity
Fraction of natural gas inputs that could be met by alternate fuels		73%	13%	13%

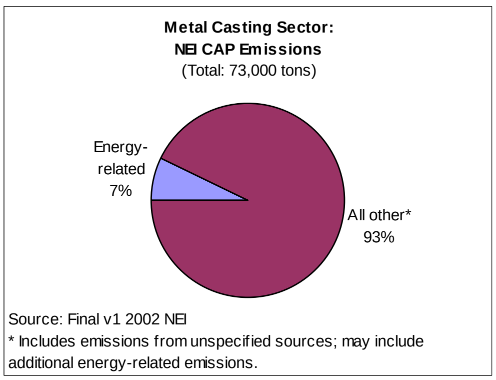
Expected Future Trends

As the CEF report does not address the metal casting sector, we are unable to present detailed energy consumption projections for this industry. DOE analysis conducted in 2003 projected that industry-wide energy consumption would increase through 2009 in response to increasing production.[221] Nonferrous casting shipments are growing due to increased demand for lighter metals (for example, in the transportation industry and for the U.S. military). According to DOE, aluminum casting production comprised 36 percent of sales and 34 percent of industry energy consumption in 2003, and energy use in the typical aluminum casting facility is 381 percent greater per ton of metal produced than is typical for iron casting operations.[222] DOE site visits indicated that inefficient melting and holding operations were common in aluminum casting facilities.

As with other energy-intensive industries (iron and steel, forest products), a gradual decrease in energy consumption per ton of production is expected for the metal casting industry. Though efforts to control energy costs are expected to drive incremental investment in energy efficiency, capital constraints are likely to limit the rate of energy efficiency improvement.

Environmental Implications

Figure 18: Metal casting sector: energy-related CAP emissions



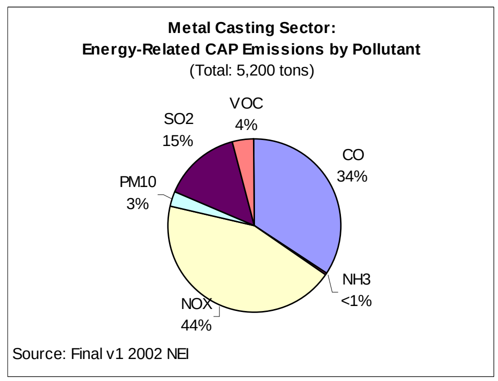
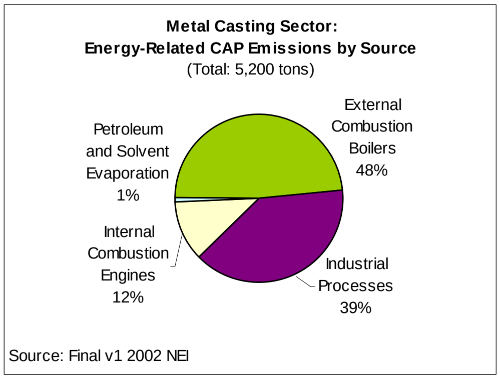


Figure 18 compares NEI data on energy-related CAP with non-energy-related CAP emissions for the metal casting industry. According to the figure, energy-related CAP emissions comprise a relatively small fraction of total CAP emissions. However, purchased electricity meets more than 30 percent of the sector's energy demand. As NEI data attribute emissions associated with electric power generation to the generating source rather than the purchasing entity, NEI data underestimate energy-related CAP emissions for this sector.

Effects of Energy-Related CAP Emissions

SO_2 and NO_x emissions contribute to respiratory illness and may cause lung damage. Emissions also contribute to acid rain, ground-level ozone, and reduced visibility.

Figure 19: Metal casting sector: CAP emissions by source category and fuel usage



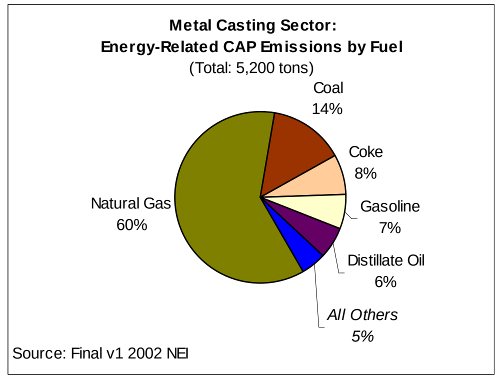


Figure 19 presents NEI data on energy-related CAP emissions by source category and fuel type. Though the largest fraction of energy-related CAP emissions is from external combustion boilers, process-related energy inputs are also substantial. As noted previously, NEI data classifications are problematic due to reporting inconsistencies, but equipment classified under "industrial processes" likely includes melting and holding furnaces that may be fired with coke, natural gas, or electricity.[223] (Cupola melting furnaces are used in ferrous metal casting and are mostly fired with coke. Holding furnaces are used to maintain the temperature of molten metal before input into pouring lines.) Other energy-using equipment that is likely classified as process-related includes equipment used in moldmaking, coremaking, and post-casting activities.

