SectorStrategies

Performance Report

2006

EPA
United States
Environmental Protection
Agency

From the Administrator

As we celebrate the U.S. Environmental Protection Agency's 35th anniversary, we are strengthening our commitment to accelerating the pace of environmental protection while maintaining the nation's economic competitiveness.

Collaborative efforts, innovative programs, and information sharing can be effective tools for today and tomorrow. Through our Sector Strategies Program, EPA works hand-in-hand with many sectors to reduce their environmental impacts in cost-effective ways and to share information with the public. By engaging a broad range of stakeholders in the process, we promote a culture of understanding and environmental stewardship.

As EPA seeks new and better ways to pursue its mission, the measurement of environmental progress becomes even more important. New policies and programs to provide regulated entities with flexibility to tackle tough problems in innovative ways demand better methods to ensure accountability and demonstrate results.

This 2006 Sector Strategies Performance Report compiles the best available information to document performance trends in participating sectors. It reveals strengths and weaknesses both in performance and in available data on environmental results. I invite you to read it carefully and make full use of its contents.

I hope that this report prompts a renewed commitment from government, industry, and other stakeholders to gather, share, and use quality performance data. Such a commitment is an essential foundation for greater collaboration, innovation, and accelerated environmental and economic progress.

Sincerely,

Stephen L. Johnson

Administrator

INTRODUCTION The U.S. Environmental Protection Agency (EPA) invites you to learn about the environmental performance of major U.S. manufacturing and service sectors in this 2nd edition of the *Sector Strategies Performance Report*. Eleven sectors are profiled in the report:

- Cement
- Colleges & Universities
- Construction
- Forest Products
- Iron & Steel
- Metal Casting
- Metal Finishing
- Paint & Coatings
- Ports
- Shipbuilding & Ship Repair
- Specialty-Batch Chemicals

These sectors participate in EPA's Sector Strategies Program, which uses collaborative partnerships to promote widespread improvement in environmental performance with reduced administrative burden.[1]

As with the 1st edition of the *Performance Report*, issued in 2004, this document has two primary objectives:

- To profile each sector, highlighting economic statistics and trends; and
- To describe, and where possible, to measure environmental progress to date, focusing on performance trends over the past 10 years.

New to this edition are two chapters that tie together information from all of the participating sectors in regard to the following themes:

- *Leadership by Trade Associations* describes how participating trade associations can serve as valuable catalysts in the effort to improve environmental performance among their members.
- *Beneficial Reuse of Materials* describes how participating sectors are turning would be wastes into substitutes for raw materials and/or sources of energy.

The 2006 report also introduces the use of toxicity-weighted data to supplement basic information on emission trends. The toxicity-weighted data provide insights about the greatest opportunities for each sector to make progress in reducing the toxicity of its releases. Detailed information on toxicity weighting, as well as all of the other data used in the report, can be found in the *Introduction to Sector Profiles* chapter.

THE SECTOR STRATEGIES PROGRAM The Sector Strategies Program develops performance improvement strategies for major manufacturing and service sectors of the U.S. economy. In 2005, there were 12 participating sectors represented by more than 20 national associations.

These sectors are significant for their contributions to the nation's economy as well as their environmental and energy footprints. Together, participating sectors represent a combined $2.1 trillion (19%) contribution to the U.S. gross domestic product, with more than 780,000 facilities and locations across the country.[2] A snapshot of their environmental footprint can be found in the *Sectors At-a-Glance* box below.[3]

Sectors At-A-Glance

The manufacturing sectors profiled in this report represent the following contributions to U.S. manufacturing totals:

- 32% of TRI releases
- 18% of hazardous waste generated
- 33% of criteria air pollutant emissions from point sources
- 20% of energy consumption

Sources: U.S. EPA, U.S. DOE.

Preface

Through the Sector Strategies Program, EPA maintains collaborative working relationships among stakeholders in business, government, and the public to address challenging environmental problems. Program staff members are experts on their sectors, providing policy analysis and facilitating dialogues to identify cost-effective actions that will reduce environmental impacts and ease regulatory burden in each sector.

Each individual sector strategy seeks to reduce major performance barriers and prompt environmental stewardship on a broad scale. These strategies may include a range of actions, from targeted regulatory changes to create environmental standards that are more performance (that is, results) oriented to promotion of environmental management systems or other recognized stewardship tools.

Participating trade associations have made commitments to proactively pursue environmental stewardship, with help from collaborative programs like Sector Strategies. This commitment is reflected in the total expenditure of more than $5 billion annually on environmental protection by the manufacturing sectors profiled in the report.[4]

Participation in the Sector Strategies Program carries with it a commitment to measure performance results through quantitative metrics. This report, and its 2004 predecessor, track sector-wide performance trends using the best available data, including those collected by associations.

For more information on the Sector Strategies Program, please visit www.epa.gov/sectors. The *2004 Sector Strategies Performance Report* is available online at www.epa.gov/sectors/performance2004.html.

National Associations Representing Participating Sectors

Agribusiness

American Meat Institute

National Food Processors Association

Cement

Portland Cement Association

Colleges & Universities

American Council on Education

APPA: Association of Higher Education Facilities Officers

Campus Consortium for Environmental Excellence

Campus Safety, Health and Environmental Management Association

Howard Hughes Medical Institute

National Association of College and University Business Officers

Construction

Associated General Contractors of America

Forest Products

American Forest & Paper Association

Iron & Steel

American Iron & Steel Institute

Steel Manufacturers Association

Metal Casting

American Foundry Society

North American Die Casting Association

Metal Finishing

American Electroplaters and Surface Finishers Society

Metal Finishing Suppliers' Association

National Association of Metal Finishers

Surface Finishing Industry Council

Paint & Coatings

National Paint & Coatings Association

Ports

American Association of Port Authorities

Shipbuilding & Ship Repair

American Shipbuilding Association

Shipbuilders Council of America

Specialty-Batch Chemicals

Synthetic Organic Chemical Manufacturers Association

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Leadership by Trade Associations

Introduction Since the early 1990s, EPA has collaborated with businesses and trade associations to establish and meet shared environmental goals. Beginning with the 33/50 and Green Lights Programs, which promoted voluntary efforts to reduce releases and transfers of priority chemicals and to increase the use of energy-efficient lighting, respectively, EPA has expanded the depth and breadth of its partnership programs to more than 40 efforts, including the Sector Strategies Program.[1]

EPA designed the Sector Strategies Program to take advantage of trade associations' leadership positions within their respective sectors. Active participation in the Sector Strategies Program now includes 24 trade associations in 12 key sectors,[2] representing a combined $2.1 trillion (19%) contribution to the U.S. gross domestic product, with more than 780,000 facilities and locations across the country.[3]

The Mission of Trade Associations Trade associations often serve as the voice of their industries before the government, public, and media. At the same time, trade associations provide a forum for their industries to share information and ideas and to work jointly on programs of benefit to the sector, such as environmental, health, and safety (EH&S) initiatives. Trade association representatives with deep knowledge of their respective industries can have valuable credibility within their sectors and can provide helpful technical, regulatory, and compliance assistance to their members and allies. Through a variety of mechanisms, ranging from Web sites, electronic newsletters, and print materials to workshops, meetings, industry events, and awards programs, trade associations can promote research, education, and other activities that address the needs and concerns of their members. Many trade associations also develop, promote, and distribute sector-specific information to the full array of small, medium, and large businesses within their industries and to affiliated groups, such as suppliers, vendors, and consultants.

Through the above mechanisms, trade associations can play an important role in promoting environmental stewardship. For example, they can provide critical technical expertise in identifying and vetting innovative ideas to advance their sectors' performance, and they can take on leadership positions to encourage the adoption of these ideas. Many trade associations promote changes that better prepare members to meet evolving market conditions, such as increasing preferences for greener products and production activities or certification to International Organization for Standardization (ISO). ISO 14001, for example, is an internationally accepted specification for environmental management systems (EMS).[4]

Trade Associations as Environmental Leaders

The 24 trade associations that participate in the Sector Strategies Program provide examples of four key roles associations can play in promoting environmental stewardship:

- Setting environmental standards for members;
- Setting "stretch" goals for the sector;
- Providing guidance and technical assistance to members; and
- Measuring environmental progress by the sector.

Setting Environmental Standards for Members A number of trade associations, including the Synthetic Organic Chemical Manufacturers Association (SOCMA), National Paint and Coatings Association (NPCA), and American Forest & Paper Association (AF&PA) have demonstrated leadership by setting and promoting specific standards for their members.

In each of these cases, conformance with the standards is a prerequisite for participating in the trade association. In addition, the American Meat Institute (AMI) developed a voluntary EMS program for its members.

ChemStewards℠ – Road to Continuous Improvement In September 2005, SOCMA launched the ChemStewards performance improvement program to advance the EH&S and security profile of its members. All active SOCMA members participate in the program as a condition of membership in the association. ChemStewards offers a three-tiered approach to participation: Fundamentals, Enhanced Performance, and Excellence. All three tiers require adherence to a set of core principles, in addition to metrics, security, and implementation of an environmental, health, safety, and security (EHS&S) management system verified by an independent third party. SOCMA promotes the program through regular outreach meetings for its members and its annual EHS&S awards program.[5]

Coatings Care® – Providing for a Cleaner, Safer Coatings Industry Coatings Care is a comprehensive program developed by NPCA to assist its members with integrating EH&S activities into corporate planning and operations. Organizations make a commitment to Coatings Care as part of their membership in NPCA. Coatings Care organizes EH&S activities into five codes of management practice – Manufacturing Management, Transportation and Distribution, Product Stewardship, Community Responsibility, and Security – and NPCA provides extensive support to its members in these areas. Coatings Care integrates EH&S practices that are consistent with other industry standards, such as those found in the ISO 14000 series.[6] Five individual paint and coatings facilities have been accepted into EPA's Performance Track program based in part on their Coatings Care EMS systems.[7]

Sustainable Forestry Initiative® – Growing Tomorrow's Forests Today® AF&PA members participate in an EH&S Principles Program, which requires annual adherence to eight principles as a condition of membership in the association. An accompanying EH&S Principles Verification Program requires members to submit data biennially to AF&PA.[8]

These programs work in harmony with the Sustainable Forestry Initiative (SFI) Program, to which member companies must also adhere. The SFI Standard, developed by an independent Sustainable Forestry Board, establishes a land stewardship ethic that integrates the reforestation, nurturing, and harvesting of trees for useful products with the conservation of soil, air and water resources, wildlife and fish habitat, and forest aesthetics.[9] The SFI Program includes 150 million acres of forestland in North America. By the end of 2005, 136 million acres had been independently certified to the SFI Standard.[10]

In the past year, the SFI Standard was expanded to include new performance measures and indicators related to international procurement, old growth forests, invasive exotic species, imperiled and critically imperiled species, landscape assessments, wood supply chain monitoring, and social issues.[11]

Environmental MAPS Program – EMS for Meat and Poultry Processing Companies AMI's Environmental MAPS Program is a voluntary program providing tools coupled with recognition to increase EMS development and implementation throughout the meat and poultry industry.[12] The program has four performance tiers – Master, Achiever, Pioneer, and Star. The EMS component of the program is based in part on the customized *EMS Implementation Guide for the Meat Processing Industry*, developed by AMI in partnership with the Sector Strategies Program.[13]

Setting "Stretch" Goals for the Sector In addition to the programmatic standards and certification requirements identified above, some trade associations, including AF&PA, American Iron & Steel Institute (AISI), and Portland Cement Association (PCA), have set voluntary goals for their sectors with respect to EMS adoption or other priority voluntary activities.

Climate VISION – Voluntary Actions to Reduce Greenhouse Gas (GHG) Emissions AF&PA, AISI, and PCA are members of Climate VISION, a voluntary program administered by the U.S. Department of Energy (DOE) to reduce GHG intensity (the ratio of emissions to economic outputs).[14]

- AF&PA expects that its members will reduce the sector's GHG intensity by 12% by 2012 (relative to 2000 levels).
- AISI has committed to achieving a 10% increase in sector-wide average energy efficiency by 2012 (from 2002 levels).
- PCA has committed to a 10% reduction in CO_2 emissions per ton of product by 2020 (from 1990 levels).[15]

Cement Manufacturing Sustainability Program – Concrete Thinking for a Sustainable World® Through PCA, the U.S. cement industry set voluntary targets to increase the adoption of auditable, verifiable EMS in cement plants across the nation. Specifically, the industry set the following goals for EMS adoption: at least 40% of U.S. cement plants will adopt EMS by the end of 2006, 75% by the end of 2010, and 90% by the end of 2020. PCA also adopted a voluntary target of a 60% reduction in the amount of cement kiln dust (CKD) disposed of per ton of production by 2020 (from a 1990 baseline).[16]

National Metal Finishing Strategic Goals Program Prior to launching the Sector Strategies Program, EPA worked with three national metal finishing trade associations and other stakeholders to develop EMS guidance and facility-level performance goals under the Strategic Goals Program (SGP). Between 1998 and 2002 more than 500 metal finishers, 20 states, and 80 local regulatory agencies participated in the SGP. Data from reporting facilities indicate substantial progress toward goals for water use, energy use, and reduction of emissions and releases. Results are available on the SGP Web site.[17] SGP activities continue in several EPA regions.

Providing Technical Assistance to Members

A fundamental role of many trade associations is to provide technical assistance to their members on areas of interest across their industries. Virtually every sector partner has played a key role in developing and promoting tools to enhance the environmental performance of its membership.

EMS Tools – Guidance, Training, and Marketing Outreach Under the Sector Strategies Program, more than a dozen trade associations and numerous member companies have provided insights and inputs to EPA in developing and disseminating sector-specific EMS guidance and training. By tapping into the partners' networks, the Sector Strategies Program maximizes the chances that the entire universe of parties EPA wants to reach is receiving the materials. The following *EMS Implementation Guides* are the direct result of investments of time, energy, and expertise on behalf of EPA and the sector trade associations:

- Die casting, created in partnership with the North American Die Casting Association (NADCA);
- Shipbuilding and ship repair, created in partnership with the American Shipbuilding Association (ASA) and the Shipbuilders Council of America (SCA);
- Meat processing, developed with AMI member companies and the state of Iowa;

- Foundries, created in partnership with the American Foundry Society (AFS) and Indiana Cast Metals Association;
- Specialty-batch chemical manufacturing, created in partnership with SOCMA;
- Metal finishing, created in partnership with the American Electroplaters and Surface Finishers Society, Metal Finishing Suppliers' Association, and National Association of Metal Finishers;
- Construction, created by the Associated General Contractors of America (AGC) with assistance from EPA; and
- Electric arc furnace operations, created in partnership with the Steel Manufacturers Association (SMA).

Each guide provides detailed, sector-specific information for facilities interested in implementing an EMS.[18] Several of the guides also incorporate lessons learned and examples drawn from the experiences of companies that participated in EPA sector pilots with die casting, foundry, meat processing, shipbuilding and ship repair, and metal finishing facilities. Both the associations and EPA have promoted these products through their Web sites, industry meetings, and other mechanisms.

Many associations, including AGC, SMA, ASA and SCA, have teamed with EPA to provide focused training workshops for facilities adopting or improving their EMS. Also, with support from the Sector Strategies Program, ASA and SCA are exploring ways to combine EMS with "lean production" principles to help companies improve efficiency, drive down costs, and increase profit margins.[19] This combined EMS/lean program will enable shipyards to increase their production efficiency while meeting environmental standards.

Members and partners from six sectors – agribusiness (meat processing), construction, metal casting, metal finishing, ports, and shipbuilding and ship repair – also worked jointly with EPA to develop sector-specific marketing materials that lay out the "business case" for implementing an EMS, highlighting the financial and environmental benefits. Each of the guides and brochures are available on the trade associations' Web sites as well as on the Sector Strategies Program Web site, further broadening the reach to target audiences.[20]

Additionally, the six national organizations representing the colleges and universities sector[21] developed a strategy to deliver outreach tools, training resources, and support to promote EMS development on college and university campuses. In 2005, the organizations sent a letter to college and university presidents/chancellors to promote the implementation of EMS and encourage environmental stewardship within their organizations.[22] The letter included a one-page business case, *EMS Fact Sheet for Senior Administrators*, which was developed to raise awareness about the benefits of an EMS and to share testimonials from universities that have realized many of these benefits.[23] In addition, a national Web site has been established to assist colleges and universities with EMS development.[24]

With Sector Strategies Program funding as seed money, the American Association of Port Authorities (AAPA) and the Global Environment and Technology Foundation established an EMS Assistance Project to help public seaports develop EMS.[25] Nine ports and two federal maritime facilities participated in the pilot project. Early results indicate improvements in environmental awareness and communication among employees and tenants, documentation and operational efficiency, integration of environmental considerations into strategic business plans, emergency response planning, and root cause analysis. Other improvements include increased purchases of sustainable energy, reductions in air emissions through retrofits and replacement of old diesel equipment and the purchase of low sulfur fuel, and reductions in waste and water quality impacts.[26] In early 2006, AAPA initiated a second round of the EMS Assistance Project with nine facilities. Some participating facilities will implement a traditional EMS, while others will use a systems approach to security management, integrating or linking the resulting system with their EMS as appropriate.[27]

Other Outreach and Assistance AGC, PCA, AISI, SCA, and ASA are galvanizing support for green initiatives.

For example, AGC is promoting green construction through its *Environmental Solutions Series* and *Constructor* magazine. AGC also is making a variety of green construction resources available to the sector through the Web, including *AGC's Green Construction Bible* and links to a green products directory, information on state and local green buildings programs, a tutorial about the Leadership in Energy and Environmental Design (LEED®) rating system, and information on recycling construction and demolition debris.[28]

PCA is embarking on an industry-wide communications program to educate peers, customers, and the public on the benefits of concrete for sustainable development and green buildings.[29] Similarly, the Steel Recycling Institute, a unit of AISI, advises architects, engineers, designers, and others on how to build green with steel framing, roofing, and siding through publications such as *Steel Takes LEED™ with Recycled Content*.[30]

SCA, ASA, and Gulf Coast shipyards, along with representatives from EPA and state environmental agencies, developed guidance and training on a series of practical, cost-effective best management practices aimed at reducing pollutants in stormwater.[31]

Partnerships with Other Voluntary Programs Several trade associations work side-by-side with EPA to promote other voluntary efforts, providing education, outreach, and assistance to their membership networks. For example, AGC, AISI, NPCA, NADCA, SMA, and SOCMA are all Performance Track Network Partners, promoting EMS and facility membership in EPA's Performance Track program.[32] Together these network partners have helped to increase the number of Performance Track member facilities in their industries from 11 to 56 between 2001 and 2005.[33] Other associations, including AGC and AAPA, are participating in EPA's National Clean Diesel Campaign through Clean Construction USA, Clean Ports USA, and other voluntary efforts to reduce diesel emissions across the country.[34]

Several trade associations in the Sector Strategies Program also participate in other agencies' voluntary programs that address environmental issues. For example, AF&PA, AFS, NADCA, AISI, and SMA participate in DOE's Industrial Technologies Program, which, through its Industries of the Future initiative, coordinates joint industry-government funding for research and development to generate new technologies to boost productivity and save energy.[35]

Measuring Environmental Progress by Sectors Many sectors in the Sector Strategies Program are collecting data on their environmental performance to establish baselines against which to measure future improvements and to increase public awareness of their achievements. Several associations have tracked performance for more than 30 years, while others are initiating data collection efforts.

Forest Products' Biennial EH&S Report In 2000, AF&PA began publishing biennial reports on EH&S program implementation and environmental performance across its membership. These reports incorporate earlier information collected by AF&PA and predecessor organizations going back to 1975. The reports display trends in areas such as energy use, air emissions, and water quality. [36]

Cement Manufacturing's Annual Survey PCA has conducted an annual survey of members since 1970 to collect data to measure performance toward reduction targets related to energy use and labor practices. Recently, PCA modified its survey to collect information on industry targets for EMS implementation, CKD reduction, and CO_2 emissions. Additionally, PCA is collecting data to set baselines for future environmental improvements in areas such as water use and air emissions of NO_x and SO_x. PCA recently reported on these results and other issues in its inaugural Sustainable Development Report.[37]

Specialty-Batch Chemical Data Collection and Reporting In January 2004, SOCMA began collecting company metrics data on energy efficiency. This information will be made available to the public in 2006. In addition, SOCMA provides information about its members' releases to air, land, and water (as reported to EPA's Toxics Release Inventory) on its Web site.[38]

Iron & Steel Reporting on Sustainability Indicators Starting with a 2004 reporting year, AISI members have agreed to begin collecting data on energy intensity, which is part of their Climate VISION commitment, as well as the following four additional sustainability indicators: GHG emissions, material efficiency, steel recycling, and EMS implementation.[39]

Preliminary Survey of Port Authorities In December 2004, AAPA initiated a survey of its U.S. member ports. The survey measured interest in environmental issues and identified indicators for environmental activities that ports are undertaking, primarily on a voluntary basis.[40] The results are described in more detail in the Ports chapter of this report

Colleges & Universities' Self-Tracking Tool The colleges and universities sector is taking steps to develop performance metrics, collect data, and track performance. In 2005, six national organizations in the sector launched a Web-enabled Self-Tracking Tool that enables colleges and universities to collect and analyze data on their campuses' environmental impacts. The Self-Tracking Tool gathers four years of retrospective data on four environmental indicators – energy use, hazardous waste, solid waste/recycling, and water use. Schools can use the tool to identify and analyze trends in their data and benchmark their environmental performance against aggregated data from other schools of similar size and type (school names are kept confidential).[41]

Conclusion Trade associations can play a vital role in leading environmental stewardship by setting goals and standards, providing assistance, and measuring progress. In addition, the collaboration between trade associations and EPA is advancing the concept of environmental stewardship throughout these sectors. Working together through voluntary approaches such as the Sector Strategies Program enables industry and EPA to meet shared environmental goals. Implementation of improved, and often certified, EH&S and EMS systems enhances environmental performance, allowing sectors to show progress through established metrics. Over the coming year, the Sector Strategies Program will continue to promote environmental leadership in cooperation with its sector partners, with emphasis on performance measures and other opportunities to improve environmental performance.

Beneficial Reuse of Materials

INTRODUCTION Almost everything we do leaves something behind, from household trash – often referred to as municipal or "post-consumer" solid waste – to industrial waste. Industrial waste, which includes both nonhazardous materials and hazardous waste, is a major component of landfills. In fact, for every ton of municipal solid waste there are more than 30 tons of industrial waste in the nation's landfills.[1] Waste can be expensive for industry and difficult for states and local governments to manage, and can impact the health of communities and ecosystems.

Many industries are finding new ways to use materials that would otherwise be discarded. Facilities are reusing byproducts or waste materials in their own operations or sending them elsewhere for reuse as a fuel or substitute raw material. This process is known as beneficial reuse – turning would-be waste into a valuable commodity.

To fulfill the objectives of beneficial reuse, recyclable materials must perform well, and they must be at least as safe for human health and the environment as the materials they replace. Companies can benefit from reuse by minimizing the fees they pay to dispose of waste, reducing the cost of purchasing virgin materials, lowering the cost of complying with waste regulations, and improving their public image.

The concept of beneficial reuse is quite simple; however, companies must overcome a number of real barriers in order to keep useful, valuable materials out of landfills. The barriers include:

- A lack of awareness regarding existing and new end-use opportunities;
- Variation in state and local waste regulations (some of which discourage reuse); and
- The cost of investing in and adapting to new processes and operations.

Additionally, the costs of transporting, processing, and using these materials must be low enough to stimulate market demand, and projects must yield economic benefits to both material generators and users. Reuse may require upfront changes in industry operations, but such investment costs often can be recovered over time.

Treating waste materials as potential resources means changing our thinking from *waste management* to *materials management*. The shift is underway at EPA. As Tom Dunne, former acting assistant administrator for EPA's Office of Solid Waste and Emergency Response, observed, "Materials management is now the tail on the dog of waste management. In the future, it must be the dog itself."[2] Several EPA programs, such as the Resource Conservation Challenge and the Sector Strategies Program, are working collaboratively with industry to facilitate the reuse of industrial materials where it is safe.[3]

Sectors participating in the Sector Strategies Program are currently engaged in at least three forms of recycling:

- Material reuse within a facility or sector;
- Use of another sector's byproducts; and
- Use of post-consumer materials.

Where recycling is a well-established practice in a sector, as is the case with forest products and iron and steel, data on beneficial reuse are often available. Data are not, however, readily available for those sectors where material recycling is only emerging or where small businesses predominate. In these cases, we have relied on examples to illustrate the potential for recycling. Over time, as recycling practices grow and better data become available, we hope to provide a more comprehensive picture of the beneficial reuse of materials by and from the sectors participating in the Sector Strategies Program.

Material Reuse Within a Facility or Sector

Many of the sectors in the Sector Strategies Program, including construction, paint and coatings, shipbuilding and ship repair, colleges and universities, and cement, have found ways to circulate byproducts back into use within their own (or similar) operations.

Construction Construction & demolition (C&D) debris refers to waste materials generated during the process of construction, renovation, or demolition of buildings, roads, and bridges. Most C&D debris can be reused or recycled. EPA estimates that 136 million tons of building-related C&D debris were generated in the U.S. in 1996, and 20% to 30% of this material was recycled.[4] Although no national trend data are available, data collected by the Florida Department of Environment Protection show a steady rise in recycling of residential C&D debris in the state between 1999–2002.[5]

C&D debris can be reused at the same job site or sent to recycling facilities for reuse by other contractors or even other sectors. For example, during the building of its new headquarters on the site of an old manufacturing facility in St. Louis, MO, Alberici Constructors reused 93% of the debris, including gypsum board, clean lumber, metal, glass, and cardboard. Alberici built a retaining wall out of salvaged materials, reused overhead crane rail beams in an existing warehouse as the support structure for part of a new parking garage, and deconstructed an old office building on the site in a way that allowed most of the brick and concrete to be used as structural fill.[6]

Paint & Coatings Paint and coatings manufacturers use solvents both as a formulation ingredient and to clean equipment. Much of the waste solvents can be recovered for reuse. According to data from EPA's *National Biennial RCRA Hazardous Waste Report*, in 2001 paint and coatings manufacturers managed more than 37,000 tons of waste solvents. Of this quantity, 62% was reclaimed and reused as solvent, and 34% was used as fuel.[7]

Shipbuilding & Ship Repair Shipyards across the country are looking for ways to reuse materials. For a number of years, shipyards have recovered and reused the blasting grit used to remove paint. Recently shipyards have begun to look at other processes that lend themselves to material reuse. For example, Bath Iron Works in Bath, ME, utilizes a solvent segregation and distillation process to recover wash solvent for continuous reuse to clean paint lines, pots and guns, and other wastewaters. In 2004 the company recovered 38,800 pounds of solvent.[8] Another shipyard, Atlantic Marine in Jacksonville, FL, has developed a method for onsite reuse of its wastewater. Nearly 1 million gallons per year of bilge and blasting wastewater are used to irrigate the facility's grounds after they have been treated to meet Florida's drinking water standards.[9]

Colleges & Universities Colleges & universities are increasingly recycling organic materials by composting manure, coal ash, food scraps, and lawn waste. For a large campus, the volume of recycled material can be equivalent to that of a small city. For example, Washington State University's (WSU) Pullman Campus, with 18,690 students, composted 138.7 tons of material between July 2004 and June 2005. WSU uses a portion of the finished compost on its golf course, grounds areas, and agricultural land, as well as for animal bedding. The remainder is sold to local garden stores, landscapers, and hydroseeders.[10]

Cement Cement kiln dust (CKD) consists of the particles released from the pyroprocessing line at cement plants. It includes partially burned raw materials, clinker, and eroded fragments from the refractory brick lining of the kilns. Recycling CKD reduces the amount of raw materials needed for cement production, and because CKD is already partially processed, recycling it also reduces energy consumption. The industry recycles more than 75% of its CKD, nearly 8 million tons, each year.[11] When normalized by annual clinker production, the amount of CKD sent to landfills has declined by 49% since 1995.[12] Newer plants (typically dry-kiln operations with preheater and precalciner technologies) are more effective at recovering CKD and reusing it in the manufacturing process.

