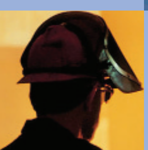
Metal Casting

PROFILE The metal casting sector[4] includes both foundries and die casting facilities. Cast metal products are found in virtually every sector of the U.S. economy, with major end-use markets including transportation, construction, agricultural equipment, and military weapons systems. The sector is dominated by small businesses, with 80% of metal casting facilities employing fewer than 100 people.[5] The majority of metal casting facilities are concentrated in the Midwest, Southeast, and California.

Both foundries and die casters melt metal ingot and/or scrap metal and then pour or inject it into molds to produce castings. However, foundries pour by gravity or inject (under low pressure or vacuum) ferrous or nonferrous metals into molds made of metal or refractory materials (e.g., sand, ceramics), while die casters inject only nonferrous metals under high pressure into metal molds. Unlike the permanent molds used by die casters, foundries must break apart their molds in order to remove the castings.



Sector At-a-Glance

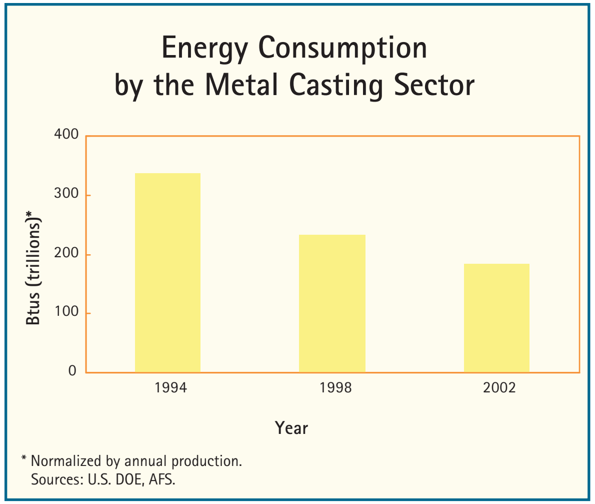
Number of Facilities:	2,336[1]
Value of Shipments:	$33 billion[2]
Number of Employees:	220,000[3]

TRENDS Despite increased foreign competition, the metal casting industry expects modest growth to continue.

- Sales of metal castings are expected to grow 14% over the next three years from $33 billion in 2005 to $37.7 billion in 2008.
- Light metals are expected to continue replacing iron and steel castings in transportation applications.
- Forecasters expect both imports and exports of metal casting products to increase in 2006. Imports are expected to total 3.2 million tons in 2006, which equates to 20.5% of U.S. demand. Exports for 2006 are expected to total 1.4 million tons.[6]

KEY ENVIRONMENTAL OPPORTUNITIES For the metal casting sector, the greatest opportunities for environmental improvements are in increasing energy efficiency, managing and minimizing toxics and waste, reducing air emissions, and conserving water.

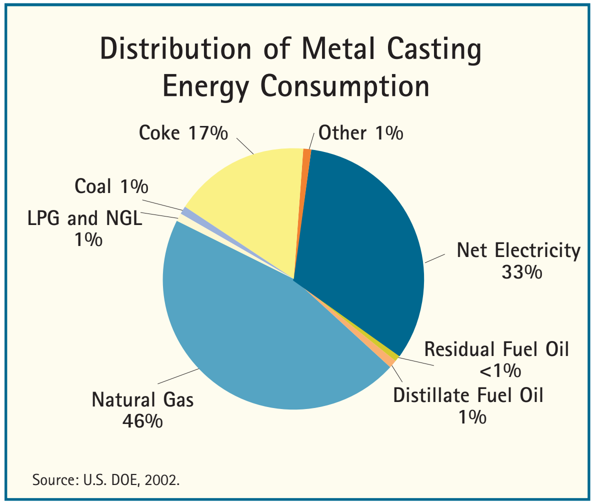
Increasing Energy Efficiency The metal casting industry is one of the most energy-intensive industries in the U.S., so reducing energy consumption is an important economic and environmental focus for the sector.[7] In 2002, the metal casting sector consumed 165 trillion Btus of energy, as shown in the *Energy Consumption* bar chart. When normalized for production, the sector's energy consumption in that year was 45% lower than in 1994. As shown in the *Distribution of Metal Casting* pie chart, the sector is primarily fueled by natural gas, which accounts for 46% of energy consumption, and net electricity, which accounts for 33% of the sector's energy use.[8]



* Normalized by annual production.
Sources: U.S. DOE, AFS.