Due to the energy-intensive nature of processes related to melting metals (which represent 55 percent of total energy consumption), DOE notes that substantial energy-savings opportunities lie with energy efficiency improvements in this area—not only to the melting furnace itself, but also in terms of equipment used for metal preparation and pretreatment, refining and treatment of molten metals, molten metal holding, and molten metal tapping and transport.[224] At the same time, onsite emissions of energy-related CAPs are small compared with other sectors considered in this analysis—approximately 5,000 tons per year compared with more than 700,000 tons per year for the chemical manufacturing industry.

3.7.2 Best Case Scenario

Opportunities

Table 45 ranks the viability of five primary opportunities for improving environmental performance with respect to energy use (Low, Medium, or High). A brief assessment of the ranking is also provided, including potential barriers.

Table 45: Opportunity assessment for the metal casting industry

Opportunity	Ranking	Assessment (including potential barriers)
Cleaner fuels	Low	The sector remains heavily dependent on natural gas and electricity, and shows little fuel-switching potential. Natural gas is likely to remain important in part due to the growth of the nonferrous casting segment of the sector (particularly aluminum casting), which prefers natural gas-driven melting technologies.[225]

Opportunity	Ranking	Assessment (including potential barriers)
Increased CHP	Low	An extensive analysis of CHP opportunities conducted on behalf of DOE indicated little potential for CHP in the metal casting industry, primarily on the basis of cost effectiveness.[226] However, there is potential for increased utilization of waste heat energy through technologies such as heat recuperators, which use heat from exhaust gases to heat incoming combustion air.[227]
Equipment retrofit/ replacement	Medium	The financial barriers in this industry indicate that retrofitting existing technology may be a more viable opportunity for the industry than equipment replacement. In iron metal casting, cupola melting efficiency can be improved with retrofits such as replacing gas-fired hot blasts with recuperative hot blasts, or installing variable speed/frequency drives on large motors.[228] Installation of automated temperature and power controls is another energy-savings opportunity available in multiple melting-related applications. As with retrofits, the greatest energy-savings opportunities from equipment replacement lie with equipment used in melting processes. For iron metal casting, replacing heel melting furnaces with modern batch melters is one such opportunity. A DOE analysis estimates that heel melters account for 60 percent of ductile iron and gray iron induction furnaces used by industry in 2003.[229] For aluminum metal casting, there are substantial energy-savings opportunities from replacing inefficient reverberatory furnaces with best practice stack melters.[230]
Process improvement	Medium	There are also energy-savings opportunities through process improvement in ferrous and nonferrous metal casting operations, e.g., implementation of energy management best practices, optimizing scheduling (continuous melting), scrap cleaning, and improving casting yield.[231]
R&D	Medium	DOE notes that given the energy requirements of melting processes, development of advanced melting technologies is an area of substantial energy-savings potential for the metal casting industry. Developing technologies that involve retrofits to existing furnaces rather than furnace replacement are most likely to be adopted, in part because retrofits may avoid permitting requirements, and also because they are typically less capital intensive. Developing retrofit technologies with substantial energy-savings potential noted by DOE include the following: oxygen-enriched fuel combustion, charge preheating, molten metal delivery, and heat recovery from flue gases. Other promising R&D opportunities noted by DOE include the following: (1) new furnace designs that allow greater scheduling flexibility and reduced energy losses in batch melting processes; (2) technologies for increased waste heat recovery; (3) technologies to promote wider applicability of induction furnaces; (4) continued development of experimental melting furnace technologies, including Isothermal Melting Technologies; and (5) technologies that translate ladle metallurgy furnaces used in wrought steel and aluminum ingot industries to the smaller capacities used in metal casting.[232] DOE notes that the greatest barriers to implementation of advanced melting technologies include the following: (1) composition of the industry (primarily small businesses) increases reluctance to take on the risks and costs associated with developing and implementing new technologies, and also means that smaller facilities may not be able to take advantage of energy-savings opportunities that are cost effective for larger-scale operations; (2) declining profit margins reduce investment capacity; (3) the diversity of the industry limits the applicability of cross-cutting technologies, meaning there is no “one-size-fits-all” approach to promoting energy efficiency improvement; and (4) new furnace technologies that require new/expanded exhaust systems may be subject to state and local permitting requirements.[233]

Optimal Future Trends

As no energy use projections are available for the metal casting industry, it is not possible to compare a business-as-usual energy scenario with an optimal energy scenario. Through research and development on technologies that will transform metal casting energy use, DOE’s goal is to achieve a 20 percent reduction in the energy required to produce a ton of product by 2020.[234] An environmentally preferable energy scenario for the industry would primarily involve faster energy efficiency retrofit and replacement rates for existing equipment used in melting processes, increased adoption of best energy management practices, and increased investment in R&D.

Environmental Implications

Improvements in melting furnace efficiency would reduce onsite emissions (both GHG and CAP) stemming from fuel inputs of natural gas and coke. Energy efficiency improvement in cupola melting furnaces—which utilize coke as the primary fuel—would reduce a particularly emissions-intensive (both in terms of GHG and CAP emissions) energy consumption process.

Reductions in electricity consumption (which currently meets over a third of the sector's energy needs) through increased energy efficiency would have a magnified impact on energy-related CAP and GHG emissions at the utility level due to the magnitude of energy losses during electric generation and transmission. As noted previously, CAP emissions reductions would affect regional air quality, while GHG emissions reductions would have a global impact.

3.7.3 Other Reference Materials Consulted

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