There are limits, however, to recycling CKD in the manufacturing process, because contaminants can build up in the CKD and compromise the quality of the clinker. The CKD that is not recycled is either disposed of at a landfill or sold to other sectors for beneficial reuse applications, such as road fill, liming agent for soil, or as stabilizer for sludge and other wastes.

USE OF ANOTHER SECTOR'S BYPRODUCTS Reuse of materials across sectors opens additional avenues for reducing costs and conserving resources. Trade associations and government agencies are collaborating to discover opportunities for one sector's trash to become another's treasure.

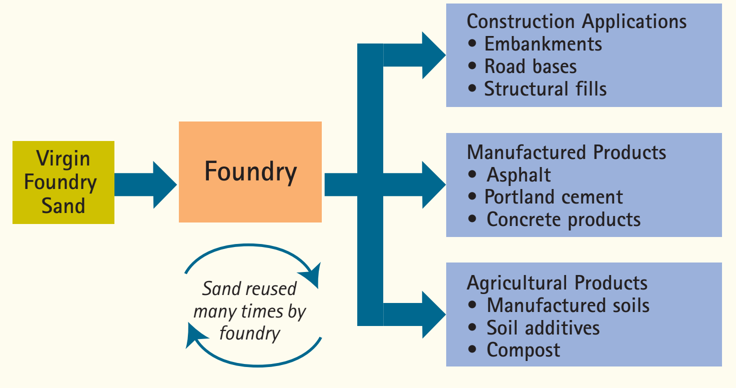
Industries participating in the Sector Strategies Program illustrate the potential for a sector to provide materials to another sector for reuse (e.g., metal casting, iron and steel, and metal finishing) and to take in materials from another sector for use as fuel or substitute raw materials (e.g., cement).

Metal Casting Foundries in the metal casting sector produce castings from sand molds. This sand can be reused several times within a facility to make new molds. In time, though, the sand deteriorates and is no longer useable by the foundry. Nearly all of this sand (98%) is a nonhazardous byproduct that could be used for other purposes, yet 9 to 13 million tons are discarded in landfills each year. Only one million tons per year are currently put to productive use.[13]

As shown in the *Beneficial Reuse of Foundry Sand from the Metal Casting Sector* figure, foundry sand can be used almost anywhere virgin sand is used. Construction contractors use it for structural fill, backfill, and pipe bedding. The cement sector uses it as an ingredient in cement. It can be used to make asphalt, bricks, concrete blocks, and other products. The agricultural sector is starting to use it in manufactured soils and for other purposes.

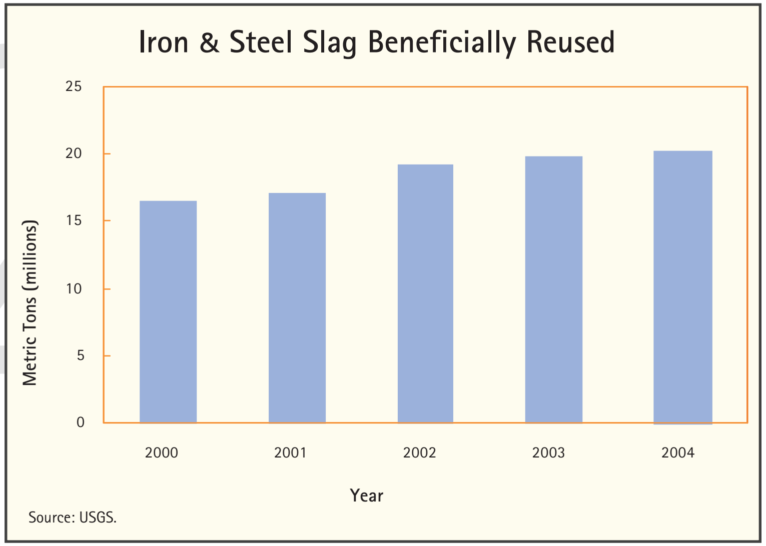
EPA is now working with the metal casting industry and key states to identify innovative approaches for improving rates of foundry sand reuse.

Beneficial Reuse of Foundry Sand from the Metal Casting Sector



Iron & Steel Iron and steel slags are co-products of iron and steel manufacturing, produced when slagging agents such as limestone or dolomite and/or fluxing materials are added to blast furnaces and steel furnaces to strip impurities from iron ore, steel scrap, and other raw materials. The molten slag floats atop the molten crude iron or steel and is tapped from the furnace separately from the liquid metal. After cooling, the slag is processed and may then be sold.[14]

Most iron and steel slags have reuse value. As shown in the *Iron & Steel Slag Beneficially Reused* bar chart, slag consumption has risen in recent years, corresponding to increases in steel production and scrap consumption overall. In 2005, about 21 million tons of domestic iron and steel slag, valued at about $326 million, were consumed.[15] Iron or blast furnace slag accounted for about 60% of the tonnage sold and was worth about $290 million; about 85% of this value was granulated slag. Steel slag produced from basic oxygen and electric arc furnaces accounted for the remainder.[16] Ferrous slags are sold for cement kiln feedstock and other uses such as aggregate for asphalt paving, fill, road base, and concrete. Ground granulated blast furnace slag, valued at more than $60 per ton, is used as a partial substitute for portland cement and blended cements. Some iron and steel slags are returned to the furnaces as ferrous and flux feed.



Source: USGS.

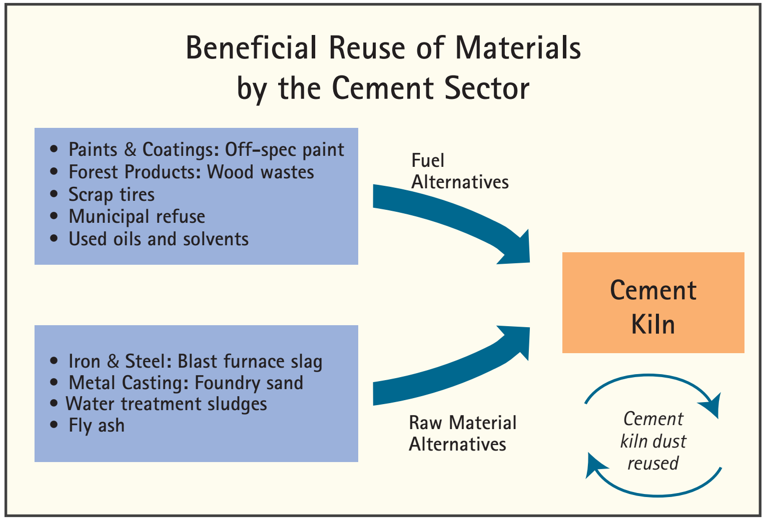
Steelmakers, iron and steel slag producers, and government agencies – including transportation departments – are partnering to identify more and better opportunities for using these materials.[17] One cement manufacturer, Texas Industries, Inc. (TXI), developed the CemStar℠ process for reusing steel slag in high quantities. By 2002, two TXI facilities were able to reuse 340,000 tons of steel slag from Chaparral Steel.[18]

Metal Finishing Wastewater sludge from metal finishing operations is a hazardous waste that contains recoverable concentrations (up to 40%) of copper, nickel, chromium, tin, zinc, and other metals.[19] Permitted hazardous waste recycling facilities can use technologies such as ion exchange canisters to recover economically valuable metals from the wastewater treatment sludges generated by the metal finishing sector. These metals can then be returned for use in metal finishing operations or sold to other industries.

EPA estimates that 76,700 tons of this sludge was generated in 2003, but only 18% was reclaimed or recovered.[20] EPA is currently exploring options for removing regulatory barriers to additional metals recovery from this sludge.

Cement Cement manufacturing uses industrial byproducts from other sectors both as production ingredients and as fuel. As shown in the *Beneficial Reuse of Materials by the Cement Sector* figure, cement production ingredients may include foundry sand and steel slag (as presented earlier in this chapter), as well as coal fly ash and other materials.

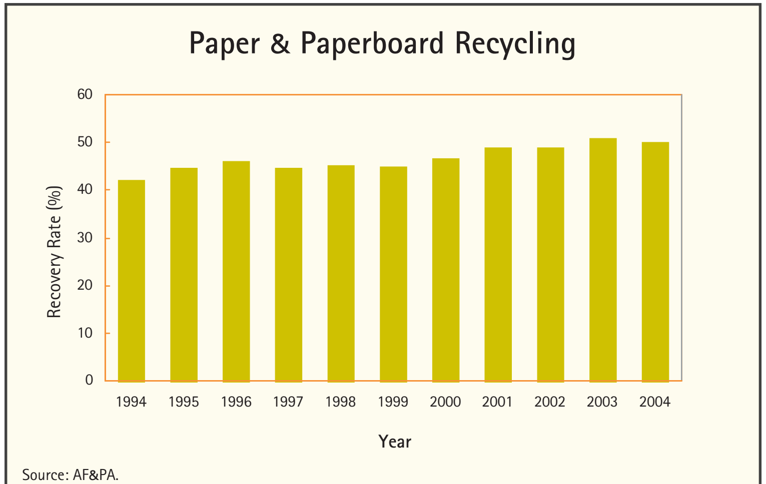
Cement manufacturing is energy-intensive, requiring thermochemical processing of raw materials in huge kilns at very high and sustained temperatures. A medium-sized cement kiln consumes up to 300 million Btus of fuel per hour.[21] However, cement manufacturers can use a variety of industrial byproducts as fuel, including scrap tires, off-specification oil-based paints, byproducts from refineries, wood wastes, aluminum potliners, spent solvents, and used carpets. The industry's use of these materials as fuel has increased over the last decade. For example, in 1998, 30 cement manufacturing facilities burned approximately 38 million scrap tires as fuel; by 2003, 43 facilities burned 53 million tires. The Rubber Manufacturers Association predicted that 50 out of 114 cement facilities would be using scrap tires by 2005.[22]



Cement trade associations, EPA, state programs, and other stakeholders are collaborating to find sensible ways for preventing potential kiln fuels from going to waste.

Use of Post-Consumer Materials Manufacturing facilities in several Sector Strategies sectors, including forest products, iron and steel, and paint and coatings, can obtain feedstock for their products from materials discarded by consumers.

Forest Products Paper manufacturing provides a well-known example of post-consumer recycling. As shown in the *Paper & Paperboard Recycling* bar chart, the paper recovery rate reached an all-time high of greater than 50% in 2003, decreasing slightly in 2004.[23] For some grades such as corrugated boxes and newspapers the recovery rate was over 70%.[24] Data available for 1994 and 2004 show a 27% increase in paper and paperboard recovery – from 40 million tons to more than 50 million tons.[25]



Source: AF&PA.

Iron & Steel Iron and steel manufacturers have a rich history of recycling scrap from used products of all kinds. All new steel is made using at least some recycled steel, and the industry's use of post-consumer scrap, rather than just industrial scrap, continues to climb.[26]

Recent increases in demand for steel have accelerated steel recycling. Since 2002, the overall recycling rate for steel has remained at a 20-year high of almost 71%.[27] Obsolete automobiles are the most recycled consumer product. Each year, the steel industry recycles more than 14 million tons of steel from end-of-life vehicles. This is equivalent to nearly 13.5 million new automobiles.[28] In 2004, the recycling rate for automobiles was 102%, indicating that the steel industry recycled more steel from automobiles than was used in the domestic production of new vehicles.[29]

Between 2003 and 2004, the use of recycled steel increased by more than 10% to 76 million tons, which for 1 year was the most scrap recycled in the United States in more than 20 years.[30] Driven by the high demand for steel and the sector's increasing efficiency, the iron and steel sector continues to expand its recycling of industrial scrap, steel from building demolition, and obsolete products such as appliances and cars. Steelmakers are exploring additional opportunities to improve recycling rates and efficiency, such as product designs that encourage and enable future dismantling and recycling.[31]

Paint & Coatings Of all household hazardous wastes, paint represents the largest cost for local governments to collect and manage.[32] In a draft report, EPA estimates that 9% to 22% of paint sold could become leftover paint.[33]

The paint and coatings industry is participating in a national product stewardship initiative to address the challenges of reducing and managing leftover paint. One of the goals is to increase reuse and recycling opportunities. There are three ways to reuse and recycle leftover paint: exchanges, consolidation, and reprocessing. Exchanges (or swaps) are a way to make unused paint available to other consumers. Consolidation entails combining leftover paints that have similar characteristics, and then mixing, filtering, and packaging the product for distribution or sale. In most cases consolidated paint has at least 95% recycled content. Reprocessed paint is a completely remanufactured product that uses leftover paint as a primary ingredient; it generally contains at least 50% recycled content. In the U.S., reprocessing is currently limited to latex paints.[34]

MOVING FORWARD As demonstrated in this chapter, environmentally sound beneficial reuse opportunities are abundant and often underutilized. These win-win opportunities for business and the environment represent one of the paths that EPA encourages for businesses to become better environmental stewards. Through the Resource Conservation Challenge and the Sector Strategies Program, EPA will continue to provide a forum for collaboration to identify potential new uses for industrial byproducts and innovative approaches to overcome barriers to beneficial reuse.

Introduction to Sector Profiles

OVERVIEW In 2004, the Sector Strategies Program released its first *Performance Report* examining key trends influencing the environmental footprints of twelve sectors and identifying opportunities for improvements. The multi-year data upon which the first report was based came from a variety of public and private sector sources in order to provide the most comprehensive and accurate picture possible of each sector's environmental performance.

The report described each sector's performance in a number of areas, such as:

- Conserving water;
- Improving water quality;
- Increasing energy efficiency;
- Managing and minimizing toxics;
- Managing and minimizing waste; and
- Reducing air emissions.

In the 2006 report, EPA has updated the information on each sector's performance, providing data from the last decade (1994–2003) with an emphasis on performance trends since 2000. In addition, EPA continues to expand both the number of data sources used and the depth of analysis presented. For example, this report includes a new discussion of the toxicity of pollutant releases in each of the sectors.

METHODOLOGY Similar to the 2004 report, the 2006 update provides current sector-specific information based upon a two-part methodology:

- Defining each sector based upon standard classification codes or pre-determined facility lists; and
- Collecting data and presenting "normalized" data trends.

Definition of Sectors For this report, sectors are defined either by standard classification codes, such as the North American Industry Classification System (NAICS) or the U.S. Standard Industrial Classification (SIC) system, or by pre-determined facility lists, such as trade association membership rosters. The endnotes for each chapter clarify how each sector was defined when accessing each data source.

Normalization of Data This report makes frequent use of normalized data when presenting trends over time. As noted in the *Glossary*, "normalizing" means adjusting the actual annual release numbers to account for changes in sector production or output over the same time period. For example, if emissions show a steady decline over time, this could be caused by declining production in the sector, rather than any real improvement in environmental performance. Without accounting for changes in production, the graph would show a downward trend. After adjusting for the declining production, the graph would look more flat.

The factor used to normalize data varies across the sectors but is clearly identified on each chart. Most charts, for example, use sales dollars, while others use productivity measures, such as tons of product.

As an example, many of the charts in this report track progress from 1994 through 2003. On these charts, EPA adjusted sales data for inflation using 1994 dollars as the base year, or similarly adjusted productivity data against the 1994 starting quantity. The formula for this adjustment is shown below:

$$\text{Measures for Year 'A'} \times \frac{\text{1994 Normalized Data (\$/production/shipment)}}{\text{Year 'A' Normalizing Data (\$/production/shipment)}}$$

Key Data Sources As noted above, the data upon which this report is based come from a variety of public and private sector sources, including EPA's Toxics Release Inventory (TRI) and National Emissions Inventory (NEI). One enhancement in the 2006 report is the utilization of EPA's Risk-Screening Environmental Indicators (RSEI) model, which enables EPA to take into account the relative toxicity of each chemical reported as released to the environment in TRI.

In addition, the 2006 report draws upon other federal data, such as EPA's *National Biennial RCRA Hazardous Waste Report* and the U.S. Department of Energy's (DOE) Manufacturing Energy Consumption Survey (MECS). Industry reporting of some of these data is required by law, while other data come from information submitted voluntarily.

Many sectors also collect their own data to track environmental performance over time. More detailed information on the federal data sources, as well as descriptions of these industry data sources, can be found in *Appendix B*.

The following summaries highlight key points regarding the primary data sources used throughout the report, including TRI, *National Biennial RCRA Hazardous Waste Report*, NEI, and MECS.

Toxics Release Inventory One of the report's key data sources is TRI, a publicly available database that contains information on the release and management of nearly 650 chemicals and chemical categories by facilities that use, process, or manufacture these chemicals at annual levels above reporting thresholds. In TRI terminology, releases include discharges to air, water, and land (including landfills), while management includes a variety of techniques, such as treatment, energy recovery, or recycling.

Although not all sectors and/or facilities are subject to TRI reporting requirements, aggregate TRI data indicate trends in the management and minimization of waste by reporting sectors. Where data are available, this report describes TRI data for each sector from 1994 through 2003 (the most current data available at the time of this report's publication).

In addition, this report includes a discussion of the toxicity of each sector's releases to air and water. Although all TRI chemicals are hazardous, their toxicity – the inherent ability of a chemical to cause harm – varies greatly. Using EPA's RSEI model, EPA can calculate a toxicity-weighted score for each sector's air and water releases, which reflects both the quantity and toxicity of the chemicals released.

RSEI results are calculated by multiplying the pounds of air or water releases by a toxicity weight specific to the chemical and media of release. The toxicity weights for chemicals increase as the toxicological potential to cause chronic human health effects increases. The resulting toxicity-weighted results provide an alternative perspective to the typical pounds-based results found in other reports.

As shown in the example on the next page, when pounds are simply summed, Facility A's total TRI air releases, being nearly double that of Facility B, would seem to be of greater concern. However, when additional information about each released chemical's toxicity is factored into the equation using the RSEI model, a different picture emerges. Applying the RSEI model, Facility B's releases, when weighted for toxicity, surpass the similarly weighted releases from Facility A due to the greater presence of mercury, which is much more toxic than methanol.

Note, however, that toxicity weighting of a chemical is *not* the same as identifying the risk potentially posed by a release of the chemical. "Risk" in that context would rely on additional information, such as the fate and transport of the chemical in the environment after it is released, the pathway of human exposure, and the number of people exposed. These and other important details concerning the RSEI model are discussed in depth in *Appendix B*.

Reported TRI Air Releases (lbs.)

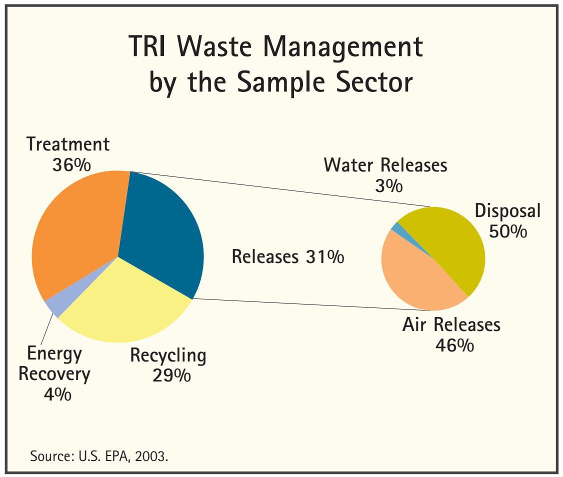
	Methanol	Mercury	Total
Facility A	40,000	10	40,010
Facility B	20,000	40	20,040

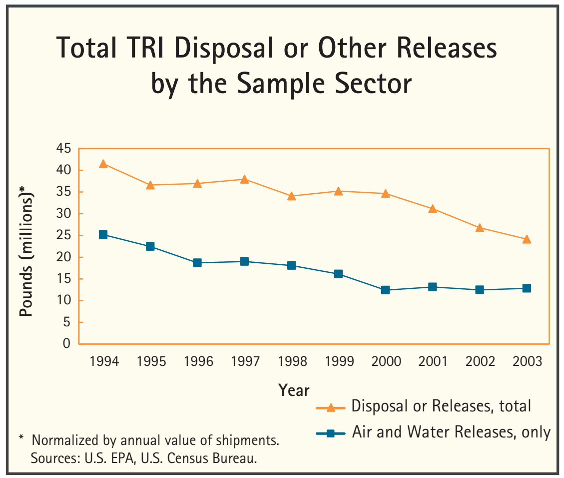
Toxicity-Weighted TRI Air Releases

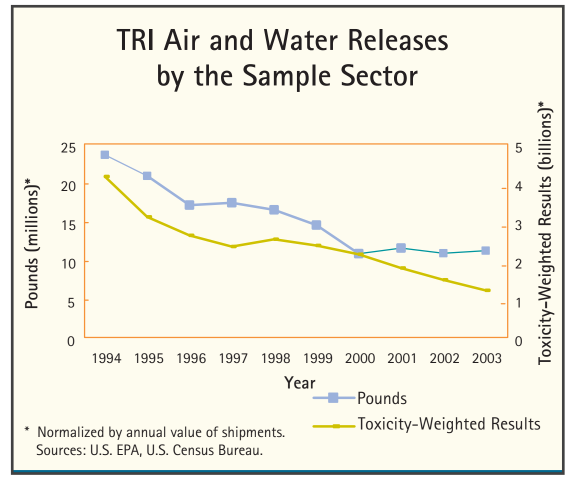
	Methanol (lbs.)	Toxicity Weight	Toxicity-Weighted Result	Mercury (lbs.)	Toxicity Weight	Toxicity-Weighted Result	Total: Both Chemicals
Facility A	40,000	0.45	18,000	10	6,000	60,000	78,000
Facility B	20,000	0.45	9,000	40	6,000	240,000	249,000

As shown in the set of examples below, the TRI data discussion in each sector chapter begins with a series of three related charts that provide a progressively focused look at the sector's TRI releases and waste management activities.

- The first chart, *TRI Waste Management by the Sample Sector*, breaks down how the sector managed all of the wastes it reported to TRI in 2003. The first, larger pie chart shows percentages for releases (including disposal), treatment, energy recovery, and recycling. A second, smaller, pie chart provides additional details on the "releases" slice of the large pie chart, showing the percentages released to air, released to water, and disposed (considered a "release" to land, in TRI terminology).
- The second chart, *Total TRI Disposal or Other Releases by the Sample Sector*, expands on the smaller pie chart by examining trends from 1994 to 2003. The top line on the chart tracks total releases (including disposal), while the bottom line details releases only to air and water. Note that these data are always normalized (in this example by annual value of shipments).
- The third chart, *TRI Air and Water Releases by the Sample Sector*, compares the total pounds of the sector's releases to air and water (the bottom line from the previous chart) to the toxicity-weighted results for those releases. Note that the scale for the pounds line is located on the left side of the chart, while the scale for the toxicity-weighted line is located on the right side of the chart. These data are always normalized.







To take the analysis one step further, the report also includes a table entitled *Top TRI Chemicals Based on Toxicity-Weighted Results* that identifies the chemicals released to air and water that accounted for 90% of the sector's total toxicity-weighted results in 2003. This table identifies the most significant opportunities for a sector to reduce the toxicity of its releases through source reduction or chemical substitution.

National Biennial RCRA Hazardous Waste Report

EPA collects information every other year on the generation, management, and final disposition of hazardous waste from large quantity generators – that is, facilities that meet minimum thresholds for reporting, such as those that generate 1,000 kilograms or more of hazardous waste per month, or 1 kilogram or more of acutely hazardous waste per month – and from facilities that treat, store, or dispose of hazardous waste. Data are reported by facilities in even-numbered years for hazardous waste activities of the previous year. The information received is stored in the Resource Conservation and Recovery Act Information System (RCRAInfo) and compiled in the *National Biennial RCRA Hazardous Waste Report*.

Most of the facilities in the sectors presented in this report do not meet reporting thresholds, and, thus, are not required to file a biennial report. Therefore, the hazardous waste generation and management practices of the reporting facilities in each sector may not be representative of the sector as a whole. However, where data are available, this report typically presents the following figures for 2003:

- Number of reporting facilities;
- Amount of hazardous waste generated;
- Percentage of total hazardous waste generated nationally accounted for by the sector;
- Predominant types of hazardous wastes generated;
- Sources of hazardous wastes generated; and
- Methods used to manage hazardous wastes.

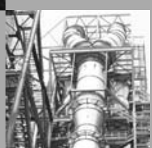
Definitional changes in the data system in 2001 prevent EPA from including comparisons of hazardous waste data with earlier years in this report.

National Emissions Inventory NEI contains EPA's emission estimates of the six criteria air pollutants – carbon monoxide, ammonia, nitrogen oxides, sulfur dioxide, particulate matter, and volatile organic compounds. The inventory is based upon inputs submitted to EPA once every three years by numerous state and local air agencies, tribes, and industry, as well as data from TRI and other sources. Gaps in data for the years between submissions are filled with emissions estimates modeled using sources such as sector-level economic data.

Manufacturing Energy Consumption Survey DOE's statistical agency, the Energy Information Administration, collects data on the energy consumption of U.S. manufacturers every four years by mailing questionnaires to a statistically valid sample of firms. The responses are then extrapolated to represent the full universe of manufacturers and presented in MECS. Where data are available, this report presents the quantity and types of fuel consumed by each sector.

Cement

PROFILE The cement sector[4] comprises 114 plants in 37 states that produce portland cement, which is used as a binding agent in virtually all concrete. Concrete, in turn, is used in a wide variety of construction projects and applications. In 2004, California, Texas, Pennsylvania, Michigan, Missouri, and Alabama were the six leading cement-producing states, accounting for approximately one-half of U.S. production.[5]


Sector At-a-Glance

Number of Facilities:	114[1]
Value of Shipments:	$8 billion[2]
Number of Employees:	17,500[3]

TRENDS Buoyed by a strong residential construction market, the U.S. cement industry has grown in recent years. Higher prices for other construction materials such as steel and lumber also contributed to greater reliance on cement and, therefore, increased the demand for cement.