Most of the energy use in the metal casting sector (approximately 55% of total energy costs) can be attributed to the melting of metals, but moldmaking and coremaking also utilize significant amounts of energy.[9] Opportunities to improve energy efficiency include updating old gas-fired equipment and substituting water for lubricant to cool heated die surfaces.[10]

The U.S. Department of Energy's Industrial Technologies Program works to boost the productivity and competitiveness of U.S. industry through improvements in energy and environmental performance. The program has identified best practices for melting and other efficiency improvement opportunities in the metal casting industry that could, if universally implemented, result in tacit energy savings of 102 trillion Btus (a 22% reduction), as well as a reduction in carbon dioxide (CO_2) emissions of 6.5 million tons per year (also a 22% reduction). Tacit energy refers to the energy required to produce and deliver the form of energy used by the facility, rather than just the amount of energy delivered to the site. Specific energy reduction techniques identified include:



Source: U.S. DOE, 2002.

- Replacing heel melting furnaces used for iron induction with modern batch melters, which would improve tacit energy efficiency for this process by more than 32%;
- Improving casting yield by 5% in all metal casting industries except ductile iron pipe, for an overall tacit energy savings of 22.7 trillion Btus per year; and
- Applying existing air/natural gas mixing methods to reduce ladle heating energy by 10%–30%.[11]

Managing and Minimizing Toxics Metal casting facilities use a variety of chemicals and report on the release and management of many of those materials through EPA's Toxics Release Inventory (TRI).

In 2003, 681 metal casting facilities reported 177 million pounds of chemicals released (including disposal) or otherwise managed through treatment, energy recovery, or recycling. Of this quantity, 71% was managed, while the remaining 29% was disposed or released to the environment, as shown in the *TRI Waste Management* pie chart. Of those chemicals disposed or released to the environment, 92% were disposed and 8% were released into air and water.

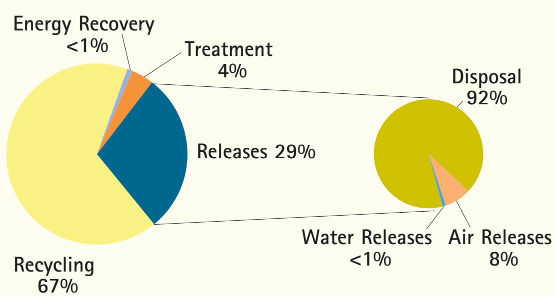
In 2003, ferrous operations accounted for 94% by weight of the sector's releases and disposal, while nonferrous operations, including die casters, accounted for the remaining 6%. Metals accounted for most of the quantity of TRI chemicals disposed or released by the sector. For example, manganese and zinc accounted for 63% by weight of total releases and disposal; chromium, lead, and copper accounted for another 23%.

As shown in the *Total TRI Disposal or Other Releases* line graph, the annual normalized quantity of chemicals disposed or released by the metal casting sector fluctuated but showed little overall change during the 1994 to 2003 time period. Much of the increase seen in 2003 was due to increases in the quantities of manganese and chromium disposed by fewer than five ferrous metal casting facilities. In contrast, over the same 10-year time period, normalized releases to air and water decreased by 54%, with almost half of this decrease occurring from 2000 to 2003.[12]

Data from TRI allow comparisons of the total quantities of a sector's reported chemical releases across years, as presented below. However, this comparison does not take into account the relative toxicity of each chemical. Chemicals vary greatly in toxicity, meaning they differ in how harmful they can be to human health. To account for differences in toxicities, each chemical can be weighted by a relative toxicity weight using EPA's Risk-Screening Environmental Indicators (RSEI) model.