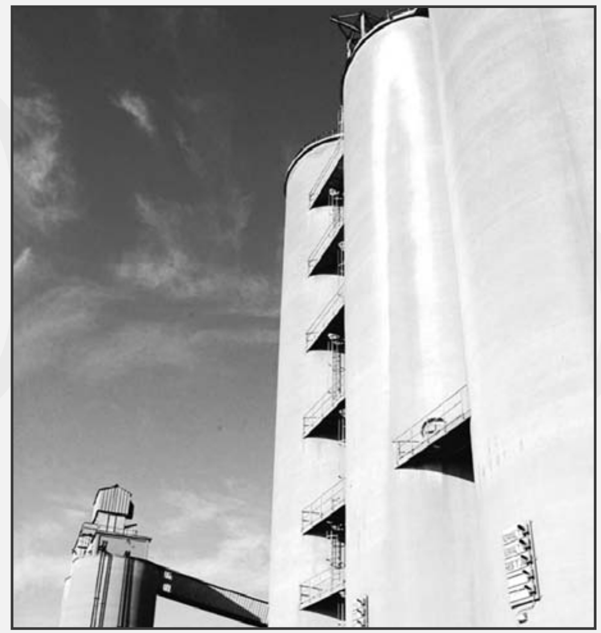
- Between 2003 and 2004, U.S. cement consumption increased by nearly 7% to a record 115 million metric tons. Forecasters expected a 5% increase in consumption in 2005.[6]
- Most of the U.S. demand for cement in 2004 was met by domestic production. Operating at maximum capacity, U.S. facilities produced 95 million metric tons of cement (including portland and masonry cement), an increase of 2% over 2003.[7]
- To meet increasing demand, U.S. cement manufacturers have announced plans to increase production capacity by 15% (nearly 15 million tons) by 2010.[8]

In addition, the effort to rebuild New Orleans and the Gulf Coast area after Hurricanes Katrina and Rita, which struck the region in August and September of 2005, is expected to increase demand for cement over the next four to five years.[9]

KEY ENVIRONMENTAL OPPORTUNITIES

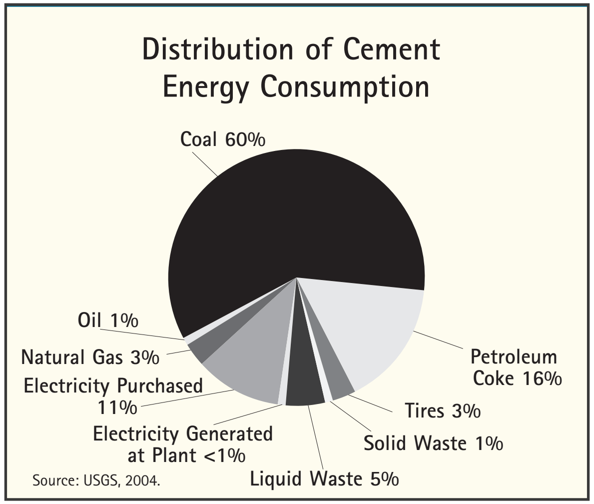
For the cement sector, the greatest opportunities for environmental improvement are in increasing energy efficiency, reducing air emissions, and managing and minimizing toxics and waste.

The cement sector voluntarily tracks its environmental performance. In recent years, the Portland Cement Association (PCA) has expanded its data collection efforts to obtain information on environmental indicators such as air emissions, implementation of environmental management systems, and handling of cement kiln dust (CKD). PCA reported on these results and other issues in its inaugural *Report on Sustainable Manufacturing* in 2005.[10]



Increasing Energy Efficiency Cement is composed of four elements – calcium, silica, aluminum, and iron – which are commonly found in limestone, clay, and sand. Cement manufacturing requires the thermochemical processing (i.e., pyroprocessing) of substantial quantities of these raw materials in huge kilns at very high and sustained temperatures to produce an intermediate product called clinker. Cement kilns use an average of nearly 5 million Btus per ton of clinker.[11] Clinker is then ground up with a small quantity of gypsum to create portland cement.

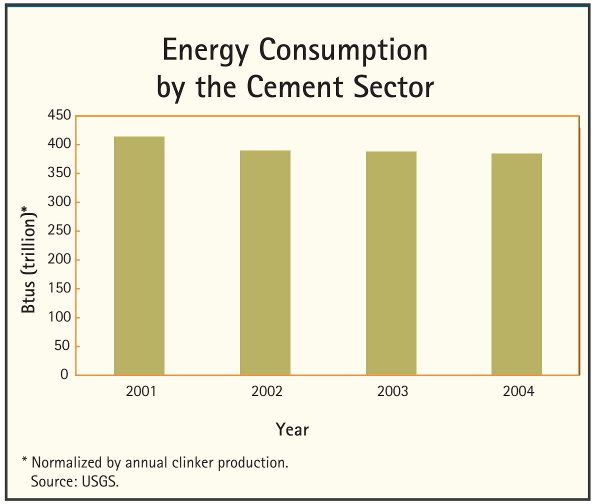
As illustrated in the *Distribution of Cement Energy Consumption* pie chart, cement manufacturing processes are fueled by coal and petroleum coke, electricity, wastes, and natural gas.



In 2004, the industry derived 60% of its energy from coal. Another 16% of the sector's energy was from petroleum coke, 5% from solid and liquid wastes, and the balance from natural gas, fuel oils, and used tires.[12]

As shown in the *Energy Consumption* bar chart, the cement sector consumed 422 trillion Btus of energy in 2004,[13] which represented almost 2% of total energy consumption by U.S. manufacturing that year.[14] When normalized for production, the sector's 2004 energy consumption was 7% lower than in 2001.

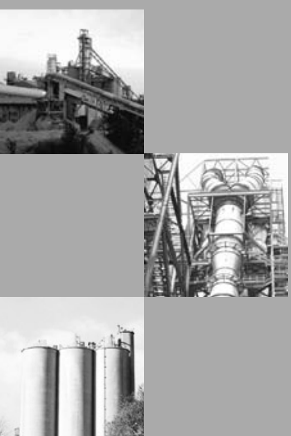
The following case study illustrates measures taken at one cement plant to save energy and reduce accompanying emissions.



Case Study: California Portland Cement Company's Energy Management Program *The California Portland Cement Company worked with EPA's ENERGY STAR program to develop a formal corporate energy management program and an energy management team at its Colton, CA, plant. The energy savings measures identified and implemented at the Colton plant included improvements in the manufacturing process, equipment upgrades or replacement, and new policies for equipment procurement. Through these efforts, the plant has significantly reduced its energy use and accompanying emissions. Between 2003 and 2004, the Colton plant reduced its energy consumption per unit of production by nearly 5%, which translated into more than $800,000 in savings and the prevention of nearly 30,000 metric tons of carbon dioxide (CO_2) emissions.*

The California Portland Cement Company's energy management program is designed to achieve continuing improvements in energy efficiency through the following actions:

- *Establishing baseline energy use through metering and other reporting methods;*
- *Setting goals based on benchmarking and industry best practices;*
- *Performing audits to identify opportunities for energy savings;*
- *Implementing energy savings measures through capital spending, operations and maintenance practices, purchasing policies, and inventory controls; and*
- *Measuring improvements.*[15]



Reducing Air Emissions Cement manufacturing operations emit criteria air pollutants and greenhouse gases (GHG).

Criteria Air Pollutants Three criteria air pollutants are released to the air during cement manufacturing: nitrogen oxides (NO_X), sulfur dioxide (SO_2), and particulate matter (PM).

The combustion of fuels at high temperatures in cement kilns results in the release of NO_X emissions. EPA's National Emissions Inventory (NEI) estimates that, in 2002, the sector released 214,000 tons of NO_X emissions. As shown in the *Nitrogen Oxide and Sulfur Dioxide Emissions* bar chart, between 1996 and 2002 the normalized quantity of NO_X emissions fell by 6% through the use of various process controls. In 2002, NO_X emissions from the cement sector accounted for approximately 1% of total U.S. non-agricultural NO_X emissions.[16]

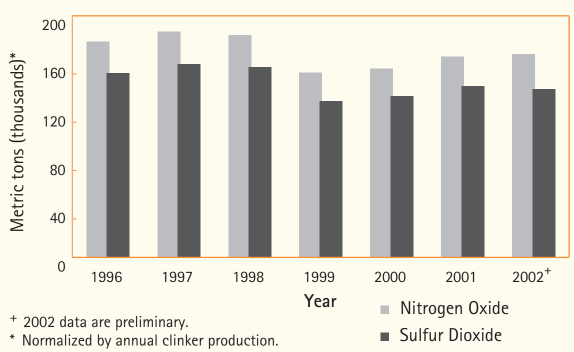
SO_2 emissions from cement plants result from the combustion of sulfur-bearing compounds in coal, oil, and petroleum coke, and from the processing of pyrite and sulfur in raw materials. To mitigate these emissions, cement plants typically install air pollution control technologies called "scrubbers" to trap such pollutants in their exhaust gases. In addition, the limestone used to produce cement has "self-scrubbing" properties, which enable the industry to handle high-sulfur fuels. NEI estimates that, in 2002, the sector released 177,000 tons of SO_2 emissions. As shown in the *Nitrogen Oxide and Sulfur Dioxide Emissions* bar chart, between 1996 and 2002 the normalized quantity of SO_2 emissions decreased by 9%.[17]

Quarrying operations, the crushing and grinding of raw materials and clinker, and the kiln line all result in PM emissions during cement manufacturing. Most of the PM in the exhaust gases from cement plants is removed by fabric filters (known as "baghouses") or by electrostatic precipitation. As described later in this section, this PM (know as CKD) is often reused in the cement manufacturing process. NEI estimates that, in 2002, the sector released 31,000 tons of PM_{10} emissions and 13,000 tons of $PM_{2.5}$ emissions. As shown in the *Particulate Matter Emissions* bar chart, between 1996 and 2002 the normalized quantity of PM_{10} emissions from the cement sector remained fairly constant, following marked improvements begun in the early years of implementing the Clean Air Act.[18]

Greenhouse Gases In the cement sector, CO_2 emissions result from the burning of fossil fuels (predominantly coal) during pyroprocessing and from the chemical reactions (calcination) that convert limestone into clinker.

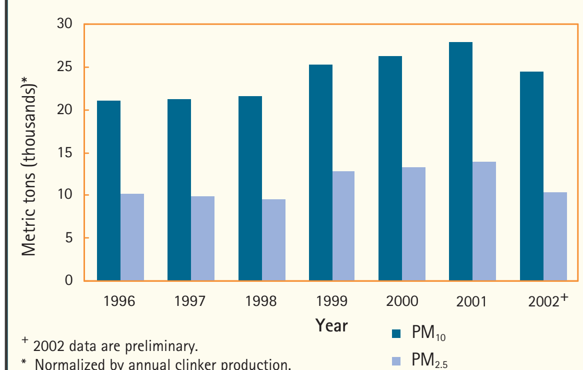
In 2003, fuel combustion accounted for about 97% of total CO_2 emissions in the U.S. – with more than 60% of that coming from power plants and motor vehicles. CO_2 emissions from all industrial processes accounted for about 2.5% of national CO_2 emissions. Within that industrial percentage, iron and steel production accounted for about 37%, while cement manufacturing contributed 29%. Although this sector is the second largest industrial source of CO_2 emissions in the U.S., it accounts for less than 1% of total U.S. CO_2 emissions.[19]

Nitrogen Oxide and Sulfur Dioxide Emissions from the Cement Sector



+ 2002 data are preliminary.
* Normalized by annual clinker production.
Sources: U.S. EPA, USGS.

Particulate Matter Emissions from the Cement Sector



+ 2002 data are preliminary.
* Normalized by annual clinker production.
Sources: U.S. EPA, USGS.

In 2003, PCA formalized its commitment to reduce CO_2 emissions from the cement sector by joining Climate VISION, a voluntary program administered by DOE. PCA committed to a 10% reduction in CO_2 emissions per ton of product by 2020 (from a 1990 baseline). The sector hopes to reach this goal through changes in the cement manufacturing process and in product formulation.[20] In addition, four cement companies have joined EPA's Climate Leaders program, which helps partners to develop long-term comprehensive climate change strategies, set corporate-level GHG reduction goals, and inventory emissions to measure progress. Partner companies include California Portland Cement Company, Holcim (US) Inc., St. Lawrence Cement, and LaFarge North America Inc.[21]

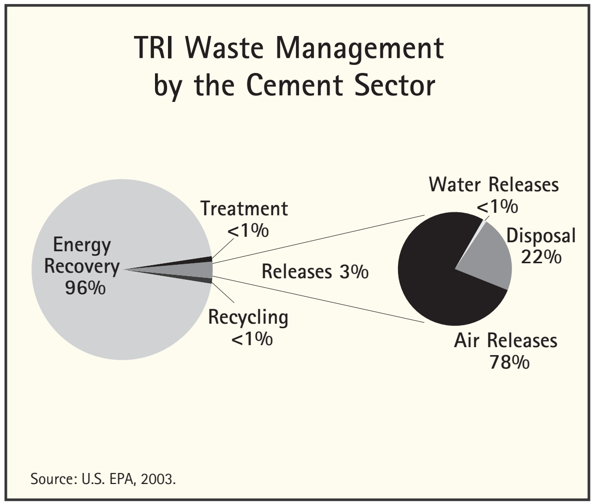
Managing and Minimizing Toxics

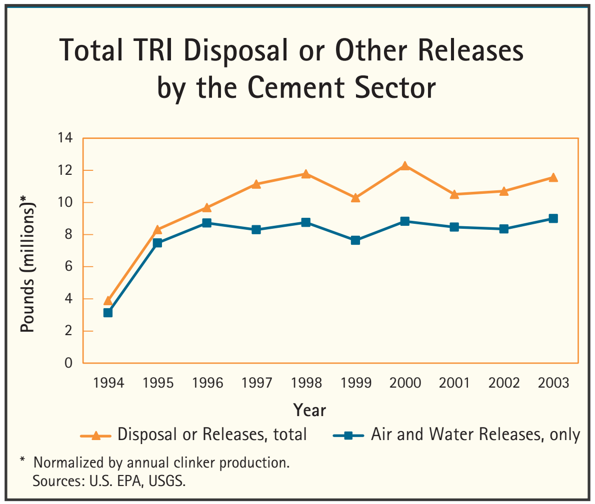
Cement manufacturing facilities use a variety of chemicals and report on the release and management of many of those materials through EPA's Toxics Release Inventory (TRI).

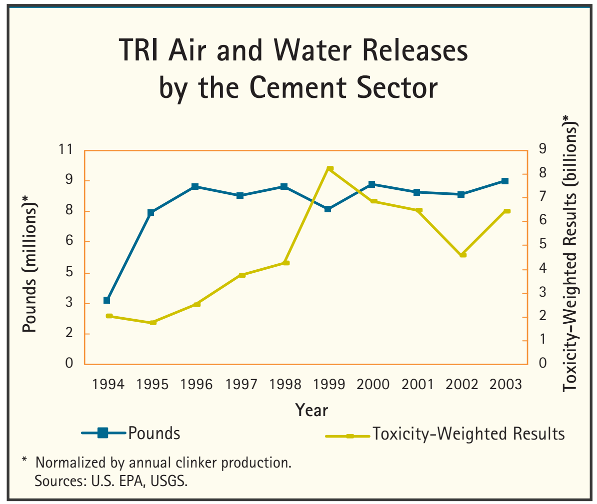
In 2003, 102 facilities in the sector reported 450 million pounds of chemicals released (including disposal) or otherwise managed through treatment, energy recovery, or recycling. Of this quantity, 96% was managed through energy recovery, while 3% was disposed or released to the environment, as shown in the *TRI Waste Management* pie chart. Of those chemicals disposed or released to the environment, 22% were disposed and 78% were released into air or water.

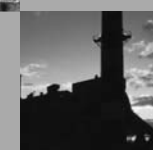
As shown in the *Total TRI Disposal or Other Releases* line graph, the annual normalized quantity of chemicals disposed or released by the cement sector increased by 196% between 1994 and 2003. This increase primarily occurred prior to 1998, and reported disposal and release quantities have remained fairly stable since then. Quantities released to air and water followed a similar trend.

In 2003, hydrochloric and sulfuric acids accounted for 51% of the amount released or disposed, while ammonia, manganese, and zinc accounted for another 24%. Along with ethylene, benzene, and lead, these chemicals accounted for 89% of all pounds reported to TRI as disposed or released by the cement sector.[22]









Data from TRI allow comparisons of the total quantities of a sector's reported chemical releases across years, as presented earlier in this chapter. 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 on the previous page presents trends for the sector's air and water releases in both reported pounds and toxicity-weighted results. When weighted for toxicity, the sector's normalized air and water releases increased by 218% from 1994 to 2003. Between 2000 and 2003, toxicity-weighted results remained fairly steady, despite some fluctuations. Increases in reported releases of sulfuric acid, manganese, and lead were the primary drivers in the overall toxicity-weighted increase in 2003.

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. 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%)
Sulfuric Acid	Lead
Manganese	Mercury
Lead	
Chromium	
Hydrochloric Acid	

Source: U.S. EPA

From 2000 to 2003, the normalized air releases of the chemicals driving the sector's toxicity-weighted results changed as follows: sulfuric acid and lead both fluctuated from year-to-year, manganese releases increased by 65%, and chromium releases decreased by 72%.

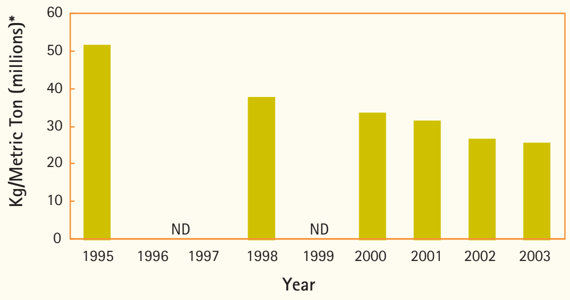
EPA's RSEI model conservatively assumes that chemicals are released in the form associated with the highest toxicity weight. With respect to chromium releases to air and water, therefore, the model assumes that 100% of these emissions are hexavalent chromium (the most toxic form, with significantly higher oral and inhalation toxicity weights than trivalent chromium).[23] Research indicates that the hexavalent form of chromium does not constitute a majority of total chromium releases in the sector.[24] Thus, RSEI analyses overestimate the relative harmfulness of chromium in the sector.

Managing and Minimizing Waste The cement sector reuses CKD generated during the cement production process and utilizes waste products from other industry sectors both as material inputs and as fuel. The cement sector also generates hazardous waste.

Cement Kiln Dust CKD consists of the particles released from the pyroprocessing line at cement plants. It includes partially burned raw materials, clinker, and eroded fragments from the refractory brick lining of the kilns. Recycling CKD reduces the amount of raw materials needed for cement production, and because CKD is already partially processed, recycling it also reduces energy consumption. The industry recycles more than 75% of its CKD, nearly eight million tons, each year.[25] When normalized by annual clinker production, the amount of CKD sent to landfills has declined by 49% since 1995, as shown in the *Cement Kiln Dust Disposed in Landfills* bar chart.[26] Newer plants (typically dry-kiln operations with pre-heater and pre-calciner technologies) are more effective at recovering CKD and reusing it in the manufacturing process.

There are limits, however, to recycling CKD in the manufacturing process, because contaminants can build up in the CKD and compromise the quality of the clinker. The CKD that is not recycled is either disposed at a landfill or sold to other sectors for beneficial reuse applications, such as road fill, liming agent for soil, or as a stabilizer for sludges and other wastes.

Cement Kiln Dust Disposed in Landfills by the Cement Sector



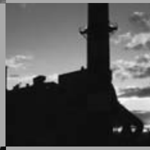
ND=No Data
* Normalized by annual clinker production.
Source: PCA.

Waste Products as an Energy Source The cement sector relies primarily on a combination of coal and petroleum coke for fuel. However, the sector also uses waste products such as tires and used motor oil as fuel sources. In a 2001 survey, PCA found that 53 of the 95 member plants that responded were using some type of waste fuel, with tire-derived fuel being the most common waste fuel used. The survey also found that waste fuels provided almost 8% of the Btus consumed by the sector in 2001.[27]

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

In 2003, 15 cement facilities reported 14,900 tons of hazardous waste generated. Nearly 86% of this waste was generated from managing wastes and production or service-related processes. The waste management method most utilized by this sector was onsite energy recovery for use as fuel.

When reporting hazardous wastes to EPA, quantities can be reported as a single waste code (e.g., lead) or as a commingled waste composed of multiple types of wastes. Quantities of a specific waste within the commingled waste are not reported. In the cement sector, individually reported wastes accounted for less than 1% of the wastes reported. With such limited data, no meaningful conclusions can be drawn about the most predominant types of waste generated by the sector.[28]



Colleges & Universities

PROFILE The college and university sector[4] includes a wide variety of campuses across the country, from small community colleges to large research universities. Funding sources for the sector include tuition, private donations, government grants, and, for public institutions, state appropriations.

Classroom education is only one of many activities taking place on college campuses. Campuses often maintain many types of facilities, including research laboratories, art studios, utility generation and transmission plants, dormitories, and water distribution systems. Many large research institutions also have specialized facilities, such as medical centers, agricultural centers, nuclear reactors, and high-security biomedical laboratories.

Sector At-a-Glance

Number of Institutions:	4,168[1]
Revenues:	$270 billion[2]
Number of Employees:	3.2 million[3]

TRENDS Due mostly to demographic changes, colleges and universities are projected to serve more students each year over the next 10 years. Enrollment in degree-granting institutions is projected to increase from 16.9 million students in 2003 to nearly 18.2 million students by 2013.[5] This growth in the student population will add to the level of activity taking place on campuses and will likely lead to the construction of new buildings and other support facilities.

KEY ENVIRONMENTAL OPPORTUNITIES
For the college and university sector, the greatest opportunities for environmental improvement are in reducing air emissions, managing and minimizing waste, conserving water, and improving water quality. In addition, some colleges and universities are planning and designing campus expansions that meet green building standards.

The colleges and universities sector has taken steps to develop performance metrics, collect data, and track performance. In 2003, six national organizations partnered with EPA's Sector Strategies Program to select key environmental performance indicators, determine appropriate methodologies to measure these indicators, and develop tools to assist institutions with the measurement process.[6]

In 2005, the sector partners launched a Web-enabled Self-Tracking Tool that allows colleges and universities to collect and analyze data on their campuses' environmental impacts.[7] The Self-Tracking Tool gathers four years of retrospective data on four environmental indicators – energy use, hazardous waste, solid waste/recycling, and water use. Schools can use the tool to identify and analyze trends in their data and benchmark their environmental performance against aggregated data from other schools of similar size and type (school names are kept confidential).

All colleges and universities are invited to input data and provide suggestions for improving the tool. To date, more than 100 institutions have registered to use the database (although far fewer have actually entered their data).

Reducing Air Emissions Many colleges and universities are committed to reducing air emissions resulting from fleet vehicles and energy use on campus. Some campuses have developed energy conservation projects and commuting programs to decrease energy needs, while others have switched their campus fleets to compressed natural gas or biodiesel, a cleaner-burning alternative to diesel made from vegetable oil.

To reduce air emissions from electricity use, more than 41 institutions are currently participating in the Green Power Partnership, a voluntary partnership between EPA and organizations that are interested in buying green power. These institutions have pledged to purchase a portion of their electricity from providers using environmentally preferable, renewable energy sources, such as solar, wind, geothermal, biomass, biogas, and low-impact hydropower. Together, they account for purchases of more than 250,000 megawatt hours of green power annually.[8] The following case study highlights another multi-campus initiative to promote renewable energy.

As part of its performance measurement initiative, the sector is now beginning to collect data on its use of both renewable and non-renewable energy.

Case Study: Pennsylvania Campuses "Getting to 10% Wind" *The Pennsylvania Consortium for Interdisciplinary Environmental Policy, through which 34 colleges and universities currently purchase wind energy, is the largest nongovernmental purchaser of wind power in the country. Moreover, the consortium accounts for nearly half of the renewable energy purchases by colleges and universities in the U.S. To encourage member institutions to purchase even more wind energy, the consortium set a goal of "Getting to 10% Wind." So far, nine institutions meet 10% or more of their total energy demand with wind energy purchases, equal to 92,200 megawatt hours. This translates to carbon dioxide reductions comparable to planting nearly 7.5 million trees, or not driving 96 million miles.*[9]

Managing and Minimizing Waste

Colleges and universities are using tools such as target goals and management plans to reduce the generation of hazardous and solid wastes and to increase recycling on their campuses. Target goals vary across campuses, from a 10% reduction in hazardous waste per laboratory student to a 50% recycling rate for solid waste.[10] In addition to their efforts to minimize wastes, a number of institutions are developing courses and degree programs in Green Chemistry.

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

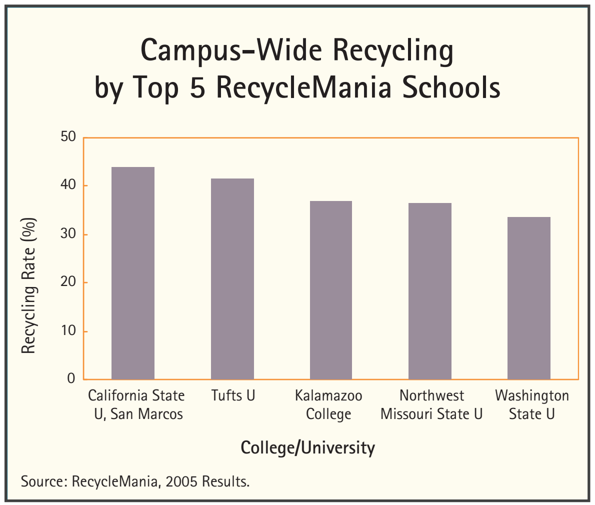
In 2003, 257 facilities in the sector generated 9,100 tons of hazardous waste. Half of this waste was from laboratory operations. Other sources of hazardous waste at colleges and universities include medical centers, art studios, and operations and maintenance activities (e.g., painting). The waste management methods most utilized by this sector were incineration and fuel blending. The sector is beginning to collect information on hazardous waste generation and permitting as part of its performance measurement initiative.[11]

Solid Waste Recycling Solid wastes from colleges and universities include common recyclables, such as cans, glass, cardboard, and office paper, and compostables, such as food scraps, animal bedding, landscape refuse, and trash. An increasing number of colleges and universities are reducing their solid waste volumes through recycling. In addition to the following case study highlights, Seattle University's waste reduction and recycling program has achieved a 62% campus-wide recycling rate;[12] the University of Oregon consistently diverts more than 40% of its waste stream;[13] and the recycling rate at the University of Massachusetts-Amherst exceeds 50%.[14]

The colleges and universities sector is also collecting information on solid waste generation and recycling as part of its performance measurement initiative. Through the Self-Tracking Tool described above, institutions are gathering retrospective data on numerous recyclables (e.g., aluminum, glass, office paper, and newsprint).

Case Study: RecycleMania *RecycleMania is a 10-week, intercollegiate competition between schools from across the country to raise student awareness of campus recycling programs.[15] Founded in 2001 by Miami University (Ohio) and Ohio University, EPA WasteWise partners and rival schools, the number of participating schools has increased from 2 to 47 in just five years. Over the last five years, the two founding universities have increased recycling on their campuses by 61% and 56%, respectively.*

RecycleMania participants compete in two categories: the Residential Areas Contest (determined by the weight of recycled material per residential student), and the Campus-Wide Competition (determined by the amount of recycled material relative to the total waste produced on campus). In 2005, Miami University (Ohio) won the Residential Areas Contest by recycling 72 pounds per student, making it a three-time winner. As shown in the Campus-Wide Recycling bar chart below, California State University in San Marcos, CA, won the Campus-Wide Competition with a 44% overall recycling rate. In total, participating schools recycled more than 10.4 million pounds of materials in 2005.[16]



Source: RecycleMania, 2005 Results.

Green Chemistry As illustrated in the following case study, sector members are developing courses and degree programs in Green Chemistry, which aims to reduce or eliminate the use or generation of hazardous substances in the design, manufacture, and use of chemical products.

Case Study: Green Chemistry at the University of Massachusetts-Boston *Dr. John Warner created the first Ph.D. program for Green Chemistry at the University of Massachusetts-Boston. Researchers and students in the university's Green Chemistry program take their "bioinspiration" by understanding how chemistry works in nature and applying these principles to real-world problems. As a result of its pioneering efforts, UM-Boston has experienced increased enrollment in undergraduate chemistry; received significant research funding in Green Chemistry program areas; found itself flush with highly qualified applicants for the Ph.D. program; and seen active interest by employers in the program's graduates.[17]*

Conserving Water With its student residences, athletic facilities, landscaping, research laboratories, and other activities, a typical college or university can use millions of gallons of water each year. With such a large volume of annual usage, even a small improvement in the efficiency of water use can translate into many gallons of water conserved. Water conservation is particularly important for institutions located in arid or drought-stricken regions of the country, as exemplified in the following case study.

Water conservation efforts on campuses often include activities such as increasing awareness of wasteful practices, using stormwater for landscaping, and implementing more efficient methods of heating and cooling buildings. The sector is beginning to collect information on water usage as part of its performance measurement initiative, gathering retrospective data on potable water and irrigation and other water usage over the last four years.

Case Study: Conserving Water at Colorado College *Faced with drought or near-drought conditions for the past several years, Colorado Springs, CO, is one of many cities along the Front Range of the Rocky Mountains that has imposed water rationing. Colorado College, a small liberal arts college in Colorado Springs, has taken additional steps to significantly reduce its water consumption. Over the last few years, Colorado College has:*

- *Installed low-flow showerheads throughout the entire campus;*
- *Implemented a computer-controlled irrigation system that releases only the necessary amount of water dictated by weather conditions;*
- *Installed drip systems to water existing flowerbeds and incorporated the principles of xeriscaping (conservation of water) in new campus landscaping; and*
- *Used 100% non-potable water for irrigation – much of which would have been released into the Arkansas River.*[18]

Improving Water Quality Stormwater discharges from colleges and universities can affect the quantity and quality of water that must be handled downstream. To help reduce stormwater runoff and pollution, Middlebury College and the University of Central Florida have developed vegetated or turf roofs on buildings. Other universities, such as the University of North Carolina at Chapel Hill, have implemented measures such as storm drain markings, porous pavements, and stream cleanups.[19] The following case study illustrates another institution's approach to controlling stormwater.

Case Study: Boston University's Stormwater Controls *In 1996, Boston University initiated a unique project to protect and improve the Charles River, which runs past its campus. The university undertook this project as a Supplemental Environmental Project to fulfill the requirements of an EPA Consent Decree. Partnering with EPA Region 1, the Charles River Watershed Association, and a local engineering firm, Boston University studied several best management practices to remove pollutants from stormwater and to minimize impacts on the river.*

The university built three stormwater control systems at three large parking lots and tested their pollutant control efficiency from 2000 through 2002. A grassy swale surrounding a storm drain with a catch basin was the most successful technique for reducing stormwater pollutants, removing more than 50% of the total suspended solids during storm events. In addition, the practice is inexpensive, requires little maintenance, and occupies a small footprint, which is important in an urban setting.[20]

Encouraging Green Construction

To promote the development of sustainable buildings, the U.S. Green Building Council developed the Leadership in Energy and Environmental Design® (LEED) Green Building Rating System.[21] In order to attain LEED certification, a new building project must demonstrate performance in five areas: sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality.

Recognizing the environmental benefits of green buildings, colleges and universities have become a leading sector in this area, accounting for approximately 51 of the 342 LEED-certified new buildings in the U.S., including those identified in the following case study.[22] As colleges, universities, and others continue to construct green buildings, and new technologies and practices are proven effective, the overall costs of green construction are expected to decline, which should make green buildings more common in the future.

Case Study: Harvard University's Green Campus Initiative *As part of its Green Campus Initiative, Harvard University is committed to adopting green building practices. The campus has completed one LEED-certified building and is working on four additional projects that are expected to achieve certification. As a LEED Silver certified building, Harvard's One Western Avenue Graduate Housing building accommodates more than 350 residents while demonstrating impressive environmental achievements. For example, the project:*

- *Purchases renewable energy certificates from landfill gas for 100% of its electricity;*
- *Restored 59% of the previously developed site to open green space;*
- *Diverted 90% of the construction waste from the landfill through recycling, reuse, or other means; and*
- *Used environmentally friendly building materials, half of which contained recycled content.*

As green building practices continue to evolve, Harvard strives to ensure that future buildings meet the standards for certification and provide the maximum return on its investment. Through its work to date, the university has learned a number of valuable lessons that contributed to successful green building projects:

- *Incorporate LEED goals as early as possible in the design process;*
- *Include building operations staff in the design process to ensure that the building will be functional;*
- *Hire construction professionals with expertise in green building design and LEED;*
- *Integrate LEED requirements into construction specifications and make contractors accountable for them;*
- *Have an internal staff member oversee LEED design and construction to save time and money; and*
- *Determine and quantify the benefits of LEED to both human health and productivity.*[23]

Construction

PROFILE The construction sector[4] comprises general and specialty contractors in the fields of building construction, residential construction, highway construction, heavy industrial construction, and municipal utility construction, as well as special trades such as plumbing, heating, and demolition. Construction is a large, trillion-dollar industry dominated by very small businesses. Of the more than 700,000 construction firms nationwide, the vast majority (85%) employ 10 or fewer people.[5]

Sector At-a-Glance

Number of Companies:	732,000[1]
Value of Construction:	$1 trillion[2]
Number of Employees:	6.4 million[3]

TRENDS In recent years, domestic construction has continued its steady growth, fueled by new residential starts, home improvement projects, and other housing-related activities, as well as growth in non-residential sectors such as health care and eduction.[6] Residential construction accounted for 55% of total construction in 2004.[7] Between 2003 and 2004:

- The value of total construction put in place increased by 11% to more than $1 trillion.
- The annual value of residential construction increased by 18% to $570 billion.
- The annual value of non-residential construction grew by a more modest 3% to $458 billion. Educational, commercial, and highway/street construction represented the largest shares of non-residential activity.[8]

The National Association of Home Builders forecasted just over 2 million residential construction starts in 2005, an increase of 6% over 2004.[9] Non-residential construction also was expected to experience modest growth in 2005.[10]

KEY ENVIRONMENTAL OPPORTUNITIES For the growing construction sector, there are opportunities for environmental improvements through managing and minimizing waste, encouraging green construction, improving water quality, and reducing air emissions.

The Associated General Contractors of America (AGC) has recognized the need for performance data and is considering ways to better assess the sector's environmental performance. Some industry surveys have been conducted, and EPA and AGC are learning from them how to obtain more comprehensive and higher quality information. However, the following factors pose challenges to measuring and improving environmental performance across the sector: the large number of construction firms (and the even larger number of construction sites), the prevalence of small businesses, and the lack of centralized data (federal or state) regarding compliance with environmental requirements.



Managing and Minimizing Waste

Construction provides various opportunities for recycling construction and demolition (C&D) debris. Additionally, the sector generates some hazardous waste.

Construction and Demolition Debris

C&D debris refers to waste materials generated during the process of construction, renovation, or demolition of buildings, roads, and bridges. C&D debris often contains bulky, heavy materials such as the following: concrete, wood, asphalt, gypsum (the main component of drywall), metals, bricks, glass, plastics, salvaged building components (e.g., doors, windows, and plumbing fixtures), and trees, earth, and rocks from clearing sites.

Comprehensive data on the amount of C&D debris being recycled nationally is difficult to obtain. As noted in the case study below, many states currently have programs that deal with C&D debris, and some have even established model contract specifications regarding C&D reuse and recycling in renovations or new construction. However, states that have been collecting data on this topic use different methodologies and terminologies, so summation of this data is difficult.

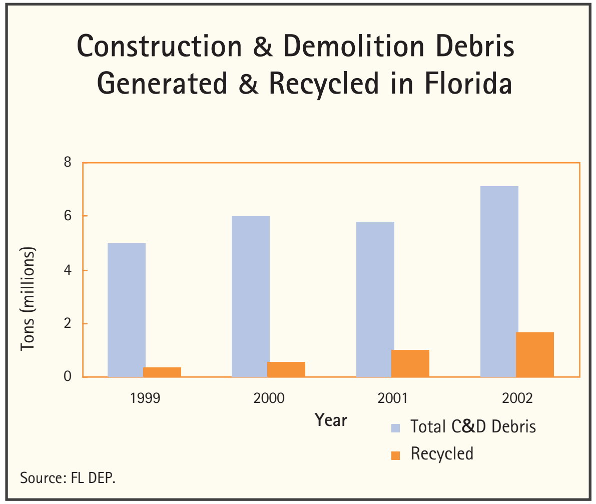
EPA is currently updating its 1998 report, *Characterization of Building-Related Construction and Demolition Debris in the United States*, which analyzed the quantity and composition of building-related C&D debris generated nationally.[11] According to the original report, in 1996 the construction, renovation, and demolition of buildings generated more than 136 million tons of C&D debris. Although 20-30% of the C&D debris was recycled, the majority (70-80%) ended up in municipal solid waste landfills or in special C&D landfills.

In 2004, AGC surveyed its members regarding their C&D debris generation and recycling practices. Of the 328 members who completed the survey, 58% indicated that they recycled some C&D debris. Steel and asphalt were the most commonly recycled materials, reflecting the inherent value of these materials.[12]

The construction sector and EPA are working collaboratively on C&D debris issues through numerous programs, including the Sector Strategies Program, Resource Conservation Challenge, WasteWise Building Challenge, GreenScapes, Green Buildings Program, and the Building Deconstruction Consortium.[13]

Case Study: Construction and Demolition Debris in Florida *As part of its mandate to evaluate municipal solid waste under Florida's Solid Waste Management Act, Florida's Department of Environmental Protection (DEP) tracks the quantity of C&D debris produced annually and the amount being recycled. Although some states count road and bridge debris, commercial structures, or land clearing debris, Florida tracks only C&D debris that is considered municipal solid waste, such as debris from residential construction or demolition. Waste data from landfills is sent to the counties, who add or subtract from these data based on their knowledge of solid waste in the county and then send annual solid waste reports to the DEP. Beginning in 1999, reporting procedures were improved to ensure that road and bridge debris was not included.*

As shown in the Construction & Demolition Debris Generated & Recycled in Florida *bar chart, while the total quantity of debris produced increased between 1999 and 2002, the proportion recycled also increased from 6% to 23% over that period.[14] Along with improved reporting, a number of factors may have contributed to this increase in C&D recycling, including: (1) increased tipping fees at state landfills, (2) the closure of a number of C&D landfills, and (3) the availability of state-sponsored continuing education for construction contractors on green construction. One such course, Build Green and Profit, was attended by about 5,000 contractors in the state.[15]*



Source: FL DEP.

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

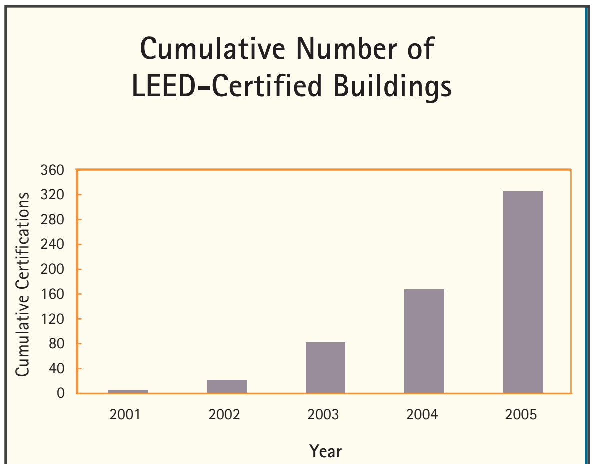
In 2003, 76 construction sites reported 13,000 tons of hazardous waste generated. When reporting hazardous wastes to EPA, quantities can be reported as a single waste code (e.g., lead) or as a commingled waste composed of multiple types of wastes. Quantities of a specific waste within the commingled waste are not reported. The construction sector reported 49% of its wastes as individual waste codes. Of the individually reported wastes, the predominant hazardous waste types reported by the 76 facilities in 2003 were lead, benzene, and wastewater treatment sludge.[16]

Encouraging Green Construction

AGC and other stakeholders in the construction sector have increasingly promoted methods to reduce the environmental impact of construction activities. These methods are known collectively as "green construction." Tracking the sector's activities in the area of green construction provides some indication of movement toward more sustainable construction practices. Progress can be measured in part by the number of green buildings constructed and by the number of construction professionals with training in green construction techniques.

The Leadership in Energy and Environmental Design® (LEED) Green Building Rating System is a voluntary standard for evaluating high-performance, sustainable buildings. This rating system was developed by members of the U.S. Green Building Council (USGBC), which counts 680 contractor or builder firms among its 6,000 member companies and organizations. In order to attain LEED certification, a new building project must demonstrate performance in five areas: sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality.[17]

As shown in the *Cumulative Number of LEED-Certified Buildings* bar chart below, the number of LEED-certified buildings in the U.S. is increasing at an accelerating rate. By the end of 2005, there were 325 LEED-certified buildings.[18]



Source: U.S. Green Building Council.

Construction professionals can demonstrate their understanding of green building practices and principles and their familiarity with LEED requirements, resources, and processes by becoming LEED-accredited. Contractors currently account for 1,387 (nearly 7%) of the 20,663 LEED-accredited professionals in the U.S.[19]

The Green Globes™ design and assessment system is another commercial building rating system gaining attention among both construction and design professionals. In 2005, more than 500 professionals received training on the Green Globes system, of which 20% were construction professionals.

The following case study highlights how one construction firm has met LEED certification requirements at its new corporate headquarters.

Case Study: Alberici's LEED-Certified Corporate Headquarters *Alberici Constructors, a construction firm based in St. Louis, MO, recently converted a 50-year-old manufacturing facility into the new headquarters for its parent company, Alberici Corporation. Because of the building's siting, design, materials, landscaping, construction methods, and other features, it received LEED Platinum certification, the highest level awarded by the USGBC. In fact, the building scored the highest point total for any LEED-certified building in the world.*

To create the new headquarters, Alberici deconstructed and reused parts of a 60,000-square-foot warehouse on the property, diverting more than 90% of the material from landfills. Fifty-seven percent of all material used was manufactured within 500 miles of the site, and 52% of all the raw materials used were extracted locally. Recycled and rapidly renewable materials were used extensively.

To reduce lighting and energy costs, the building was designed to maximize sun exposure. Virtually all employees have a direct view to the outdoors from their workstations. The raised floor system used throughout the building allows individual air flow and temperature control through floor vents. Ventilation and low-emitting adhesives, sealants, paints, carpets, and composite wood ensure indoor air quality.

A 65-kilowatt wind turbine will generate 20% of the building's total energy needs, and a passive solar preheat system heats the water. The building is 60% more energy efficient than a conventional building of similar size.

Two retention ponds and native plants on the property virtually eliminate stormwater runoff and the need for a permanent irrigation system. A rainwater catchment system is used for sewage conveyance, which saves an estimated 146,000 gallons of potable water annually. Six acres of restored prairie and reconstructed wetlands provide wildlife habitat.[20]

Improving Water Quality Stormwater runoff from construction and other land-disturbing activities can significantly impact water quality. Operators of regulated construction sites are required to develop and implement stormwater pollution prevention plans and obtain National Pollution Discharge Elimination System (NPDES) permits from an authorized state or from EPA. Stormwater permits require construction firms to implement certain management practices, but they do not require any water-quality monitoring, so no national data are available to track water quality improvements from the changes in stormwater management practices of the construction sector.

Comprehensive, national data on the construction sector's compliance with stormwater permit requirements also are not available. This data gap is due in part to the large number of construction sites nationwide compared with the small number of sites that EPA and state governments inspect each year.

At this time, the best proxy available is to track the sector's awareness of stormwater permit requirements. An indicator of awareness is the number of stormwater permits applied for and issued to construction site operators in the states for which EPA is the NPDES permitting authority. EPA issues Construction General Permits for five states – Alaska, Idaho, Massachusetts, New Hampshire, and New Mexico. Permits applied for and issued in those states totaled more than 5,300 in 2004. This number will be tracked in future reports to detect trends in permit applications.[21]

Reducing Air Emissions Most air emissions from the construction sector come from non-road mobile sources (e.g., construction equipment such as excavators, off-highway trucks, and portable generators) and construction processes (e.g., grading and asphalt paving).

Diesel engines power many construction vehicles and equipment, such as earth-moving equipment, generators, and compressors. Currently there are 1.8 million pieces of diesel-powered construction equipment in operation in the U.S.[22] These engines are a major source of air pollution, particularly emissions of nitrogen oxides (NO_X) and particulate matter (PM). Diesel exhaust also contains sulfur, which contributes to sulfur oxide (SO_X) emissions.

Current EPA data combine construction-related emissions with other sources, and the portion of these emissions due to construction activities alone cannot be determined. According to EPA's National Emissions Inventory, as a group, non-road diesel engines (e.g., construction and agricultural equipment) contributed 17% of NO_X emissions nationally (3.5 million tons per year) and 31% of NO_X emissions from mobile sources in 2002. These percentages can be considerably higher in some urban areas.[23]

On a national basis, the strategy for controlling air pollution from diesel engines involves stricter pollution requirements for new diesel engines and rules covering the fuel used by these engines. Diesel engines on existing equipment will not be subject to the new regulations, yet they may remain in operation for another 25 to 30 years. Therefore, EPA and its partners are encouraging firms to retrofit existing diesel vehicles with pollution controls.

AGC is working actively with EPA to ensure the success of a new federal diesel emissions reduction program for the construction sector called Clean Construction USA. This is part of EPA's National Clean Diesel Campaign to reduce the pollution emitted from diesel engines through the implementation of varied control strategies. In 2005, EPA awarded 9 grants totaling $945,000 for reducing diesel emissions from off-road construction equipment.[24] As illustrated in the case study below, several states have instituted retrofitting programs of their own.

Case Study: Voluntary Diesel Retrofit Programs in California and Texas *Across the nation, construction companies are participating in voluntary programs to reduce air emissions from their equipment fleets. California's Carl Moyer Memorial Air Quality Standards Program (Carl Moyer Program) and the Texas Emissions Reduction Plan (TERP) are two programs in which construction companies are participating.*

For the past seven years, California's Carl Moyer Program has been providing incentive-based funds for the reduction of NO_X and PM emissions from various sources, including construction equipment. In the first four years of the program, 106 construction off-road engines were retrofitted with pollution control equipment or repowered with newer engines. Combined, these projects have reduced NO_X emissions from construction equipment by 190 tons per year, at an average cost of $4,400 per ton of NO_X reduced. This compares favorably with California Air Resources Board estimates for the 2003 State Implementation Plan, which averaged about $8,300 per ton of NO_X reduced. PM emissions from construction equipment have been reduced by nearly 16 tons per year.[25]

In 2001, TERP was established to improve air quality by providing voluntary financial incentives to companies to offset the incremental cost of reducing NO_X emissions. Construction contractors participating in the program have improved their fleets by purchasing cleaner equipment, replacing old diesel engines, retrofitting engines with emissions reduction technology, and/or using cleaner burning fuel. As of the December 2004 grant cycle, 45 AGC member companies in Texas have conducted 64 retrofit projects. These projects are projected to remove a total of almost 6,000 tons of ozone-producing NO_X from the air over the life of the projects.[26]

Forest Products

PROFILE The forest products sector[4] includes companies that grow, harvest, or process wood and wood fiber for use in products such as paper, lumber, board products, fuels, and many other specialty materials. While the industry has operations in all 50 states, Wisconsin, California, and Georgia are the nation's top three producers of forest products.[5]

The forest products sector can be divided into two major categories: (1) pulp, paper, and paperboard products and (2) engineered and traditional wood products. After decades as a global leader, the American industry is increasingly challenged by traditional competitors (e.g., Canada, Scandinavia) as well as emerging nations (e.g., Brazil, China, Indonesia). Despite this competition, however, the U.S. remains the world's leading producer of pulp and paper products and wood products.[6]

Sector At-a-Glance

Number of Facilities:	14,400[1]
Value of Shipments:	$215 billion[2]
Number of Employees:	765,600[3]

TRENDS The depreciation of the U.S. dollar against other major currencies in 2004 enhanced the competitiveness of U.S. forest products producers in both domestic and export markets.[7] With the exception of newspaper, domestic consumption of forest products generally increased from 2003 to 2004. Low interest rates spurred the residential construction industry, which led to increased demand and prices for lumber and other forest products used in residential construction.

According to a recent long-term analysis of U.S. forest products markets by the U.S. Forest Service, per capita consumption of forest products is expected to remain static, and population growth will be the primary driver of increased consumption of forest products.[8]

KEY ENVIRONMENTAL OPPORTUNITIES
For the forest products sector, the greatest opportunities for environmental improvements are in increasing energy efficiency, reducing air emissions, managing and minimizing waste and toxics, conserving water, improving water quality, and encouraging sustainable forestry.

The forest products sector has tracked its environmental performance for more than 30 years. Through its Environmental, Health, and Safety (EHS) Principles Program and Verification Program, the American Forest & Paper Association (AF&PA) has published three biennial reports on EHS program implementation and environmental performance of its membership.[9] The results of these data collection efforts are described in more detail throughout this chapter.

Increasing Energy Efficiency Despite major advances in energy efficiency and productivity over the last several decades, the forest products industry remains one of the most energy-intensive in the country.[10] In 2002, the forest products sector consumed 2,657 trillion Btus of energy, which represented nearly 12% of total energy consumption by U.S. manufacturing industries that year. As illustrated in the *Energy Consumption* bar chart, when normalized by annual value of shipments, the sector's 2002 energy consumption was 10% lower than in 1994. Within the sector, the pulp and paper segment accounted for 86% of the energy used, while wood products accounted for the remaining 14%.[11]

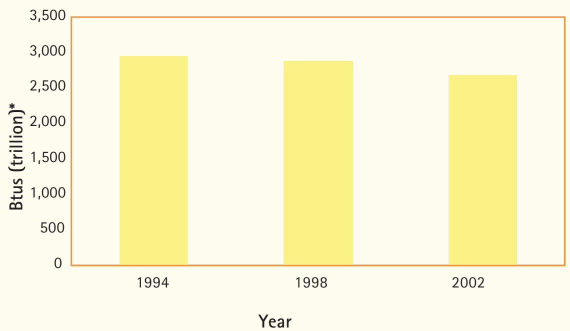
To minimize the environmental impact of its energy consumption, the sector is investing in a variety of generation technologies and alternative fuels, including co-generation and biomass fuel.

Cogeneration The forest products sector is a leader in the utilization of co-generation, a highly efficient process that produces electricity and heat from a single fuel source. Within the sector, more than 65% of the industry's electricity demand is co-generated onsite, making it the largest co-generator in the U.S. manufacturing sector.[12]

Biomass Fuel Although the forest products industry ranks third among U.S. industrial sectors in fossil fuel consumption, it is unique in the extent to which it uses byproducts generated in the manufacture of pulp, paper, lumber, and other wood products as a biomass fuel source. The forest products industry currently meets more than half of its energy needs with renewable fuel sources.

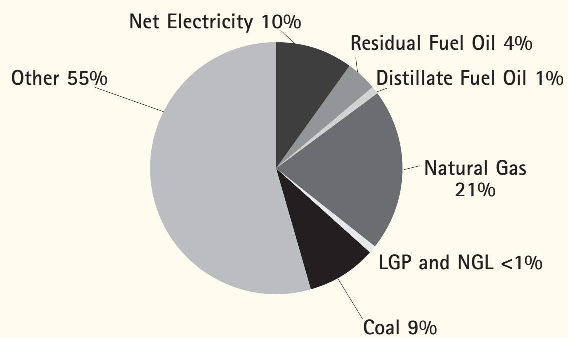
As shown in the *Distribution of Forest Products Energy Consumption* pie chart, the sector is fueled primarily by "other" fuels, composed of byproducts such as pulping/black liquor (accounting for nearly 60% of "other" fuels) and wood wastes such as wood chips and bark (accounting for more than 30% of "other" fuels).[13] The forest products industry is the largest user of these wood byproduct fuels, representing 93% of total use by U.S. manufacturers. The following case study illustrates sector initiatives to generate more energy from biomass.

Energy Consumption by the Forest Products Sector



* Normalized by annual value of shipments.
Sources: U.S. DOE, U.S. Census Bureau.

Distribution of Forest Products Energy Consumption



Source: U.S. DOE, 2002.

Case Study: Agenda 2020 Technology Alliance

The forest products industry is developing new, more efficient technologies to generate energy from biomass through the Agenda 2020 Technology Alliance, an industry-led partnership with academia and government. Agenda 2020 aims to reinvent the forest products industry through innovations in materials, processes, and markets. The partnership has implemented pilot projects under seven platforms: advancing the forest biorefinery, nanotechnology for the forest products industry, breakthrough manufacturing and technologies, next generation fiber recovery and utilization, positively impacting the environment, advancing the wood products revolution, and the technologically advanced workforce.[14]

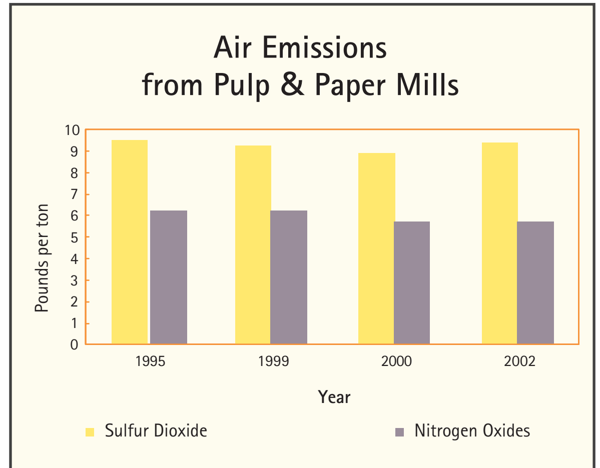
As part of Agenda 2020's Advancing the Forest Biorefinery platform, Georgia-Pacific's Big Island, VA, facility has installed a steam reformer, a type of gasification technology. The reformer (see picture on this page) uses heat and pressure to convert spent pulping liquors to a gas, which can then be burned to produce energy to power mill operations and, potentially, generate surplus energy that can be sold to the grid.

Compared to existing baseline operations, this technology will result in a reduction in process emissions of 10,000 tons per year. This technology also has the potential to eliminate the need for power boilers, a significant source of criteria air pollutants from this industry.

Over the past year, Georgia-Pacific has made several design improvements, and the reformers are now in continuous operation. Currently 100% of the product gas is converted to process heat. Georgia-Pacific's goal is to demonstrate the ability of the system to operate reliably and achieve designed levels of energy and chemical recovery while maintaining environmental emissions at or below the limits set by the environmental permits. This steam reformer technology, once refined, offers the possibility of significant reductions of process air emissions from pulp and paper mills located throughout the U.S.[15]

Reducing Air Emissions The forest products sector tracks releases of two criteria air pollutants – nitrogen oxides (NO_X) and sulfur dioxide (SO_2) – and is developing tools to calculate releases of greenhouse gases (GHG) into the air.