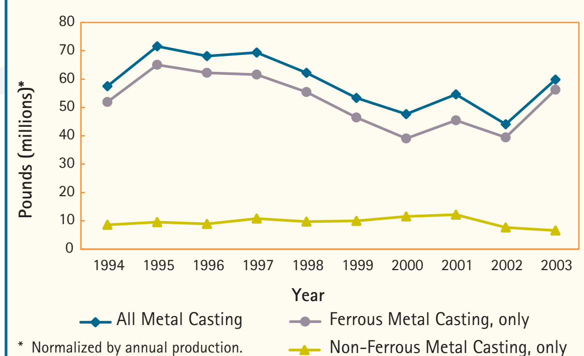
The *TRI Air and Water Releases* line graph presents trends for the entire sector's air and water releases in both reported pounds and toxicity-weighted results. When weighted for toxicity, the sector's normalized releases to air and water declined by 41% between 1994 and 2003, with more than half of this decline occurring between 2000 and 2003.[13]

TRI Waste Management by the Metal Casting Sector



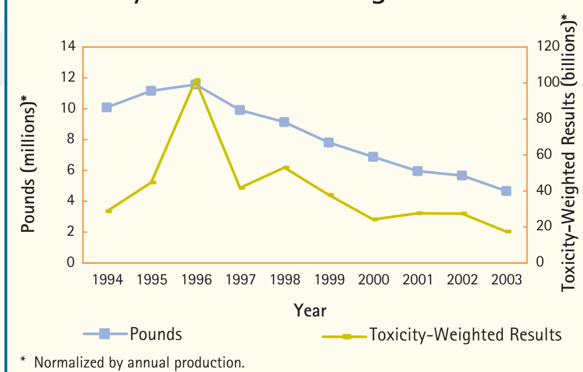
Source: U.S. EPA, 2003.

Total TRI Disposal or Other Releases by the Metal Casting Sector



* Normalized by annual production.
Sources: U.S. EPA, AFS.

TRI Air and Water Releases by the Metal Casting Sector



* Normalized by annual production.
Sources: U.S. EPA, AFS.

The table below presents a list of the chemicals released that accounted for 90% of the sector's total toxicity-weighted releases to air and water in 2003. Ferrous operations drove the metal casting sector's toxicity-weighted results and accounted for 90% of the results in 2003. More than 99% of the sector's toxicity-weighted results were attributable to air releases, while discharges to water accounted for less than 1%. Therefore, reducing air emissions of these chemicals represents the greatest opportunity for the sector to make progress in reducing the toxicity of its releases.

Top TRI Chemicals Based on Toxicity-Weighted Results

AIR RELEASES (99%)	WATER RELEASES (<1%)
Manganese	Lead
Chromium	Copper
Nickel	
Lead	
Diisocyanates	

Source: U.S.EPA

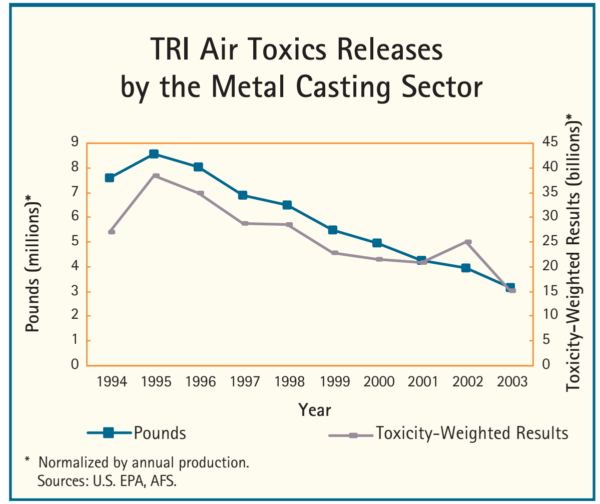
Manganese and chromium releases, the primary contributors to the sector's toxicity-weighted results for air releases, decreased by 28% and 35%, respectively, between 2000 and 2003.