Nitrogen Oxides and Sulfur Dioxide As shown in the *Air Emissions* bar chart, between 2000 and 2002, emissions of NO_X per ton of production in the forest products sector remained unchanged in both segments of the industry (pulp and paper, and wood products), while emissions of SO_2 per ton of production increased by 6%.[16] This increase in SO_2 may be attributed to facilities switching fuels in response to the increasing price of natural gas.



Source: AF&PA.

Greenhouse Gases Working with their international counterparts, the U.S. forest products industry has developed calculation tools for estimating greenhouse gas emissions from pulp and paper mills and wood products facilities. These calculation tools address the industry's unique attributes, such as the neutrality of biomass fuel emissions, and allow the international industry to collect credible, transparent data that is comparable around the world. The methodologies, which are based on the Greenhouse Gas Protocol created by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), received international peer review and were subsequently adopted by WRI/WBCSD as the industry modules for their protocol.[17]

Additionally, the industry has developed a tool to assess the amount of carbon dioxide (CO_2) stored in wood and paper products. CO_2, the primary greenhouse gas, is removed from the atmosphere by trees, and a portion of the CO_2 that trees absorb remains fixed in wood and paper products throughout their useful lives. Essentially, harvesting and manufacturing of forest products transfers CO_2 from forests to products. The new product calculation tool, which has been accepted by the international industry, represents the first consensus method for calculating the amount of CO_2 stored in products. The tool has been submitted to WRI/WBCSD for peer review.[18]

In 2003, AF&PA joined Climate VISION, a voluntary program administered by the U.S. Department of Energy to reduce GHG intensity (the ratio of emissions to economic outputs). AF&PA has committed to a 12% decrease in GHG intensity by 2012 relative to 2000.[19]

In addition, three forest products companies have joined EPA's Climate Leaders program, which helps partners to develop long-term comprehensive climate change strategies, set corporate-level GHG reduction goals, and inventory emissions to measure progress. Partner companies include International Paper, Boise Cascade, and The Collins Companies.[20]

MANAGING AND MINIMIZING WASTE The forest products sector generates hazardous waste and is working to increase the recovery rate for post-consumer paper.

Hazardous Waste EPA hazardous waste data on large quantity generators, as reported in the *National Biennial RCRA Hazardous Waste Report*, indicate that the forest products sector accounted for less than 1% of the hazardous waste generated nationally in 2003. In 2003, 189 forest products facilities reported 54,000 tons of hazardous waste generated. The majority of this waste (98%) was from pulp and paper product manufacturing operations, while 2% was generated from wood product manufacturing operations. The majority (78%) of this waste was generated through secondary processes, such as routine leak collection and floor sweeping. Destruction and treatment were the waste management methods most utilized by this sector.

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 forest products sector reported more than 82% of its wastes as individual waste codes. Of the individually reported wastes, the predominant hazardous waste types reported in 2003 include corrosive waste (38,000 tons), ignitable waste (5,400 tons), chromium, and spent non-halogenated solvents. Additional quantities of these wastes also were reported as part of commingled wastes.[21]

Paper Recycling In 2003, the paper recovery rate reached an all-time high of greater than 50%. For some grades such as corrugated boxes and newspapers the recovery rate was more than 70%. Members of AF&PA aim to increase recovery of all paper consumed in the U.S. to 55% by 2012.[22]

Managing and Minimizing Toxics

Forest products 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).

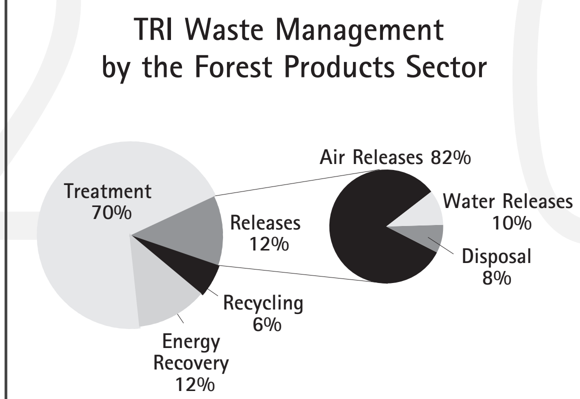
In 2003, 843 facilities reported 1.4 billion pounds of chemicals released (including disposal) or otherwise managed through treatment, energy recovery, or recycling. Of this quantity, 88% was managed, while the remaining 12% was disposed or released to the environment, as shown in the *TRI Waste Management* pie chart. Of those chemicals disposed or released to the environment, 8% were disposed, while 92% were released into air and water.

As shown in the *Total TRI Disposal or Other Releases* line graph, the annual normalized quantity of chemicals disposed or released by this sector decreased by 27% from 1994 to 2003, with more than one-third of this decline occurring between 2000 and 2003. Over the same 10-year period, the sector's normalized releases to air and water declined by 31%, with one-quarter of this decline occurring from 2000 to 2003.

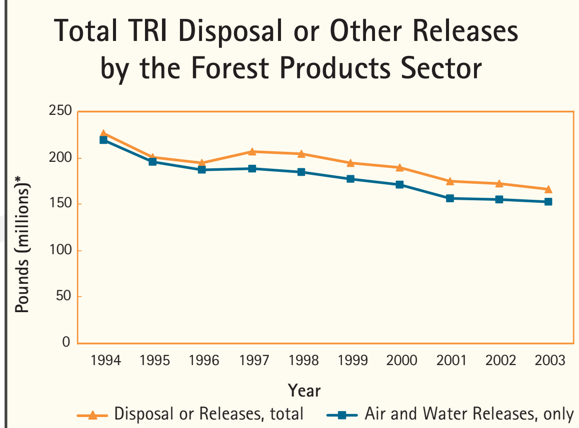
In 2003, the total pounds of TRI chemicals disposed or released by the sector were dominated by methanol, which accounted for 49% of total releases and disposal. Ammonia, manganese, and hydrochloric acid together accounted for another 22%.[23]

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.

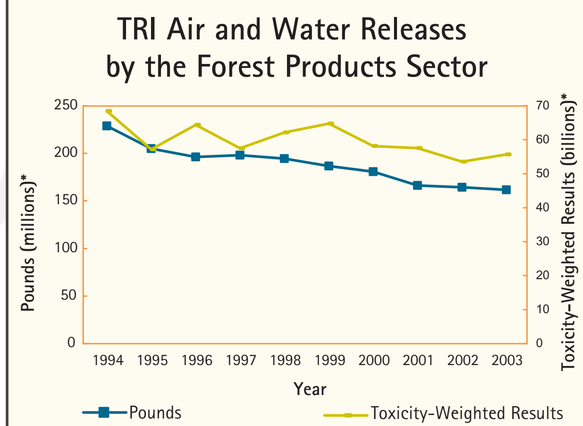
The *TRI Air and Water Releases* line graph presents trends for the sector's air and water releases in both reported pounds and toxicity-weighted results. When weighted for toxicity, the sector's normalized air and water releases decreased by almost 20% from 1994 to 2003, with almost one-quarter of this decline occuring between 2000 and 2003.



Source: U.S. EPA, 2003.



* Normalized by annual value of shipments.
Sources: U.S. EPA, U.S. Census Bureau.



* Normalized by annual value of shipments.
Sources: U.S. EPA, U.S. Census Bureau.

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. 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%)
Acrolein	Lead
Manganese	Acetaldehyde
Sulfuric Acid	Polycyclic Aromatic Compounds
Formaldehyde	Manganese
Chlorine Dioxide	
Diisocyanates	

Source: U.S. EPA

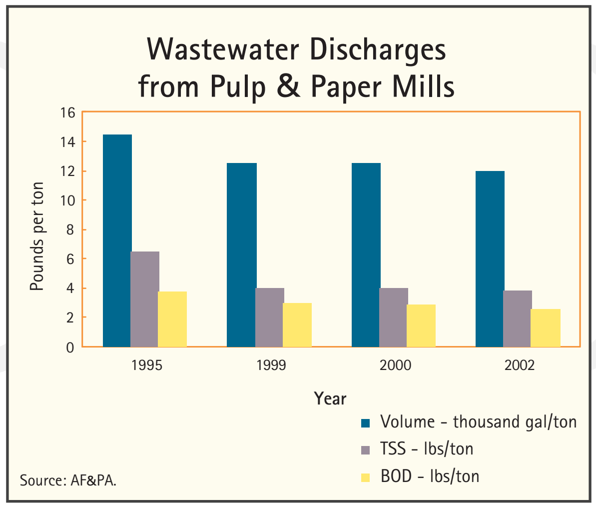
The normalized air releases of the chemicals driving the sector's toxicity-weighted results fluctuated as follows: acrolein increased by 30% from 2000 to 2002, but then decreased by 11% from 2002 to 2003; while sulfuric acid decreased by 20% and manganese increased by 51% from 2000 to 2003. The dominant source of manganese emissions at forest products facilities is the burning of wood and solid fuels such as coal.[24] In 1997, clarification of TRI reporting requirements regarding combustion byproducts resulted in additional facilities reporting manganese and thus an increase in the amount reported to TRI.[25]

Conserving Water The forest products sector is the third largest industrial consumer of water among U.S. manufacturers, with the pulp and paper segment accounting for most of the water consumption.[26] The pulp and paper industry has significantly reduced water consumption in past decades and continues to make progress in this area. Between 2000 and 2002, the pulp and paper industry lowered the volume of water discharged per ton of production by 5%, as shown in the *Wastewater Discharges* bar chart.[27]

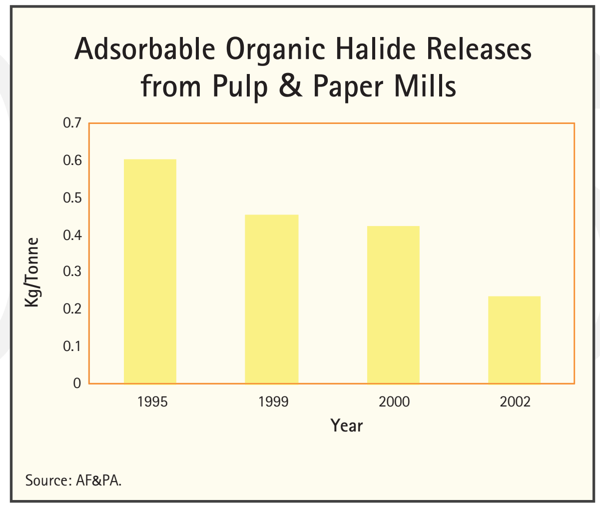
Improving Water Quality Due to the large volumes of water used in pulp and paper processes, wastewater from virtually all U.S. mills is treated using primary and secondary treatment, either onsite or at a wastewater treatment plant, to remove various pollutants from manufacturing process wastewater. Pulp and paper mills measure the total volume of water discharged as well as the quality of the water they discharge to public wastewater treatment facilities or into receiving waters.

Key water quality indicators include biochemical oxygen demand (BOD), total suspended solids (TSS), and adsorbable organic halides (AOX). As shown in the *Wastewater Discharges* bar chart, between 2000 and 2002, the discharge rate of BOD, a measure of the amount of organic contaminants present in wastewater, decreased by 10%. During the same time period, TSS discharges decreased by 5%, from 4 pounds per ton to 3.8 pounds per ton.

In compliance with EPA's Pulp and Paper Cluster Rule, which requires the reduction of toxic pollutants released to water and air, the industry has substituted chlorine dioxide for elemental chlorine as a bleaching agent, virtually eliminating dioxin from its wastewater.[28] This substitution also has resulted in a 44% reduction of AOX, which is an indicator of chlorinated organic substances, between 2000 and 2002, as shown in the *Adsorbable Organic Halide Releases* bar chart.[29]



Source: AF&PA.



Source: AF&PA.

The following case study illustrates research efforts underway to determine the potential impacts of mill effluent on aquatic communities.

Case Study: Measuring Mill Impacts on Aquatic Communities *In 1998, the National Council for Air and Stream Improvement, an independent, nonprofit research institute, embarked on a long-term study of mill receiving waters to determine the potential impacts of mill effluent on aquatic communities. The study is designed to determine whether aquatic communities are stable, healthy, and diverse by analyzing population and community-level measurements at points both above and below mill discharge points on a seasonal and yearly basis. All of the research is carried out under the advisement of experts in aquatic biology. The study includes the following four U.S. locations, which represent a spectrum of pulp and paper mill processes, effluent concentrations, and freshwater ecosystem types: Codorus Creek, PA; the McKenzie and Willamette Rivers, OR; and the Leaf River, MS. Six years into the study, preliminary results show no downstream increases in algal growth, minor nutrient contributions, weak or non-detectible water quality associations with macroinvertebrates, and fish community patterns appearing driven by habitat rather than water quality.*[30]

Encouraging Sustainable Forestry

America's forests cover 747 million acres or 33% of the country. Of this acreage, approximately 504 million acres are classified as timberland, the majority of which is owned by private, non-industrial owners; 13% of timberland is owned by the forest products industry.

Increasingly, timberland is being managed using sustainable forestry practices. Participation in the Sustainable Forestry Initiative® (SFI) program is a condition of membership in AF&PA. The SFI Standard, developed by an independent Sustainable Forestry Board, establishes a land stewardship ethic that integrates the reforestation, nurturing, and harvesting of trees for useful products with the conservation of soil, air and water resources, wildlife and fish habitat, and forest aesthetics. By the end of 2005, over 136 million acres had been independently certified to The SFI Standard. In the past year The SFI Standard has been expanded to include new performance measures and indicators. These indicators include new provisions related to international procurement, old growth, invasive exotic species, imperiled and critically imperiled species, landscape assessments, wood supply chain monitoring, and social issues.[31]

PROFILE The iron and steel sector[4] manufactures the steel used in the production of thousands of manufactured products, ranging from toasters to automobiles to defense applications. Steel is also a key material in infrastructure such as office buildings and bridges. Construction, automotive, and industrial equipment account for more than 75% of total U.S. steel consumption, with construction representing 22% of total steel shipments.[5]

The highest geographic concentration of steel mills is in the Great Lakes region, including Indiana, Illinois, Ohio, Pennsylvania, Michigan, and New York. Approximately 80% of U.S. steelmaking capacity is in these states.[6]

To produce steel, facilities use one of two processes, which utilize different raw materials and technologies.

- Integrated steel mills use a blast furnace to produce iron from iron ore, coke, and fluxing agents. A basic oxygen furnace (BOF) is then used to convert the molten iron, along with up to 30% steel scrap, into refined steel.
- Minimills use an electric arc furnace (EAF) to melt steel scrap and limited amounts of other iron-bearing materials to produce new steel.

Sector At-a-Glance

Number of Facilities:	87[1]
Value of Shipments:	$43.3 billion[2]
Number of Employees:	123,543[3]

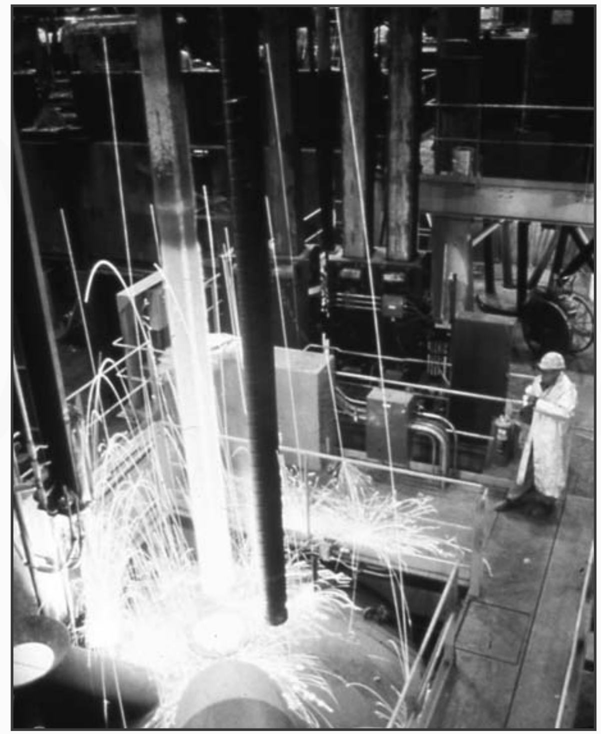
TRENDS Advances in technology, changes in markets, and global competition have led to significant restructuring in the iron and steel sector. Between 2000 and 2003, high levels of imports and other factors caused many U.S. steel companies to declare bankruptcy. For example, more than 30 companies declared bankruptcy during 2001 and 2002. As a result, the domestic steel industry now has fewer companies and fewer steel mills.[7]

- From 2000 to 2003, labor productivity in the U.S. iron and steel sector increased by an average of nearly 6% per year. Over the same period, the sector's workforce declined by nearly 22,000 employees to approximately 124,000 in 2003.[8]
- To better compete in the global market, the U.S. steel industry is developing new process technologies and expanding into new markets. Steel producers anticipate increasing their capital spending by 30% over the next two years.[9]

KEY ENVIRONMENTAL OPPORTUNITIES

For the iron and steel sector, the greatest opportunities for environmental improvements are increasing energy efficiency, managing and minimizing waste and toxics, and reducing air emissions.

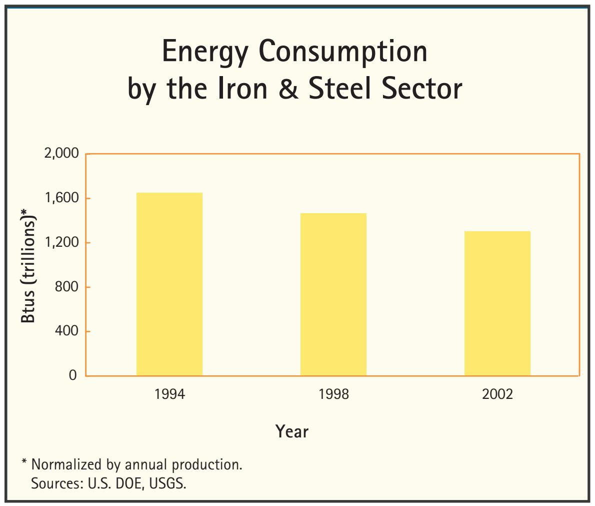
The iron and steel sector is working to generate better data on the sector's environmental performance. For example, the American Iron and Steel Institute (AISI) collects data for five indicators of sustainability: energy intensity, greenhouse gas (GHG) emissions, material efficiency, steel recycling, and implementation of environmental management systems.



INCREASING ENERGY EFFICIENCY

The iron and steel industry is one of the most energy-intensive industries in the U.S.[10] As shown in the *Energy Consumption* bar chart, in 2002, the iron and steel sector consumed 1,308 trillion Btus of energy, accounting for almost 6% of total U.S. manufacturing energy consumption. When normalized for production, this represents a 21% decrease over the eight-year period from 1994 to 2002. As shown in the *Distribution of Iron & Steel Energy Consumption* pie chart, the iron and steel sector is primarily fueled by coal (31%), natural gas (26%), coke (20%), and net electricity (12%).[11]

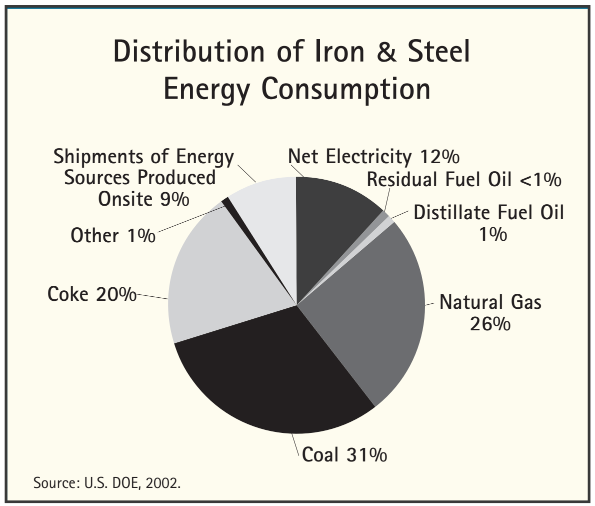
The energy intensity of producing steel via the two types of steelmaking technology differs. In a 1994 study, the U.S. Energy Information Administration estimated the average intensity of producing semi-finished steel at integrated mills using BOF steelmaking to be about 20 million Btus/ton, versus about 8 million Btus/ton for EAF steel producers.[12] When making steel with scrap rather than virgin materials (iron ore, coal, and limestone), steelmakers save natural resources and reduce annual energy consumption by an amount that would power 18 million households for one year.[13]



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

The iron and steel sector is continuing to search for new ways of improving the energy efficiency of its operations. In 2003, AISI joined Climate VISION, a voluntary program administered by the U.S. Department of Energy (DOE) to reduce GHG intensity (the ratio of emissions to economic outputs). Because of the close relationship between energy use and GHG emissions, the steel industry has set energy targets and is actively funding research of energy-efficient technologies to help achieve this goal.[14]

As part of its Climate VISION commitment, AISI has committed to improving its members' energy efficiency by 10% by 2012 (from 2002 levels).[15]



Source: U.S. DOE, 2002.

Between 2002 and 2003, the industry reduced its energy intensity per ton of steel shipped by approximately 7%. The industry's aggregate carbon dioxide (CO_2) emissions per ton of steel shipped were reduced by a comparable percentage during this same period.[16]

The following case study illustrates efforts by the sector to improve the energy efficiency of automobiles, an end user of steel products.

Case Study: Improved Fuel Economy Through Steel Innovation *An international consortium of steel companies recently completed a series of research projects to help automakers improve the energy efficiency of automobiles by reducing their weight. Reducing vehicle weight is one way to improve fuel economy, but it is very challenging to do so while maintaining vehicle safety and affordability (as was done in this study).*

This research effort involved 35 steel manufacturers representing 22 countries. More than $60 million was dedicated over nine years to developing new types of advanced high-strength steel (AHSS) for vehicle applications. The research culminated in prototype vehicles that incorporated innovations in the use of steel for auto bodies, closures, and suspensions. The mid-size design achieved combined city-highway gas mileage of over 50 miles per gallon while meeting or exceeding crash safety requirements and affordability criteria.

The consortium has communicated its findings globally and has assisted automakers in replicating these innovative applications in their own vehicles. These innovative steel applications can now be found in nearly every vehicle on the road today..[17]

MANAGING AND MINIMIZING WASTE All new steel is made using at least some recycled steel, allowing steel to remain America's most recycled material.[18] At the same time, the sector generates hazardous waste.

Steel Recycling The Steel Recycling Institute announced a recycling rate for steel of 71% in 2004, with total tons of steel recycled increasing by more than 7 million tons from 2003. In addition, the composition of the steel recycled in 2004 contained almost 35% more post-consumer scrap than in 1980.[19] To achieve this recycling rate, the steel industry has become an efficient user of raw materials and has increased its demand for post-consumer scrap. The industry is now one of the largest consumers of recycled materials in the world.[20] Even with this success, however, steelmaking continues to present a variety of opportunities to further improve the recycling stream, increase reuse of co-products and byproducts, and reduce releases to the environment.

Obsolete automobiles are the most recycled consumer product. Each year, the steel industry recycles more than 14 million tons of steel from end-of-life vehicles. This is equivalent to nearly 13.5 million new automobiles.[21] In 2003, the recycling rate for automobiles was 103%, indicating that the steel industry recycled more steel from automobiles than was used in the domestic production of new vehicles.[22]



The following case study highlights efforts to reduce mercury emissions resulting from automotive recycling.

Case Study: Reducing Mercury in the Recycling Stream *One pressing problem in the use of scrap from vehicles is the presence of mercury. Automakers use mercury in various applications. Until recently, the most prevalent use was in hood and trunk convenience light switches and anti-lock braking systems (ABS) in domestic automobiles.*

In 2003, automakers phased out the use of mercury-containing switches in new vehicles. However, few automotive dismantlers currently remove these switches from the retired vehicles they receive before the vehicles are flattened or shredded, so mercury is being carried into the recycling stream.[23]

To address this problem, several states have passed laws or created voluntary programs prompting the recovery of mercury switches from end-of-life vehicles. EPA, steelmakers, automakers, recyclers, states, and other stakeholders are now trying to address the problem nationally in order to recover mercury switches and reduce associated emissions from steelmaking in the short-term and to reduce the use of toxic materials in new products in the future.[24]

Hazardous Waste EPA hazardous waste data on large quantity generators, as reported in the *National Biennial RCRA Hazardous Waste Report*, indicate the iron and steel sector accounted for 4% of the hazardous waste generated nationally in 2003.

In 2003, 79 facilities in the iron and steel sector reported 1.3 million tons of hazardous waste generated. More than 83% of this waste consisted of residuals from air pollution control devices. The waste management method most utilized by this sector was deepwell or underground injection, although one facility accounted for the majority of the waste reported as managed by this method. Other common methods included metals recovery, landfill or surface impoundment, and stabilization or chemical fixation.

When reporting hazardous wastes to EPA, quantities can be reported as a single waste code (e.g., spent pickle liquor) or as a commingled waste composed of multiple wastes. Quantities of a specific waste within the commingled waste are not reported. The iron and steel sector reported more than half of its wastes as individual waste codes. Of the individually reported wastes, the predominant hazardous waste types reported in 2003 included emission control dust or sludge (629,100 tons), spent pickle liquor (72,800 tons), cadmium, and chromium. Additional quantities of these wastes were also reported as part of commingled wastes.[25]

MANAGING AND MINIMIZING TOXICS Iron and steel 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, 82 facilities in the iron and steel sector reported 636 million pounds of chemicals released (including disposal) or otherwise managed through treatment, energy recovery, or recycling. Of this quantity, 62% was managed, while the remaining 38% 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, 96% were disposed and 4% were released into air and water.

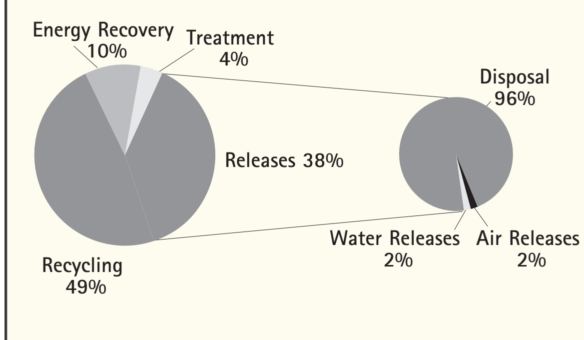
As shown in the *Total TRI Disposal or Other Releases* line graph, the annual normalized quantity of chemicals disposed or released to the environment by the iron and steel sector increased by 171% from 1994 to 2003, with one-third of this increase occurring from 2000 to 2003. Over the same 10-year period, the sector's normalized releases to air and water declined by 42% and remained fairly steady between 2000 and 2003.

These contrasting trends occurred during a period of time in which numerous steel mills installed or upgraded air pollution control equipment, which often results in the generation of additional pollution control residues, such as EAF dust and filter cakes. The disposal of the toxic chemicals in these residues must be reported to TRI.[26] Although many pollution control dusts can be recycled, economic factors can make disposal more likely. For example, zinc prices reached record lows in the mid-1990s and in 2002, making the recycling of EAF dust less economical.[27]

In 2003, metals accounted for the majority of the total pounds of chemicals disposed or released by the sector. Zinc accounted for 72%, and manganese accounted for another 16%. Along with lead and chromium, these metals accounted for 93% of all pounds reported to TRI as disposed or released by the iron and steel sector.[28]

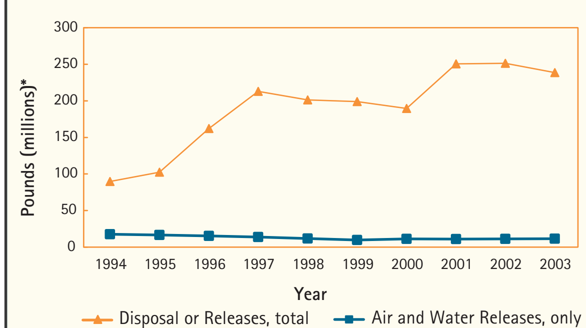
Data from TRI allow comparisons of the total quantities of a sector's reported chemical releases across years, as presented below. However, this comparison does not take into account the relative toxicity of each chemical. Chemicals vary greatly in toxicity, meaning they differ in how harmful they can 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 sector's air and water releases in both reported pounds and toxicity-weighted results. When weighted for toxicity, the sector's normalized air and water releases show a 69% decline from 1994 to 2003.



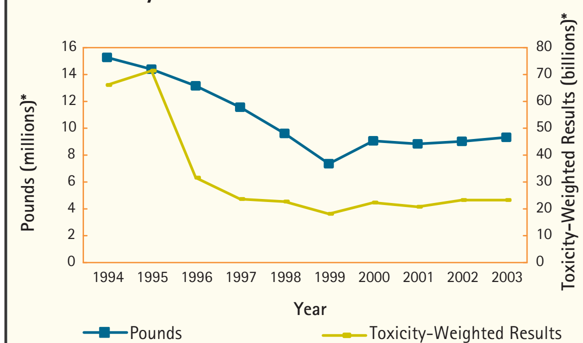
TRI Waste Management by the Iron & Steel Sector

Source: U.S. EPA, 2003.



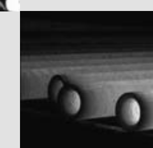
Total TRI Disposal or Other Releases by the Iron & Steel Sector

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



TRI Air and Water Releases by the Iron & Steel Sector

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



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. More than 99% of these 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
Lead	Chromium

Source: U.S. EPA

Manganese, chromium, and lead releases to air, the primary contributors to the sector's toxicity-weighted results, have remained steady in recent years. Manganese is inherent in the iron and steel production process and is one of the chemicals that drives the toxicity-weighted results.

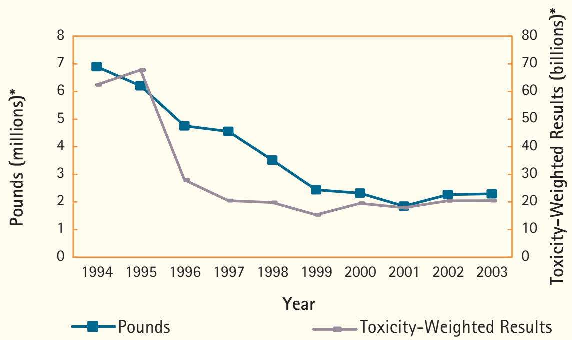
EPA's RSEI model conservatively assumes that chemicals are released in the form associated with the highest toxicity weight. With respect to chromium releases to air and water, therefore, the model assumes that 100% of these emissions are hexavalent chromium (the most toxic form, with significantly higher oral and inhalation toxicity weights than trivalent chromium).[29] Research indicates that the hexavalent form of chromium does not constitute a majority of total chromium releases from this sector.[30] Thus, RSEI analyses overestimate the relative harmfulness of chromium in the sector.

REDUCING AIR EMISSIONS Steelmaking generates a variety of air emissions, including air toxics and GHG. 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.

In 2003, 75 facilities in the sector reported air toxics releases of 2.1 million pounds. As shown in the *TRI Air Toxics Releases* line graph, normalized air toxics releases decreased by 70% from 1994 to 2003. Since 2000, normalized air toxics releases have remained fairly steady.[31] Toxicity-weighted results for air toxics releases declined by 69% over the 10-year period.[32]

TRI Air Toxics Releases by the Iron & Steel Sector

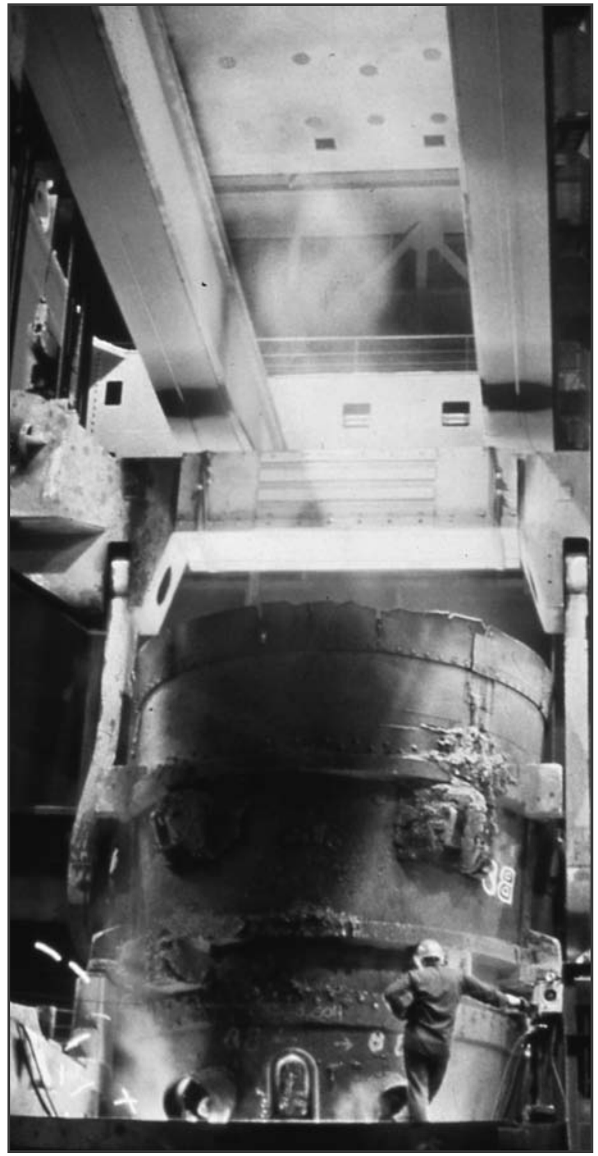


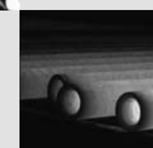
* Normalized by annual production.
Sources: U.S. EPA, USGS.

Greenhouse Gases Steelmaking generates GHG emissions both directly and indirectly. For example, integrated mills produce CO_2 when transforming coke and iron ore into iron. Additionally, both minimills and integrated mills consume significant amounts of electricity, the generation of which often results in GHG emissions. Between 1994 and 2003, the sector's aggregate GHG emissions fell by more than 25%.[33]

In 2003, AISI joined Climate VISION, a voluntary program administered by DOE to reduce GHG intensity.[34] Between 2002 and 2003, the industry reduced its energy intensity per ton of steel shipped by approximately 7%. Because of the close relationship between energy use and GHG emissions, the industry's aggregate CO_2 emissions per ton of steel shipped were reduced by a comparable percentage during this period.[35]

In addition, one steel manufacturer (U.S. Steel Corporation) has joined EPA's Climate Leaders program, which helps partners to develop long-term comprehensive climate change strategies, set corporate-level GHG reduction goals, and inventory emissions to measure progress.[36] Internationally, the industry has established the CO_2 Breakthrough Program to fund the development of new steelmaking technologies that do not emit CO_2. The program also includes research and development into technologies that capture and sequester CO_2.[37]

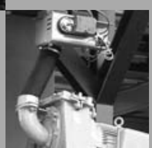




Metal Casting

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

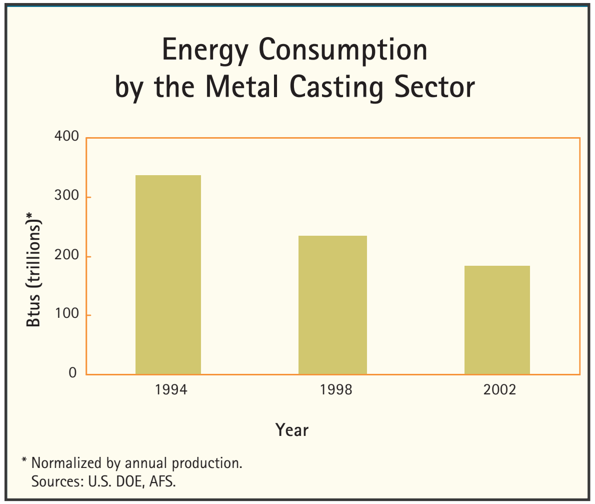
Number of Facilities:	2,336[1]
Value of Shipments:	$33 billion[2]
Number of Employees:	220,000[3]

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]

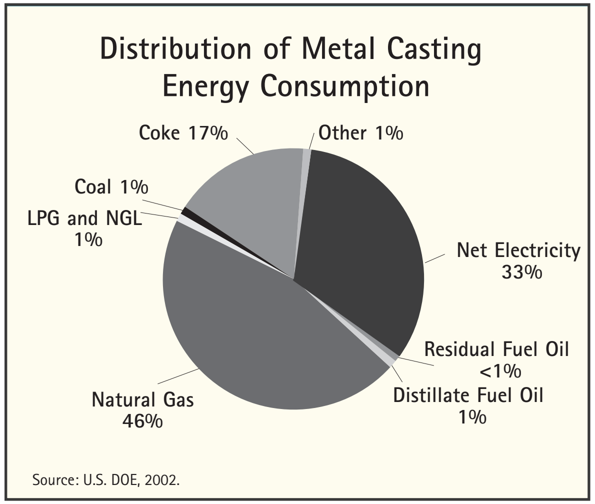
KEY ENVIRONMENTAL OPPORTUNITIES For the metal casting sector, the greatest opportunities for environmental improvements are in increasing energy efficiency, managing and minimizing toxics and waste, reducing air emissions, and conserving water.

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]



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:



- 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.

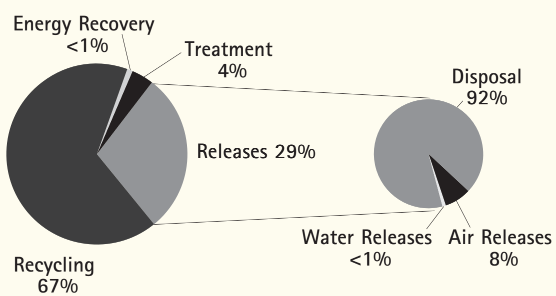
In 2003, ferrous operations accounted for 94% by weight of the sector's releases and disposal, while nonferrous operations, including die casters, accounted for the remaining 6%. Metals accounted for most of the quantity of TRI chemicals disposed or released by the sector. For example, manganese and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

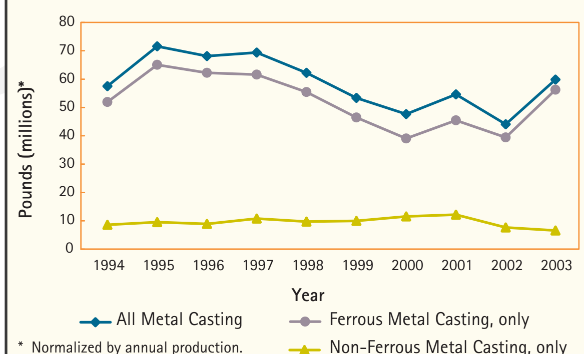
The *TRI Air and Water Releases* line graph presents trends for the entire sector's air and water releases in both reported pounds and toxicity-weighted results. When weighted for toxicity, the sector's normalized releases to air and water declined by 41% between 1994 and 2003, with more than half of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

TRI Waste Management by the Metal Casting Sector



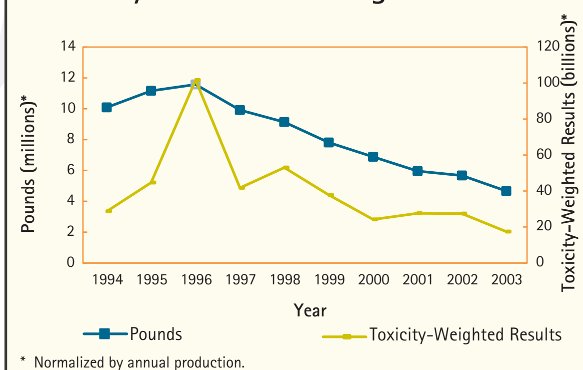
Source: U.S. EPA, 2003.

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.

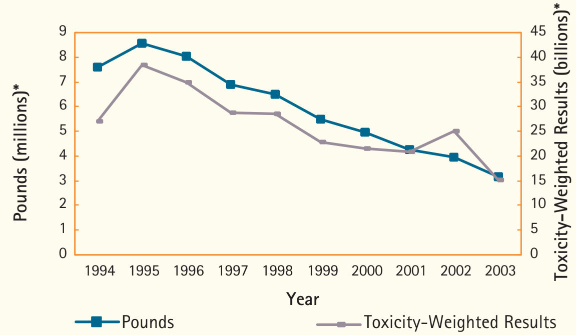
EPA's RSEI model conservatively assumes that chemicals are released in the form associated with the highest toxicity weight. With respect to chromium releases to air and water, therefore, the model assumes that 100% of these emissions are hexavalent chromium (the most toxic form, with significantly higher 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]

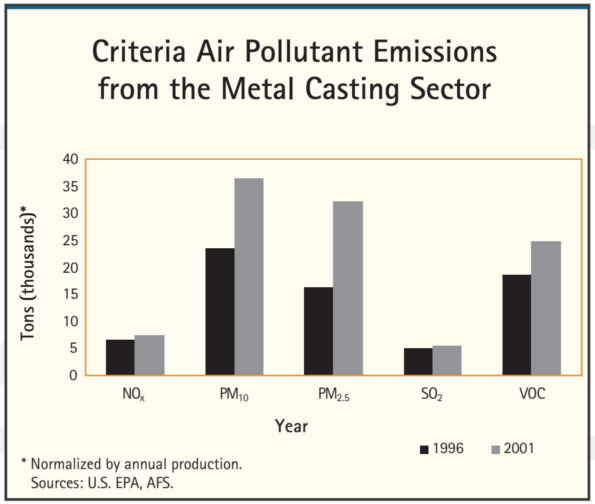
TRI Air Toxics Releases by the Metal Casting Sector



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

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]



* 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.

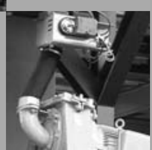
Hazardous Waste EPA hazardous waste data on large quantity generators, as reported in the *National Biennial RCRA Hazardous Waste Report*, indicate that the metal casting sector accounted for less than 1% of the hazardous waste generated nationally in 2003.

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.

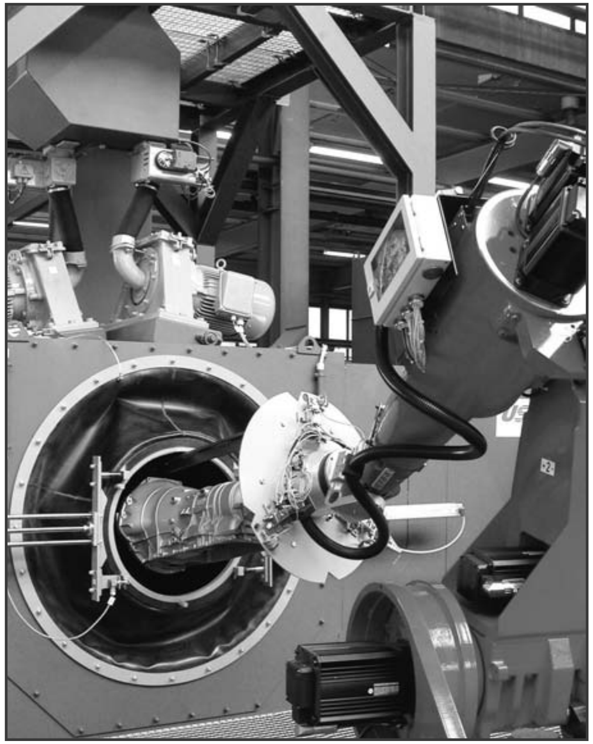
When reporting hazardous wastes to EPA, quantities can be reported as a single waste code (e.g., chromium) or as a commingled waste composed of multiple types of wastes. Quantities of a specific waste within the commingled waste are not reported. The metal casting sector reported more than 70% of its 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]



PROFILE The metal finishing sector[4] encompasses a variety of surface finishing and electroplating operations that coat an object with one or more layers of metal to improve its resistance to wear and corrosion, alter its appearance, control friction, or impart new physical properties or dimensions. Applications range from common hardware items and automotive parts to sophisticated communications equipment and aerospace technologies.

Most metal finishing shops are small, independently owned facilities that perform on a contract basis. Nearly 90% of the roughly 3,000 U.S. metal finishing establishments in existence in 2003 had fewer than 50 employees.[5] Other metal finishing operations are part of larger manufacturing facilities.

Sector At-a-Glance

Number of Facilities:	2,946[1]
Value of Shipments:	$5.8 billion[2]
Number of Employees:	58,962[3]

TRENDS The 2001 economic recession and the accompanying decline in manufacturing activity hurt the U.S. metal finishing sector. The globalization of manufacturing that has occurred since that time has kept the sector from recovering to the levels of output and employment it experienced in the 1990s.

- Since 2000, the number of metal finishing establishments in the U.S. has fallen by 11% to around 3,000. Over the same time period, the number of employees in the metal finishing sector declined by 21% to just under 59,000.[6]
- After declining for two years, the value of shipments by U.S. metal finishing firms increased to $5.8 billion in 2003, an increase of nearly 6% from 2002.[7]

KEY ENVIRONMENTAL OPPORTUNITIES For the metal finishing sector, the greatest opportunities for environmental improvement are in managing and minimizing toxics and waste, reducing air emissions, and conserving water.

Managing and Minimizing Toxics

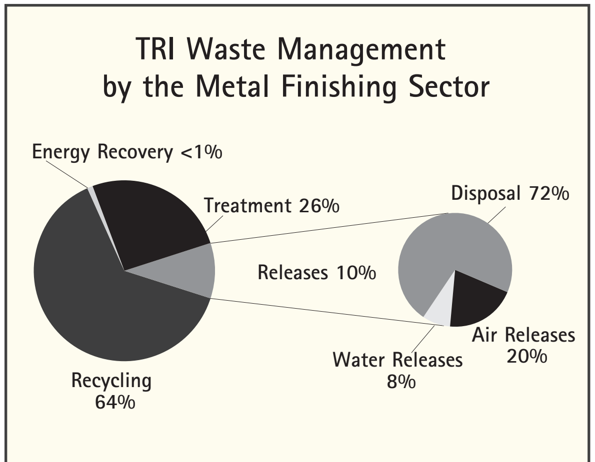
Metal finishing facilities use a variety of chemicals and report on the release and management of many of those materials through EPA's Toxics Release Inventory (TRI).

In 2003, 632 facilities in the metal finishing sector reported 95 million pounds of chemicals released (including disposal) or otherwise managed through treatment, energy recovery, or recycling. Of this quantity, 90% was managed, while the remaining 10% 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, 72% were disposed and 28% were released into air or water.

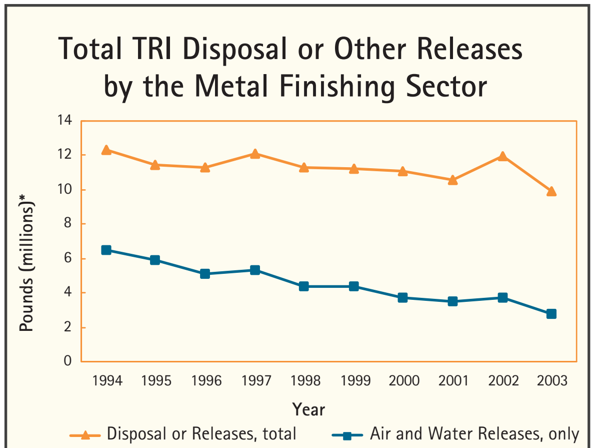
As shown in the *Total TRI Disposal or Other Releases* line graph, the annual normalized quantity of chemicals disposed or released to the environment by the metal finishing sector decreased by 20% between 1994 and 2003, despite an increase in 2002. Over the same 10-year period, the sector's normalized releases to air and water declined by 58%, with one-quarter of this decline occurring between 2000 and 2003. Total pounds of chemicals disposed or released by the sector in 2003 were dominated by metals, with zinc, chromium, and nickel accounting for 59% of the total. Nitrate compounds and nitric acid accounted for another 16%.[8]

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.

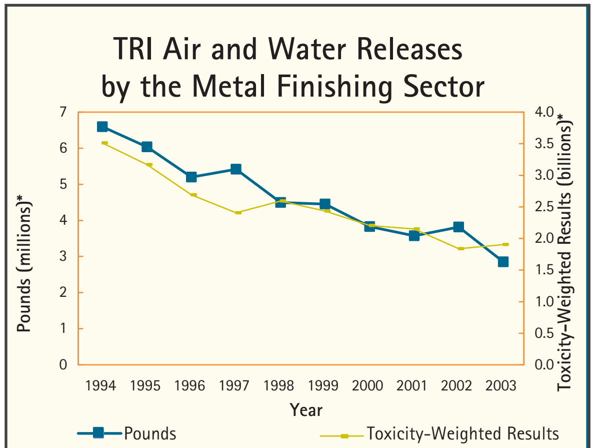
The *TRI Air and Water Releases* line graph presents trends for the sector's air and water releases in both reported pounds and toxicity-weighted results. When weighted for toxicity, the metal finishing sector's normalized air and water releases decreased by 47% from 1994 to 2003.



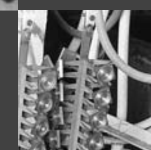
Source: U.S. EPA, 2003.



* Normalized by annual value of shipments.
Sources: U.S. EPA, U.S. Census Bureau.



* Normalized by annual value of shipments.
Sources: U.S. EPA, U.S. Census Bureau.


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. 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%)
Nickel	Lead
Chromium	Copper
	Chromium

Source: U.S. EPA

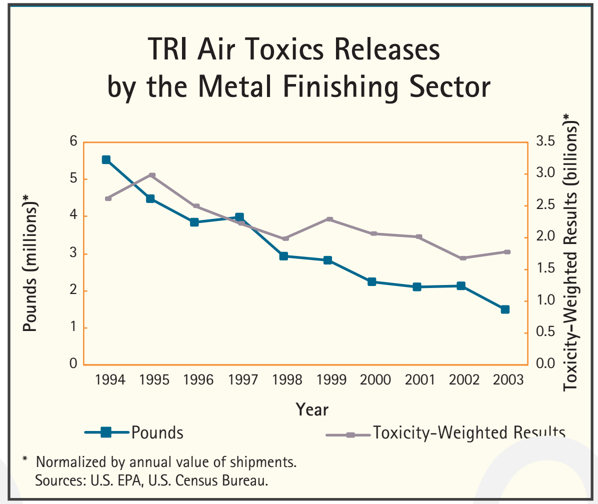
Both air and water toxicity-weighted results were dominated by metals. From 2000 to 2003, the sector's normalized nickel releases to air increased by 9%, while normalized chromium releases to air have been generally declining, with a 28% decrease over this time period.

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 by this sector. Thus, RSEI analyses may overestimate the relative harmfulness of chromium.[9]

Reducing Air Emissions The metal finishing sector releases a variety of air toxics. 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 this chemical category.

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.

In 2003, 259 facilities in the sector reported air toxics releases of 1.4 million pounds. As shown in the *TRI Air Toxics Releases* line graph, normalized air toxics releases decreased by 73% from 1994 to 2003, with almost one-quarter of this decline occurring between 2000 and 2003.[10] Toxicity-weighted results for air toxics releases decreased by 32% over the 10-year period.[11]



Managing and Minimizing Waste The metal finishing sector generates hazardous waste and is working to increase the recovery of metals from wastewater sludge.

Hazardous Waste EPA hazardous waste data on large quantity generators, as reported in the *National Biennial RCRA Hazardous Waste Report*, indicate that the metal finishing sector accounted for 2% of the hazardous waste generated nationally in 2003.

In 2003, 703 metal finishing facilities reported 582,000 tons of hazardous waste generated. However, facility data on the physical and chemical characteristics of the reported waste indicate that 331,000 tons of the reported amount were wastewater rather than hazardous waste.[12] When focusing on the sector's hazardous waste, most was reported as generated from plating and phosphating processes. The management methods most utilized by this sector for hazardous waste were cyanide destruction and other chemical precipitation.

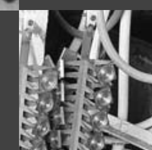
When reporting hazardous wastes to EPA, quantities can be reported as a single waste code (e.g., lead) or as a commingled waste composed of multiple types of wastes. Quantities of a specific waste within the commingled waste are not reported. The metal finishing sector reported 59% of its wastes as individual waste codes. The waste of greatest interest to this sector is the metals-bearing sludge remaining after wastewater treatment processes. Of the individually reported wastes, 49,800 tons of this sludge was generated in 2003. Additional quantities of this waste also were reported as part of commingled wastes.[13]

Metals Recovery Through Sludge Recycling During the metal finishing process, some portion of the materials used in production is not totally captured on the finished product and can exit the process in wastewater and waste. EPA effluent guidelines require metal finishers to treat their wastewater to remove or reduce pollutants prior to discharge to either a wastewater treatment plant or a public waterway. To comply, metal finishers add chemicals to the wastewater to remove metals and other constituents. Most metals then settle and are dewatered to form sludge. This sludge, known as F006 in the RCRA classification system, is regulated as a hazardous waste.

EPA and the industry are working together to increase recovery of metals from metals-bearing sludge. Permitted hazardous waste recycling facilities can use techniques such as ion exchange canisters to recover economically valuable metals from the wastewater treatment sludges generated by the metal finishing sector. Metal recovery reduces land disturbance, resource depletion, energy consumption, and other environmental impacts that result from the mining and processing of virgin metal ore. In 2003, nearly 7,000 tons of the plating sludges reported by the sector using the single waste code F006 were reclaimed or recovered, leaving approximately 40,000 tons that were managed through other means such as land disposal. Note that the neither the amount nor fate of the F006 sludge reported as part of commingled wastes could be determined.[14] EPA is currently exploring options to remove regulatory barriers to additional metals recovery from this sludge.

Improving Water Quality Electroplating involves the use of large volumes of water in plating baths, with the subsequent generation of wastewater. The industry has long promoted the use of best management practices in the pretreatment of wastewater prior to discharge. EPA's recently issued Pretreatment Streamlining Rule has provided additional flexibility for metal finishers to work cooperatively with their wastewater treatment plants to enhance onsite facility cleanup of wastewater effluent.[15] In addition, the industry and EPA's Office of Research and Development have a longstanding partnership to promote the use of more effective pretreatment technologies by metal finishing job shops. As illustrated in the following case study, onsite pretreatment of metal finishing wastewater not only results in cleaner effluent leaving the plant but also promotes water conservation by enabling water reuse in the electroplating process.