EPA's RSEI model conservatively assumes that chemicals are released in the form associated with the highest toxicity weight. With respect to chromium releases to air and water, therefore, the model assumes that 100% of these emissions are hexavalent chromium (the most toxic form, with significantly higher oral and inhalation toxicity weights than trivalent chromium). However, the hexavalent form of chromium may not constitute a majority of total chromium releases in this sector. Thus, RSEI analyses may overestimate the relative harmfulness of chromium.[14]

Reducing Air Emissions The metal casting sector releases both air toxics and criteria air pollutants. While emissions of air toxics during the manufacturing process are largely captured in the TRI air releases discussed above, this section takes a closer look at both of these chemical categories.

Air Toxics Air toxics, also called hazardous air pollutants, are a subset of the TRI chemicals presented above. The Clean Air Act designates 188 chemicals (182 of which are included in TRI) that can cause serious health and environmental effects as air toxics. Common air toxics from metal casting operations include organic air pollutants and metals. Organic air pollutants are primarily generated while making the core portions of the molds, shaking the mold away from the casting, and pouring the molten metal. Metals are primarily generated during the melting, pouring, and finishing processes.

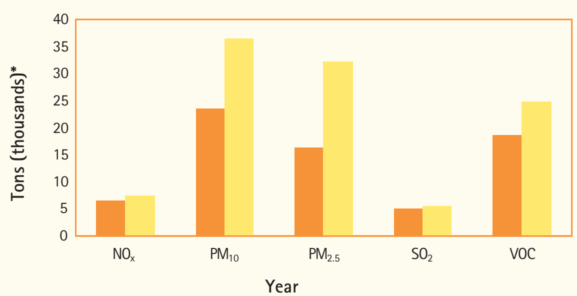
In 2003, 511 ferrous and nonferrous casting operations reported air toxics releases of 2.9 million pounds. As shown in the *TRI Air Toxics Releases* line graph, normalized air toxics releases decreased by 58% from 1994 to 2003, with more than one-third of this reduction occurring between 2000 and 2003. Air toxics releases from the sector were primarily (94%) from ferrous operations.[15] Toxicity-weighted results for air toxics releases showed a 44% decline over the 10-year period.[16]



Criteria Air Pollutants EPA's National Emissions Inventory estimates that, in 2001, the metal casting sector released 6,879 tons of nitrogen oxides (NO_X), 33,779 tons of particulate matter (PM_{10}), 29,815 tons of fine particulate matter ($PM_{2.5}$), 5,064 tons of sulfur dioxide (SO_2), and 22,868 tons of volatile organic compound (VOC) emissions.

As shown in the *Criteria Air Pollutant Emissions* bar chart, between 1996 and 2001 normalized emissions of each of these pollutants increased. The largest changes were in PM_{10}, $PM_{2.5}$, and VOC emissions which increased by 55%, 97%, and 32%, respectively.[17]

Criteria Air Pollutant Emissions from the Metal Casting Sector



* Normalized by annual production.
Sources: U.S. EPA, AFS.

Managing and Minimizing Waste

The metal casting sector generates hazardous waste and is working to increase the reuse of industrial byproducts such as scrap metal and foundry sand.

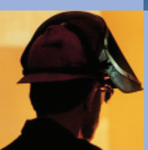
Hazardous Waste EPA hazardous waste data on large quantity generators, as reported in the *National Biennial RCRA Hazardous Waste Report*, indicate that the metal casting sector accounted for less than 1% of the hazardous waste generated nationally in 2003.