Case Study: Efficient Wastewater Management at America's Best Quality Coatings Corporation
America's Best Quality Coatings Corporation (ABQC) plant in Milwaukee, WI, is one of the largest metal finishing facilities in North America. The company recently installed a state-of-the-art wastewater treatment system capable of treating 500 gallons of effluent per minute and monitoring the resulting treatment efficiency on a real-time basis. In addition to efficient wastewater management, ABQC has reduced its water discharges by 20% in the past year by updating the cooling system in its plating baths so that, rather than flowing continuously, the water flow now shuts off when the desired temperature is reached.[16]


Paint & Coatings

PROFILE The paint and coatings sector[4] manufactures a variety of products that preserve, protect, and beautify the objects to which they are applied. There are four main types of paint and coatings products:

- Architectural coatings used in homes and buildings, such as interior and exterior paints, primers, sealers, and varnishes;
- Industrial coatings that are factory-applied to manufactured goods as part of the production process;
- Special purpose coatings, such as aerosol paints, marine paints, high-performance maintenance coatings, and automotive refinish paints; and
- Allied paint products, including putties, paint and varnish removers, paint thinners, pigment dispersions, and paint brush cleaners.

Sector At-a-Glance

Number of Facilities:	1,371[1]
Value of Shipments:	$20.3 billion[2]
Number of Employees:	47,279[3]

TRENDS The paint and coatings manufacturing industry has been going through a period of consolidation, marked by a large number of mergers, acquisitions, and spin-offs during the last decade. Although hundreds of small- and medium-sized private firms continue to operate on local and regional levels, consolidation will likely continue due to shifting market dynamics.[5]

- In 2003, 53% of the gallons of paint and allied products sold were architectural coatings, 27% were industrial coatings, 10% were special purpose coatings and 10% were allied products.[6]
- Shipments of architectural coatings increased nearly 7% from 2002 to 2003, while shipments of special purpose coatings increased 4% and shipments of industrial coatings and allied products remained essentially flat.[7]
- Industry analysts forecast that the U.S. paint and coatings market will grow nearly 15% from 2004 to 2008, with the architectural segment of the sector continuing to comprise the largest share of the market.[8]

KEY ENVIRONMENTAL OPPORTUNITIES
This report focuses primarily on the environmental footprint of the paint and coatings manufacturing process. Data on the impacts of paint application and the disposal of post-consumer paint also are provided where possible.

For the paint and coatings manufacturing sector, the greatest opportunities for environmental improvements are in managing and minimizing toxics and waste, reducing air emissions, and promoting product stewardship.

Managing and Minimizing Toxics

Paint and coatings manufacturing 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).

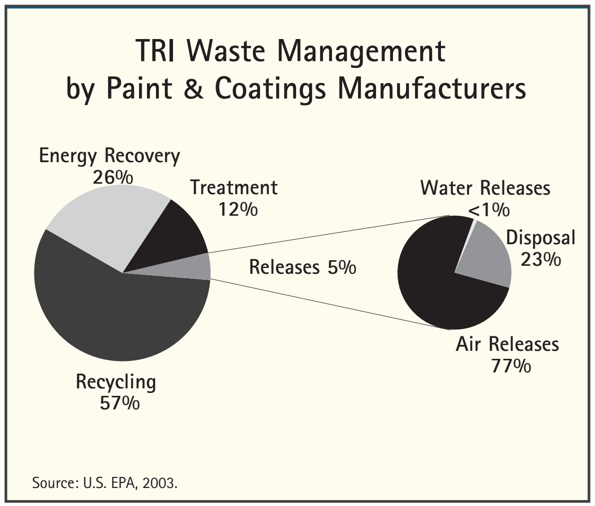
In 2003, 481 facilities in the sector reported 130 million pounds of chemicals released (including disposal) or otherwise managed through treatment, energy recovery, or recycling. Of this quantity, 95% was managed, while the remaining 5% was disposed or released to the environment, as shown in the *TRI Waste Management* pie chart. Of those chemicals disposed or released to the environment, 23% were disposed and 77% were released into air or water.

As shown in the *Total TRI Disposal or Other Releases* line graph, the annual normalized quantity of chemicals disposed or released to the environment by the paint and coatings manufacturing sector decreased by 42% between 1994 and 2003, with almost half of this decline occurring between 2000 and 2003. Over the same 10-year period, the sector's normalized releases to air and water declined by 52%, with one-third of this decline occurring between 2000 and 2003.

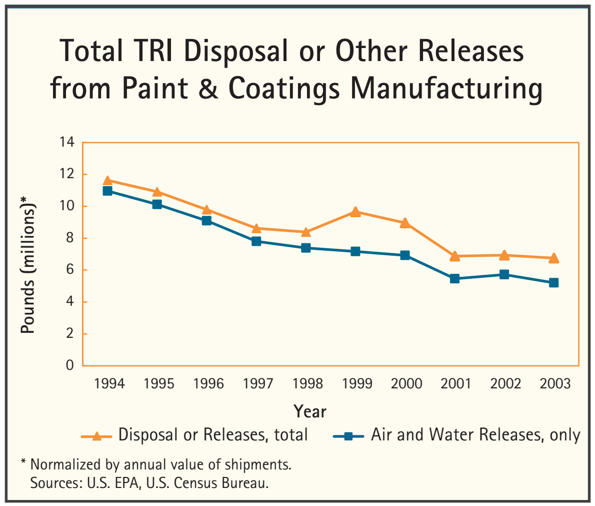
In 2003, the total pounds of chemicals disposed or released by the sector were dominated by organics. For example, xylene, toluene, methyl ethyl ketone, certain glycol ethers, and ethylene glycol accounted for 57% of the total releases and disposal for the sector.[9]

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.

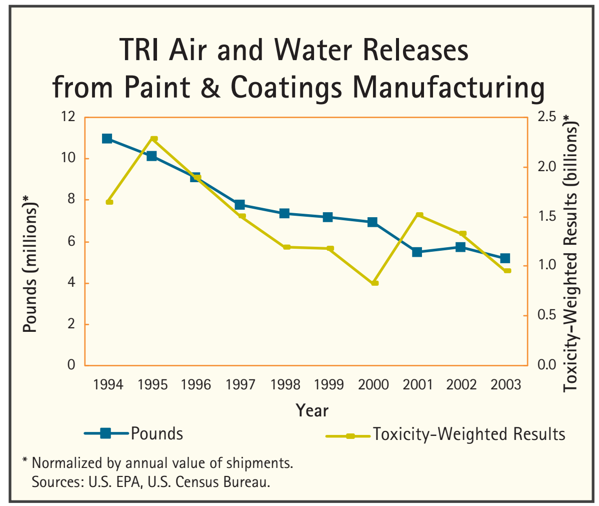
The *TRI Air and Water Releases* line graph presents trends for the sector's air and water releases in both reported pounds and toxicity-weighted results. When weighted for toxicity, the sector's normalized air and water releases show a 42% decline from 1994 to 2003, despite a marked increase in 2001 that is explained on the next page.



Source: U.S. EPA, 2003.



* Normalized by annual value of shipments.
Sources: U.S. EPA, U.S. Census Bureau.



* Normalized by annual value of shipments.
Sources: U.S. EPA, U.S. Census Bureau.

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. 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%)
Diisocyanates	Antimony
Chromium	Copper
1,2,4-Trimethylbenzene	Lead
Cobalt	Chromium
Certain Glycol Ethers	
Xylene	
Toluene Diisocyanate	
Nickel	

Source: U.S. EPA, 2003

In 2003, toxicity-weighted air releases were dominated by diisocyanates and chromium, accounting for 74% of the sector's total toxicity-weighted releases to air. From 2000 to 2003, normalized diisocyanate releases to air fluctuated considerably, including a marked increase in 2001, followed by declines in 2002 and 2003. The increase in 2001 resulted from the first-time reporting of diisocyanates by three individual facilities. Due to the high toxicity weight assigned to diisocyanates by the RSEI model, the increase reported by the three facilities in 2001 was sufficient to create a spike in the sector's overall toxicity-weighted results, as reflected in the *TRI Air and Water Releases* line graph. Normalized chromium releases to air remained fairly steady from 2000 to 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 toxicity weights than trivalent chromium).[10] Research indicates that the hexavalent form of chromium does not constitute a majority of total chromium releases from paint and coatings manufacturing operations.[11] Thus, RSEI analyses overestimate the relative harmfulness of chromium releases from the sector.

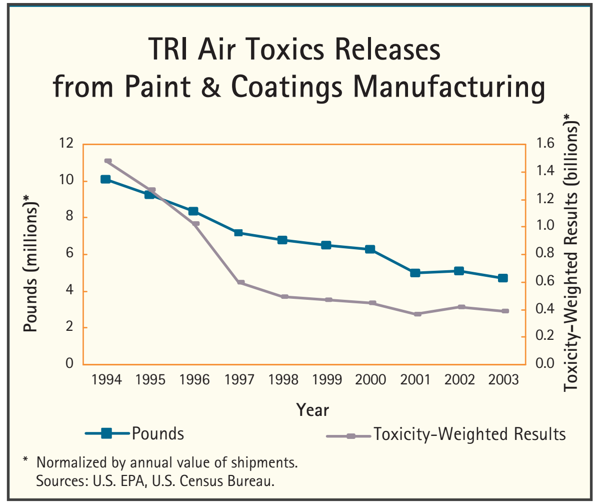
Reducing Air Emissions Organic solvents are used in the production of oil-based paint and coatings due to their ability to dissolve and disperse other coating constituents. They also are used in smaller quantities in the production of water-based paint and coatings, as well as in other aspects of the manufacturing process. As organic solvents evaporate, they release emissions of volatile organic compounds (VOCs) and air toxics. These releases occur inside production facilities as well as when paint and coatings products are ultimately applied to building structures, consumer products, and other surfaces. Although emissions of VOCs and air toxics during the manufacturing process are largely captured in the TRI air releases discussed above, this section takes a closer look at these chemical categories.

EPA's National Emissions Inventory estimates that, in 2002, paint and coatings manufacturers released 7,000 tons of VOCs. During the same year, VOC emissions resulting from the use of paint and coatings products were estimated at 2 million tons. As shown in the *Volatile Organic Compound Emissions* bar charts, between 1996 and 2002, the normalized quantity of VOC emissions resulting from the manufacture of paint and coatings products remained relatively stable, while the normalized quantity of VOC emissions resulting from the use of paint and coatings products declined by 9%.[12] Air toxics, also called hazardous air pollutants (HAPs), are a subset of the TRI chemicals presented in the previous section. 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.

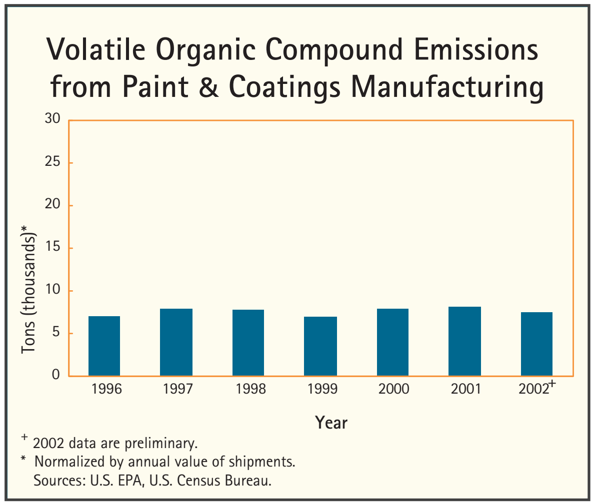
In 2003, 420 facilities in the paint and coatings manufacturing sector reported air toxics releases of 4.7 million pounds. As shown in the *TRI Air Toxics Releases* line graph, normalized air toxics releases resulting from the manufacture of paint and coatings decreased by more than half (53%) between 1994 and 2003, with more than one-quarter of this reduction occurring between 2000 and 2003.[13] Toxicity-weighted results for air toxics releases declined by 73% over the 10-year period.[14]

A downward trend in VOC and air toxics emissions is likely to continue because of new regulatory requirements, improved industrial housekeeping, and technological advances related to solventless and low-VOC/HAP coatings products, as well as improvements in the manufacturing process and changing consumer preferences. These factors already have contributed to the following developments:

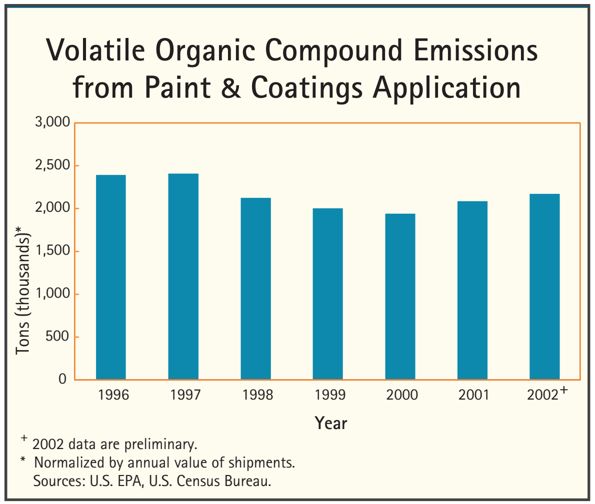
- From 1994 to 2003, environmentally preferable water-based paint increased from 76% to 82% of architectural coatings sales, further eroding the market share of oil-based paint.[15]
- Markets for industrial and special purpose coatings also have undergone transformation as customers have demanded, and manufacturers have introduced, more environmentally benign coatings products, including a wide variety of water-based, high-solids, powder, and radiation-cured coatings.



* Normalized by annual value of shipments.
Sources: U.S. EPA, U.S. Census Bureau.



+ 2002 data are preliminary.
* Normalized by annual value of shipments.
Sources: U.S. EPA, U.S. Census Bureau.



+ 2002 data are preliminary.
* Normalized by annual value of shipments.
Sources: U.S. EPA, U.S. Census Bureau.

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

In 2003, 351 paint and coatings manufacturing facilities reported 120,900 tons of hazardous waste generated. Approximately 60% of this waste was generated from cleaning out process equipment and from product and byproduct processing. The waste management methods most utilized by this sector were fuel blending, solvents recovery, and onsite energy recovery.

When reporting hazardous wastes to EPA, quantities can be reported as a single waste code (e.g., lead) or as a commingled waste composed of multiple types of wastes. Quantities of a specific waste within the commingled waste are not reported. The paint and coatings manufacturing sector reported 32% of its wastes as individual waste codes. Of the individually reported wastes, the predominant hazardous waste types reported by the sector in 2003 were ignitable and corrosive wastes and specific spent non-halogenated solvents.[16]

The following two case studies illustrate some of the pollution prevention initiatives underway across the sector to minimize waste generation, promote recycling, and reduce VOC emissions.

Case Study: Collaborative Waste Minimization and Recycling Initiative *The National Paint and Coatings Association (NPCA) and EPA recently completed the first phase in a joint initiative to analyze the sector's hazardous waste flows and waste management practices. The goal of this initiative is to identify opportunities for increased waste minimization and recycling.*

Through a review of data from EPA's National Biennial RCRA Hazardous Waste Report and discussions with NPCA and industry experts, two types of hazardous waste were found to warrant special attention based on the quantity of the wastes generated and their ability to be recycled or reworked into new product: (1) spent wash solvents used to clean out process equipment and (2) rejected, out-of-date, or off-specification products. For the second phase of the initiative, NPCA and EPA will determine the factors that preclude or limit the recycling or reclamation of these wastes, including technical constraints, financial considerations, operational concerns, and regulatory restrictions.[17]

Case Study: New Eco-Efficient Products from BASF *The market for automotive refinish coatings in North America exceeds $2 billion annually for both collision repairs and commercial vehicle applications. More than 50,000 body shops in North America use these products. For more than a decade, automotive refinishers and coatings manufacturers have faced increasing regulation of emissions of VOCs. As regulatory thresholds for VOC emissions have been lowered, manufacturers have reformulated their reactive coatings to meet lower emissions standards and the demand for faster film setting without compromising quality.*

Through research and development, BASF invented a new primer system that performs better than the current conventional urethane technologies. The new system cures 10 times faster, requires fewer preparation steps, has a lower application rate, is more durable, controls corrosion better, and has an unlimited shelf life. BASF's primer contains only 1.7 pounds of VOCs per gallon, in contrast to 3.5 to 4.8 pounds of VOCs per gallon of conventional primers – a reduction of more than 50%, even before accounting for the fact that less coating is required. Moreover, the one-component nature of the product reduces hazardous waste and cleaning of equipment, which typically requires solvents. Applications in repair facilities over the past year have shown that only one-third as much primer is needed, with waste reduced from 20% to nearly zero.[18]

Promoting Product Stewardship

Product stewardship in the paint and coatings sector comprises a range of practices, including developing cleaner products, recycling leftover paint, and taking adequate measures to inform consumers about the past use of lead-based paint.

Leftover paint is a top concern for product stewardship efforts because of its high volume in the household hazardous waste stream, high waste management costs, and the potential for increased reduction, recovery, reuse, and recycling. Of all household hazardous wastes, paint represents the largest cost for local governments to collect and manage.[19] In a draft report, EPA estimates that 9% to 22% of paint sold could become leftover paint.[20]

NPCA and its members are actively participating in the National Post-Consumer Paint Management Dialogue, a collaborative multi-stakeholder effort to reduce the environmental impacts and cost of managing leftover latex and oil-based paint.[21] The primary goal of this Paint Product Stewardship Initiative is to develop an agreement that will result in reduced paint waste; the efficient collection, reuse, and recycling of leftover paint; increased markets for products made from leftover paint; and a sustainable financing system to cover any resulting end-of-life management costs for past and future products.[22] NPCA is contributing to the initiative's joint research agenda by funding projects targeting (1) consumer education, (2) paint reuse, (3) a lifecycle cost-benefit assessment of leftover paint management options, and (4) the evaluation of environmental, health, and safety regulations for recycled paint products.

The following case study illustrates another product stewardship effort underway that addresses the hazards of lead-based paint.

Case Study: Product Stewardship Effort by NPCA and Attorneys General *In 2004, NPCA and the State Attorneys General reached an agreement with Attorneys General from 46 states, plus the District of Columbia and three territories, which establishes a national program of consumer paint warnings, point-of-sale information, and education and training to avoid the potential exposure to lead-dust hazards. The agreement calls for a universal product sticker program and permanent product labeling on paint to alert consumers that lead dust exposure may occur during the renovation and remodeling of buildings that may contain old, lead-based paint. The agreement also requires manufacturers to distribute new point-of-sale consumer information containing the elements of a designated EPA brochure. In addition, NPCA devised and deployed a new national training program, which is offered without cost to contractors, state and local officials, and others. This four-year educational and training program seeks to offer 150 sessions in roughly 50 locations across the U.S. annually.*[23]

Ports

PROFILE The public port sector[4] consists of 85 port authorities and agencies located along the coasts, on estuaries and rivers, and around the Great Lakes. Port authorities develop and maintain many of the shore-side facilities for the intermodal transfer of cargo between ships, barges, trucks, and railroads. Some ports also build and maintain cruise terminals for the passenger cruise industry. In addition, port authority operations may include other entities, such as airports, bridges, ferries, and railroads. While many port authorities directly operate marine terminals, others instead serve as landlords to tenant operations, providing the underlying land and some infrastructure and water-side access, but leaving operations fully in the hands of private tenants.

TRENDS In recent years, the U.S. port sector has been accommodating a steadily increasing volume of freight carried by larger and larger vessels.

- In 2003, waterborne imports and exports increased by 4% to nearly 1.4 billion tons.[5] Domestic waterborne commerce totaled approximately 700 million tons.[6]
- Imports and exports of containerized cargo at U.S. ports totaled 21.3 million 20-foot equivalents in 2003, an increase of 8% from 2002.[7] Container traffic at U.S. ports is expected to grow by more than 4% annually, resulting in a doubling in traffic volume within the next 15 years.[8]

Sector At-a-Glance

Number of U.S. Ports:	85[1]
Value of Shipments:	$718 billion[2]
Number of Employees:	57,000[3]

In addition:

- From 2003 to 2004, the number of cruises leaving U.S. ports increased by 10% to more than 4,200. The number of cruise passengers increased by 14% to 9 million in 2004.[9]
- In 2002, ports invested nearly $1.7 billion to update and modernize their facilities, including $140 million for general cargo, about $942 million in investments related to containers, and $241 million on infrastructure improvements. Between 2003 and 2007, public ports predict that they will spend $10.4 billion (a record level).[10]

KEY ENVIRONMENTAL OPPORTUNITIES

For ports, the greatest opportunities for environmental improvements are in reducing air emissions, improving water quality, managing dredge material, and minimizing the impacts of growth.

The port sector is working to generate better data on the sector's environmental performance. In December 2004, the American Association of Port Authorities (AAPA) initiated a survey of its U.S. member ports. The survey measured interest in environmental issues and identified metrics for environmental activities that U.S. ports are undertaking, primarily on a voluntary basis. Forty-eight (60%) of AAPA's 85 U.S. member ports responded. The results of the survey are described in more detail throughout this chapter.

Reducing Air Emissions Air emissions from diesel-powered boats, ships, and land-based equipment are a concern because of the proximity of many ports to urban areas with high overall levels of air pollution. As illustrated in the *Locations of U.S. Ports and Areas Exceeding National Ambient Air Quality Standards* figure, nearly 40 of the country's largest ports are located in areas that do not meet EPA National Ambient Air Quality Standards for ozone (8-hour standard). Fourteen of those ports are located in areas that also do not meet EPA's fine particulate matter ($PM_{2.5}$) standards.[11]

Using emission inventories, ports can quantify current emissions and develop strategies to decrease air pollution. This section takes a closer look at efforts to reduce diesel emissions and develop emissions inventories at ports.

Diesel Emissions Marine vessels, tug-and-tow operations (harborcraft), and land-based cargo-handling equipment, trucks, and trains all contribute to air emissions at ports. Common air pollutants from this transportation equipment, which is primarily diesel-powered, include particulate matter (PM), nitrogen oxides (NO_X), and sulfur oxides (SO_X).

Twelve of the 48 ports that responded to the AAPA survey indicated that they have emission control or reduction strategies, and 14 ports indicated they use low-emission fuel types. Some ports (notably Los Angeles, CA, Long Beach, CA, and Seattle, WA) have installed shore-side power for vessels at berth, which can dramatically reduce emissions by reducing the use of the auxiliary diesel engines that ships use to keep lights, refrigeration, and other equipment and facilities operating.[12]

AAPA and its member ports are involved in a number of cooperative efforts to reduce diesel air emissions. For example, AAPA is working with EPA to establish a national diesel emissions reduction program for ports and related industries called Clean Ports USA. The program offers assistance, grants, and incentives to port authorities to reduce pollution emitted from diesel engines through the implementation of a variety of control strategies.[13]

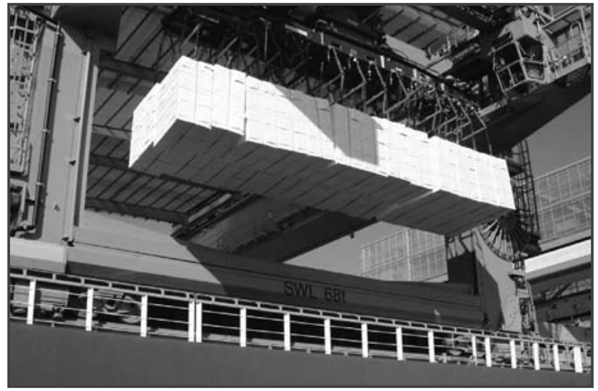
A related effort on a regional scale is the West Coast Collaborative, which is a partnership among leaders from government, the private sector, and environmental groups in six Western states, Canada, and Mexico who are committed to reducing diesel emissions along the Pacific Coast. The collaborative leverages funds from a variety of sources to implement diesel emissions reduction projects in several industry sectors, including ports. Nine of the 28 projects funded by the collaborative thus far have targeted marine vessels and ports. These projects have reduced air emissions by:

- Increasing the use of ultra-low sulfur diesel, biodiesel, and liquefied natural gas;
- Funding the installation of control technologies such as diesel oxidation catalysts; and
- Educating truckers and equipment operators about strategies to reduce engine idling.[14]

The following case studies illustrate how two ports have reduced PM and NO_X emissions from diesel equipment through the use of control technologies, alternative fueled vehicles, alternative power for ships at dock, and other "green" measures.

Case Study: Healthy Harbor Long Beach *In 2003, more than 4.6 million containers and other cargo worth $95.9 billion moved through the Port of Long Beach, CA. In order to reduce the impacts of port activity on public health and the environment, the port implemented a series of programs known collectively as Healthy Harbor Long Beach. One of these programs, the Air Quality Improvement Plan, has achieved measurable reductions in air pollutant emissions from port operations, particularly PM from diesel equipment.*

A key component of this effort is the Diesel Emission Reduction Program, which introduced state-of-the-art emissions control technologies and alternative fueled vehicles. The port has installed nearly 600 diesel oxidation catalysts – a pollution-control device installed in the exhaust system, much like a muffler, that removes particulates from exhaust – on all terminal equipment, including utility trucks, forklifts, and cranes. As exhaust gases pass through the honeycomb structure of the catalysts, pollutants are oxidized to water vapor and carbon dioxide. To date, the Diesel Emission Reduction Program has reduced total annual emissions from the port by more than 14 tons of PM and 43 tons of NO_X.[15]



Case Study: Port of Los Angeles' Alternative Maritime Power Program *As the busiest port in the country, the Port of Los Angeles, CA, strives to balance its operations, growth, and development with its role as an environmental steward. In October 2001, the port developed the Alternative Maritime Power (AMP) program to help meet its goal of "no net increase" in air emissions despite the port's continued growth. Rather than using onboard auxiliary diesel engines while at dock, AMP ships "plug in" to shore-side electrical power, which is less polluting. AMP ships eliminate an estimated 1 ton of* NO_X *and PM emissions per day while in port compared to ships using diesel fuel.*

In June 2004, the Port of Los Angeles and China Shipping Container Line opened the China Shipping Terminal, the first container terminal in the world to use AMP. Five other shipping lines at the Port of Los Angeles have signed memoranda of understanding to implement AMP at their terminals in the future. NYK Shipping Line built the first new vessel to include AMP specifications.

Additionally, the Los Angeles Harbor Commission selected P&O Nedlloyd Container Line's competitive bid to develop the first "green terminal" at the Port of Los Angeles. The agreement requires P&O Nedlloyd, the tenant, to include technology aimed at reducing air pollution in its terminal operations. For example, the tenant will incorporate shore-side power for vessels, rail access that will reduce the number of truck trips, use of low-sulfur or alternative fuel, clean yard equipment, and other programs consistent with the port's environmental management system.[16]

Emissions Inventories Emissions inventories enable port authorities, those doing business at ports, and other interested parties to understand the air quality impacts of current port operations, as well as port expansion projects and projected growth in port activities. An inventory also provides a baseline from which to create and implement emissions reduction strategies and to track performance over time.

Eleven of 48 ports that responded to the AAPA survey indicated that they have conducted an air emissions inventory, and 13 others anticipated conducting an inventory in the coming year. Ports such as Corpus Christi, TX, and those in the Greater Puget Sound region (including the Ports of Seattle, Tacoma, and Everett, WA) are proactively conducting emissions inventories even though they are located in areas that currently meet national air quality standards.[17]

Of the ports that have conducted air emissions inventories, 10 included yard equipment, 10 included marine vessels, 6 included tenant equipment, and 10 included other sources, such as port-related truck and rail traffic, auto emissions from roll-on/roll-off operations (i.e., a type of ferry, cargo ship, or barge that carries wheeled cargo such as automobiles, trailers, or railway carriages), or an adjacent power plant.[18]

With AAPA's assistance, EPA recently prepared a document entitled *Current Methodologies and Best Practices in Preparing Port Emissions Inventories*.[19] This report is intended to help port authorities and others who want to prepare a port emissions inventory.