In 2003, 138 metal casting facilities reported 48,700 tons of hazardous waste generated. Almost 70% of this waste was generated from dip, flush, or spray rinsing and air pollution control devices. The waste management methods most utilized by this sector were chemical reduction and stabilization or chemical fixation.

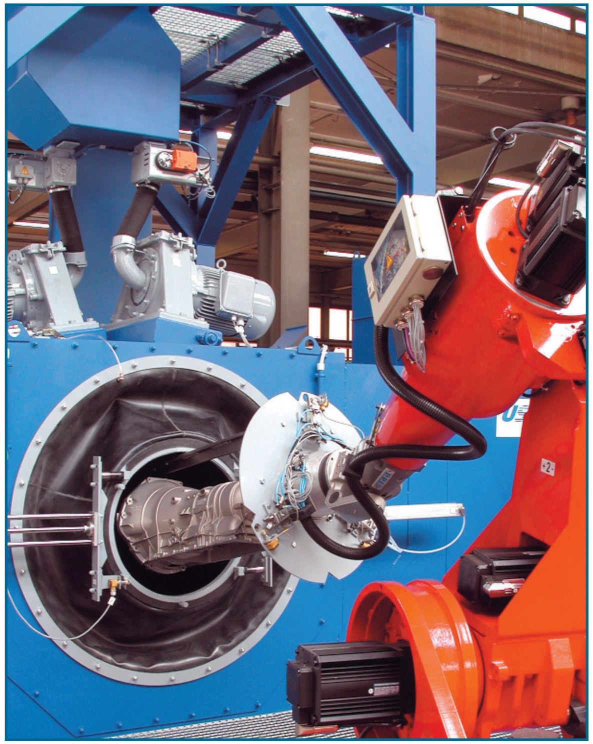
When reporting hazardous wastes to EPA, quantities can be reported as a single waste code (e.g., chromium) or as a commingled waste composed of multiple types of wastes. Quantities of a specific waste within the commingled waste are not reported. The metal casting sector reported more than 70% of its wastes as individual waste codes. Of the individually reported wastes, the predominant hazardous waste types reported in 2003 included chromium, lead, cadmium, and corrosive waste.[18]

Scrap Metal & Foundry Sand The metal casting industry is one of the largest recyclers in North America, using scrap metal as 85% of its feedstock for ferrous casting.[19] The industry diverts roughly 15 million to 20 million tons of scrap metal from disposal at U.S. landfills each year.[20]

Also, metal casters use almost 100 million tons of foundry sand annually, of which 10 million tons are available for reuse applications. Virtually all of this sand is a nonhazardous byproduct that could be used for other purposes, yet only about 500,000 tons of the available sand is currently reused. Increased sand reuse represents a prime opportunity for the metal casting sector to save money and improve the environment.[21] EPA is working with industry and states to identify innovative approaches to improve rates of foundry sand reuse.



CONSERVING WATER Water is used for a variety of purposes in metal casting, including direct contact and non-contact cooling. To conserve water, the metal casting sector is exploring technologies for recovering and recirculating the wastewater used to lubricate and cool dies during the die casting process. Potential water conservation measures include reusing non-contact cooling water in other plant operations, installing cooling towers, and recovering surface treatment chemicals. The following case study illustrates one company's success in conserving water.



Case Study: ThyssenKrupp Waupaca's Closed-Loop Water Recycling System *ThyssenKrupp Waupaca's Plant 5 facility in Tell City, IN, installed a closed-loop water recycling system, replacing a system that discharged water after a single use. The system recirculates water used to cool process equipment, such as the molten iron handling equipment. The new system uses cooling towers, heat exchangers, pumps, tanks, and piping to cool and recirculate the water. Prior to the system installation, the Tell City facility was using 58 million gallons of municipal water per month. With the closed-loop system, the facility uses 18 million gallons of water per month, resulting in significant reductions in the facility's wastewater discharges, as well as its strain on the city water supply.*[22]