The following case study highlights one port authority's success in using its inventory to quantify emissions reductions following off-road fleet modernization.

Case Study: Port Authority of New York and New Jersey's Emissions Inventory *In 2004, the Port Authority of New York and New Jersey conducted an update of its emissions inventory of the cargo-handling equipment owned and operated by its five terminal operators. For this effort, they received AAPA's 2005 Environmental Award.*

The goal of the inventory update was to determine whether air emissions from the off-road fleets in the five terminals had improved since originally measured in 2002. After the initial inventory in 2002, terminal operators modernized their off-road fleet with new machines powered by EPA-certified on-road engines.

Results of the inventory update are very encouraging. Even though the size of the operators' off-road fleets had increased by 19% since 2002, average operating hours had increased by 5%, and the total number of containers had risen by 25%, overall emissions estimates for key pollutants decreased significantly. Emissions of NO_X*, volatile organic compounds, carbon monoxide,* PM_{10}*, and sulfur dioxide (in tons per year) decreased by 31%, 32%, 32%, 32%, and 35%, respectively.*[20]

IMPROVING WATER QUALITY To improve the quality of surrounding waters, some ports have enhanced stormwater management and explored new technologies to reduce the impact of invasive species.

Stormwater Stormwater management is increasingly important in improving water quality near port facilities. As illustrated in the case study on the next page, most large ports have hundreds of acres of paved waterfront property for cargo handling, where stormwater runoff may pick up various pollutants before entering waterways. Most stormwater discharges at ports are considered point sources and require a National Pollutant Discharge Elimination System (NPDES) permit. For some ports, the neighboring municipality holds the NPDES permit; in other cases, the port or tenant holds the permit.

Many NPDES permits require preparation of a Stormwater Pollution Prevention Plan (SWPPP), which evaluates potential pollutant sources at the site and identifies appropriate measures to prevent or control the discharge of pollutants via stormwater runoff. Thirty-two of the 48 ports that responded to the AAPA survey indicated they have written SWPPPs, and 33 ports noted that they advise tenants periodically on stormwater compliance responsibilities.[21]

Case Study: Managing Stormwater at the Virginia Port Authority *An under-wharf detention basin, believed to be the first of its type in the country, was completed at the Virginia Port Authority's Norfolk International Terminals (NIT) at the end of 2004. The detention basin treats stormwater runoff from approximately 108 acres of NIT. The basin has a 30-hour detention time, which allows nutrients and suspended solids to settle out before the water is discharged. A series of weirs also has been installed to handle overflow during a 10-year storm event. The detention basin will remove 318 pounds of phosphorous per year, thereby reducing NIT's phosphorous discharges by 35%. In addition, a series of drop inlet filters has been installed to remove an additional 55 pounds of pollutants per year, including metals, oils, and greases. The total pollutant removal provided by current and proposed structures at NIT is 1,560 pounds per year. This is 46% greater than the pollutant removal required by the Virginia Department of Conservation and Recreation for this facility.*[22]

Invasive Species The spread of invasive species is another environmental issue of great concern to the port sector. Ships can inadvertently contribute to the spread of invasive species through their use of ballast water. The port sector is working closely with the U.S. Coast Guard, the International Maritime Organization, and other interested groups to promote effective policies for ballast water management and to develop new technologies for the treatment of ballast water.[23]

MANAGING DREDGE MATERIALS Dredging of navigation channels, harbor access channels, and shipping berths is necessary to reach and maintain the required water depths for vessels, including the newer, larger freighters that are now in operation. The U.S. Army Corps of Engineers removes nearly 300 million cubic yards of dredged material from navigation channels each year, and another 100 million cubic yards are dredged from berths and private terminals.[24]

More than 90% of the nation's top 50 ports involved in foreign waterborne commerce require regular maintenance dredging.[25]

Ports are working to minimize the negative environmental impacts of the disposal of dredged materials, and increasingly they are finding uses for the material that actually benefit the environment. As part of their dredge material management plans, 18 of the 48 ports responding to the AAPA survey had provisions for beneficial reuse (e.g., wetlands creation), and 20 ports had provisions for management of upland disposal areas.[26]

The Port of Oakland, CA, for example, is using dredged material to enhance habitat and restore Bay Area wetlands. The Port of Baltimore, MD, has used an open, science-based process with citizen involvement called the Dredged Material Management Program to develop its long-term dredging placement plans and to identify new deposit sites. This program is focusing on beneficial reuse projects such as rebuilding islands, creating wetlands, or shoring up eroding coastlines.[27]

Minimizing Impacts of Growth To accommodate increased trade volume and the increasing size of freight vessels, many ports must increase their capacity. Although port capacity can be increased through improvements in technology and operational efficiency, many ports also require physical expansion. When planning for expansion, ports must consider how best to minimize and compensate for wetland or habitat loss and to address other impacts of port growth on neighboring communities.

Many ports looking to expand have revitalized nearby abandoned or underutilized brownfield properties, which may have been contaminated by previous industrial activity.

Redeveloping these brownfields in or near ports (called “portfields”) can concentrate land-use development, enhance the local economy, and provide environmental benefits. Environmental remediation and habitat restoration are often integral components of redevelopment efforts at or near ports.

Three ports have been participating in pilot projects for two years in the Portfields Initiative, a federal interagency effort to help revitalize ports and improve the nation’s marine transportation system while restoring and protecting coastal resources. Lessons learned from these pilot projects at the ports of Bellingham, WA, New Bedford, MA, and Tampa, FL, will be shared with other ports and port communities.[28]

Case Study: Port of Seattle’s Phoenix Award *In 2004, the Port of Seattle, WA, won EPA’s Phoenix Award for Excellence in Brownfields Redevelopment for its Terminal 18 Redevelopment Project. The port’s need to expand cargo-handling facilities led to a redevelopment project on Harbor Island, which had been listed as a Superfund site in 1986. The port worked with EPA and more than 30 existing private property owners on Harbor Island to shape purchase agreements that discounted the property sale price by the amount of estimated cleanup costs. Among other improvements, the 90-acre expansion accomplished cleanup of contaminated soils, reduced runoff and groundwater impacts, and improved vehicle and rail transportation.*[29]

PROFILE The shipbuilding and ship repair sector[4] builds and repairs ships, barges, and other large vessels for military and commercial clients. The sector also includes operations that convert or alter ships, as well as facilities that manufacture offshore oil and gas well drilling and production platforms. Most facilities that build ships also have the ability to repair ships, although some smaller yards do only repair work.

Sector At-a-Glance

Number of Facilities:	346[1]
Value of Contracts:	$16 billion[2]
Number of Employees:	92,400[3]

TRENDS Over the past four years, the shipbuilding and ship repair industry has been relatively stable.

- Appropriations for construction of new military ships showed a modest increase (6%) from 2000 to 2006, but declined by 35% over the last year.[5]
- Between 2000 and 2004, employment within the sector fell from 102,000 to 92,400.[6]
- The U.S. now has less than a 1% share of the world's new construction market for commercial vessels of more than 1,000 gross tons, lagging behind the world's shipbuilding leaders such as South Korea, Japan, China, Germany, Italy, and Poland.[7]

In the fall of 2005, hurricanes hit Gulf Coast shipyards hard. Time will tell whether these facilities will fully recover from the damage the storms inflicted.

KEY ENVIRONMENTAL OPPORTUNITIES
For the shipbuilding and ship repair sector, the greatest opportunities for environmental improvement are in managing and minimizing toxics and waste, reducing air emissions, and improving water quality.

Managing and Minimizing Toxics

Given the diversity of their industrial processes, shipbuilding and ship repair 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).

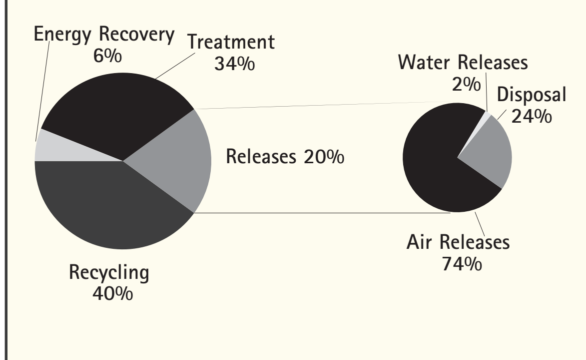
In 2003, 41 facilities in the sector reported 10.5 million pounds of chemicals released (including disposal) or otherwise managed through treatment, energy recovery, or recycling. Of this quantity, 80% was managed, while the remaining 20% was disposed or released to the environment, as shown in the *TRI Waste Management* pie chart. Of those chemicals disposed or released to the environment, 24% were disposed and 76% were released into air or water.

As shown in the *Total TRI Disposal or Other Releases* line graph, the annual normalized quantity of chemicals disposed or released by this sector decreased by more than half (58%) from 1994 to 2003, with one-third of this decline occurring between 2000 and 2003. From 2000 to 2003, there was a similar decline of 37% in the sector's normalized quantity of chemicals released to air and water.

In 2003, the chemicals disposed or released by the sector were dominated by n-butyl alcohol and xylene, which accounted for 42% of the total pounds. Zinc, copper, and 1,2,4-trimethylbenzene accounted for another 26% of the sector's total.[8]

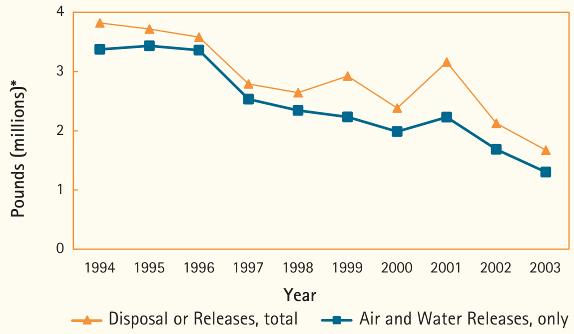
Data from TRI allow comparisons of the total quantities of a sector's reported chemical releases across years, as presented below. However, this comparison does not take into account the relative toxicity of each chemical. Chemicals vary greatly in toxicity, meaning they differ in how harmful they can 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 sector's air and water releases in both reported pounds and toxicity-weighted results. When weighted for toxicity, the sector's normalized air and water releases show a 73% decline from 1994 to 2003, with little overall change from 2000 to 2003, despite an increase in 2001. The spike in 2001 is attributable to an increase in manganese releases to air, with one facility accounting for 68% of those releases.



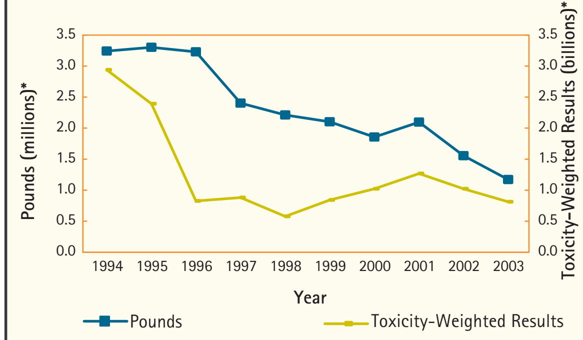
TRI Waste Management by the Shipbuilding & Ship Repair Sector

Source: U.S. EPA, 2003.



Total TRI Disposal or Other Releases by the Shipbuilding & Ship Repair Sector

* Normalized by annual value of shipments.
Sources: U.S. EPA, U.S. Census Bureau.



TRI Air and Water Releases by the Shipbuilding & Ship Repair Sector

* Normalized by annual value of shipments.
Sources: U.S. EPA, U.S. Census Bureau.

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. 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 presents 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	Copper
Chromium	Lead
Nickel	
Sulfuric Acid	

Source: U.S. EPA

In 2003, toxicity-weighted results were driven by manganese, nickel, and chromium. In recent years, normalized manganese and chromium releases to air fluctuated but resulted in little overall change between 1999 and 2003. During this time period, nickel releases increased steadily, more than tripling. One facility accounted for 69% of the industry's nickel emissions in 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).[9] Research indicates that the hexavalent form of chromium does not constitute a majority of total chromium releases by shipyards. Thus, RSEI analyses overestimate the relative harmfulness of chromium in the sector.[10]

Reducing Air Emissions Most large ships are built of steel and must be periodically cleaned and coated in order to preserve the steel and provide specific performance characteristics to the surface. The shipbuilding and ship repair sector releases particulate matter (PM), volatile organic compounds (VOCs), and air toxics during surface preparation and the application of paint and coatings. Although emissions of VOCs and air toxics during these processes are largely captured in the TRI air releases discussed above, this section takes a closer look at PM and these chemical categories.

Particulate Matter Surface preparation is critical to the coating life cycle, since it provides both the physical and chemical requirements for long-term coating adhesion. To prepare surfaces for coating applications, shipyards predominantly use a dry-abrasive blasting process. This dry-abrasive blasting is typically performed outdoors, as the sheer size of a ship makes enclosure difficult and expensive.

The blasting operation generates PM emissions from both the breakup of the abrasive material and the removal of the existing coating. Over the past 10 years, shipyards have developed several methods to reduce PM emissions to the environment, including:

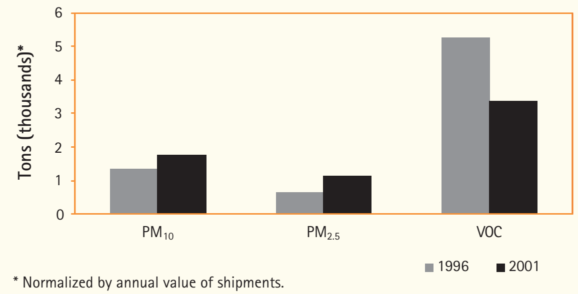
- Temporary containment of blasting operations;
- Material substitutions; and
- Alternative surface preparation technologies.

Early attempts at temporary containment consisted of hanging curtains from scaffolding, wires, dock-arms, and other structures around the ship. Generally, these temporary structures were open at the top and reduced PM emissions by reducing the wind speed in the blasting area. This practice has evolved to include the construction of temporary shrink-wrap enclosures of entire ships in drydock.

EPA's National Emissions Inventory (NEI) estimates that, in 2001, the sector released 1,963 tons of PM_{10} and 1,257 tons of $PM_{2.5}$.

As shown in the *PM & VOC Emissions* bar chart, between 1996 and 2001, normalized PM_{10} and $PM_{2.5}$ emissions from this sector increased by approximately 31% and 74%, respectively.[11] However, these emissions estimates may not reflect the shipyards' efforts in the last five years to contain PM emissions from abrasive blasting by using shrouds, shrink-wrap, and other forms of containment. In addition, many shipyards have switched blasting materials from coal slag and steel shot to garnet, high-pressure water, and other lower emission technologies. The following case study highlights one shipyard's success in reducing PM emissions by adopting an alternative blasting technology.

PM & VOC Emissions from the Shipbuilding & Ship Repair Sector



* Normalized by annual value of shipments.
PM = Particulate Matter; VOC = Volatile Organic Compounds
Sources: U.S. EPA, U.S. Census Bureau.

Case Study: Ultra-High Pressure Water Blasting at Atlantic Marine *In an effort to reduce its PM emissions, Atlantic Marine in Jacksonville, FL, has stopped all open-air abrasive blasting in favor of ultra-high pressure (UHP) water blasting. This technology uses high-pressure streams of water, instead of grit, to remove the coatings from ships. Unlike abrasive blasting, there are no PM emissions from the water stream, and the flakes of paint are larger so they do not end up in the air. Over the last six years, Atlantic Marine has avoided more than 460 tons of PM emissions through the adoption of the UHP technology, as shown in the following table.*[12]

PM Emissions Avoided by Atlantic Marine

YEAR	TONS AVOIDED
1999	32.0
2000	43.1
2001	121.7
2002	83.2
2003	76.0
2004	104.4
Total	460.4



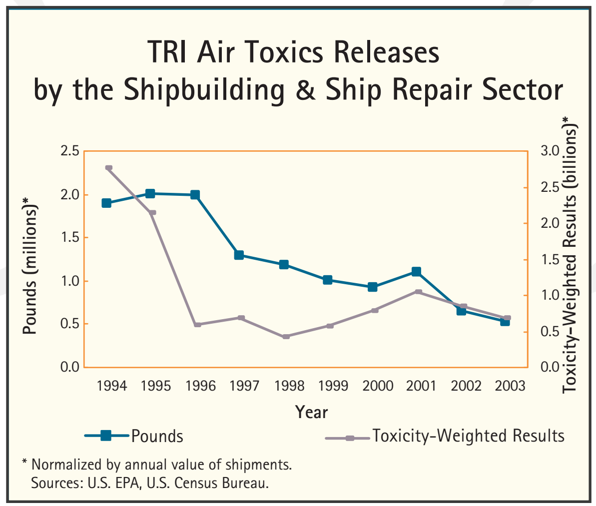
Volatile Organic Compounds & Air Toxics Once the ship's surface is properly prepared, coatings can be applied. The type of coating to be applied (typically down to the level of a specific brand) is specified by the customer (i.e., the ship owner/operator) rather than the shipyard. These coatings may contain chemicals that are released to the environment during application. When coatings are applied indoors, it is possible to utilize pollution control equipment, such as spray booths, to control the release of VOCs and air toxics. At shipyards, however, most coatings are applied outdoors. As a result, VOCs and air toxics may be released into the environment.

EPA's NEI estimates that, in 2001, the sector released 3,333 tons of VOCs. As shown in the *PM & VOC Emissions* bar chart on the previous page, normalized VOC emissions from shipyards declined by 36% between 1996 and 2001.[13]

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. In 2003, 38 facilities in the sector reported air toxics releases of 730,000 pounds.

As shown in the *TRI Air Toxics Releases* line graph, normalized air toxics releases decreased by 72% from 1994 to 2003, with more than one-quarter of this decrease occurring between 2000 and 2003.[14] Toxicity-weighted results for air toxics releases showed a similar decline over the 10-year period.[15]

Much of the decline in both VOC and air toxics emissions is due to the reformulation of marine coatings. Coatings manufacturers, working in cooperation with shipyards, have reformulated many coatings to reduce VOC and air toxics content while maintaining or improving the performance characteristics required by customers. Although more viscous and difficult to apply, these low-VOC, high-solids content coatings have become the industry standard due to their excellent performance characteristics.



The following case study highlights one shipyard's success in reducing VOC emissions through product substitution.

Case Study: VOC Emissions Reductions at Electric Boat *In order to lower VOC emissions and eliminate the need for control equipment, Electric Boat in Groton, CT, conducted an exhaustive review of more than 10,000 products listed in its inventory system to identify those materials with VOCs greater than 3.5 pounds per gallon, developed an electronic catalog system to identify specific environmental data and replacements for these materials, and implemented stringent reviews of all new materials for use in production and maintenance work. Additionally, Electric Boat initiated an electronic record system to collect air emissions data associated with boilers and generators. As a result, Electric Boat has replaced more than 100 adhesives, glues, fillers, and sealants with products that do not exceed 3.5 pounds of VOCs per gallon.*[16]

Managing And Minimizing Waste

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

In 2003, 63 facilities in the sector reported 12,000 tons of hazardous waste generated. Half of the sector's waste was generated through wastewater treatment, and another 21% was generated from painting and coating processes. The waste management methods most utilized by this sector were chemical precipitation, fuel blending, and landfill or surface impoundment.

When reporting hazardous wastes to EPA, quantities can be reported as a single waste code (e.g., lead) or as a commingled waste composed of multiple types of wastes. Quantities of a specific waste within the commingled waste are not reported. The shipbuilding and ship repair sector reported 68% of its wastes as individual waste codes. Of the individually reported wastes, the predominant hazardous waste types reported by the sector in 2003 included corrosive waste (6,000 tons), lead (1,000 tons), ignitable waste, and chromium. Additional quantities of these wastes also were reported as part of commingled wastes.[17]

Over the past decade, the shipbuilding and ship repair sector has made progress in reducing waste generation and increasing reuse and recycling rates. Improvements in hazardous waste management at shipyards can be attributed to several practices, including:

- Development of improved coating application technologies, such as in-line plural component mixers that only mix the amount of coating necessary, as it is required, to avoid the waste of excess paint;
- Use of paint waste for fuel blending, rather than solidifying it for land disposal; and
- Reclamation of spent solvents from spray paint equipment.

Improving Water Quality Releases of chemicals into water account for a small fraction of the TRI toxicity-weighted results for this sector. However, pollutants generated by shipyards can be released into the environment through stormwater runoff.

Over the last several years, a group of Gulf Coast shipyards led an effort with EPA to develop best management practices for stormwater.[18] Additionally, many shipyards on the West Coast capture and treat stormwater before discharging it.

Case Study: Eliminating Stormwater Discharges at Todd Pacific Shipyard *Before Todd Pacific Shipyard Corporation could effectively remediate the contaminated sediment that had accumulated around its facility over the past century, the shipyard needed to prevent future releases of contaminants to the water. Located on Harbor Island in Seattle, WA, Todd Pacific's various construction, repair, and maintenance operations take place on a 10.5-acre paved industrial yard. In the past, rainwater that fell on the pavement was discharged to surrounding waters via outfalls and served as a major source of sediment contamination. To prevent future contamination, the company has implemented a system that collects the stormwater runoff from the primary yard pavement and discharges the water into the sewer so it can be treated at the Seattle Public Utilities treatment plant. Key design features of this system include the following elements:*

- *Industrial runoff from the paved yard is channeled through catch basin sumps for solids removal and then passes through a second-stage treatment method for additional solids removal as well as oil and grease separation.*
- *Runoff from roofs and the employee parking lot is separated from the industrial runoff and discharged through existing outfalls.*
- *New 450,000-gallon detention tanks are large enough to handle runoff from a 10-year storm event.*
- *Discharges from the detention tanks to the Seattle Public Utilities sewer are metered so as not to exceed the capacity of the sanitary system.*

This new stormwater control system at Todd Pacific exceeds regulatory requirements and eliminates all routine industrial stormwater discharges to adjacent waters.[19]



PROFILE The specialty-batch chemical sector[4] is composed of companies that produce chemicals to meet the specific demands of their customers on an "as needed" basis. In contrast to the production of commodity chemicals, in batch manufacturing the raw materials, processes, operating conditions, and equipment change on a regular basis to respond to the needs of customers. Specialty-batch chemicals are often not a final product but rather a key ingredient in a final product. The following products either are or use specialty-batch chemicals: pharmaceuticals, cosmetics, food additives, flavorings, dyes and pigments, and cleaning agents.

The specialty-batch chemical sector is dominated by small enterprises. More than 89% of the manufacturers in the Synthetic Organic Chemical Manufacturers Association (SOCMA) employ 500 people or less.[5]

Sector At-a-Glance

Number of Facilities:	451[1]
Value of Shipments:	$14 billion[2]
Number of Employees:	150,000[3]

TRENDS As with other sectors, over the last decade specialty-batch chemical manufacturing has been affected by changes in markets and global competition. The sector is increasingly consolidating, particularly in mature markets that are becoming more commodity-like, such as water treatment chemicals, lubricants, adhesives, dyes, and inks.[6] The pharmaceutical segment remains the largest in the sector, although its share of the sector's sales has decreased significantly since 2003.

- Although 75% of firms have seen an increase in sales from 2004, there is some downward pressure on sales from competition in China and India.
- There is some upward influence on sales from the development of new technologies to provide unique products. Research and development investment remains strong, increasing from 5% to 7% of revenue between 2004 and 2005.[7]

Additionally, while facility security has always been a priority, it has become an even larger concern since the attacks of September 11, 2001. SOCMA and its members have been aggressive in addressing heightened concerns about the overall security of the chemical sector. In 2005, selected chemical plants participated in a pilot program to rank critical infrastructure based on their vulnerability to a terrorist attack using the U.S. Department of Homeland Security's Risk Analysis and Management for Critical Asset Protection methodology. Legislation is now pending on risk-based approaches to site security.

KEY ENVIRONMENTAL OPPORTUNITIES

For the specialty-batch chemical sector, the greatest opportunities for environmental improvement are in managing and minimizing toxics and waste and in reducing air emissions.

In January 2004, SOCMA began collecting data from its members on energy efficiency and releases to air, land, and water reported to EPA's Toxics Release Inventory (TRI). These metrics will be available to the public on SOCMA's Web site in 2006.

Managing and Minimizing Toxics

Specialty-batch chemical facilities use a variety of chemicals and report on the release and management of many of those materials through TRI.

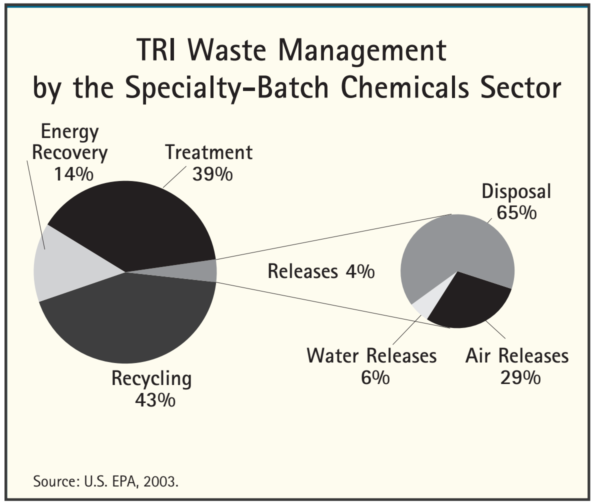
In 2003, 313 facilities in the sector reported 2.7 billion pounds of chemicals released (including disposal) or otherwise managed through treatment, energy recovery, or recycling. Of this quantity, 96% was managed, while the remaining 4% was disposed or released to the environment, as shown in the *TRI Waste Management* pie chart. Of those chemicals disposed or released to the environment, 65% were disposed and 35% were released into air or water.

As shown in the *Total TRI Disposal or Other Releases* line graph, the annual normalized quantity of chemicals released by the specialty-batch chemical sector decreased by 6% from 1994 to 2003, including a continuous decline in recent years. During the same 10-year period, normalized releases to air and water decreased by 35%, remaining fairly steady from 2000 to 2003.

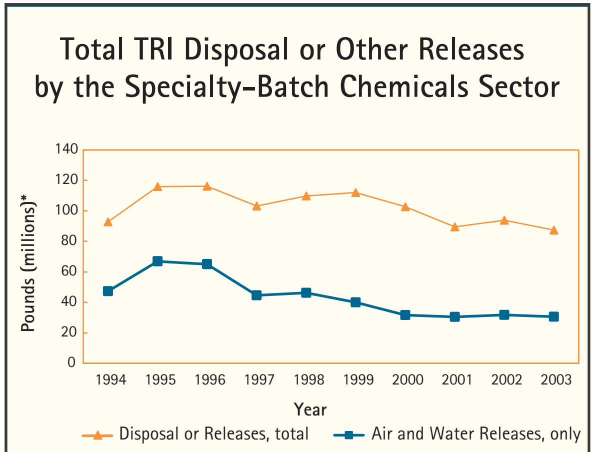
In 2003, the releases by the sector were made up of many chemicals. Nitrate compounds accounted for 20% of the total pounds, while ammonia, methanol, ethylene, and acrylonitrile accounted for another 32%.[8]

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.

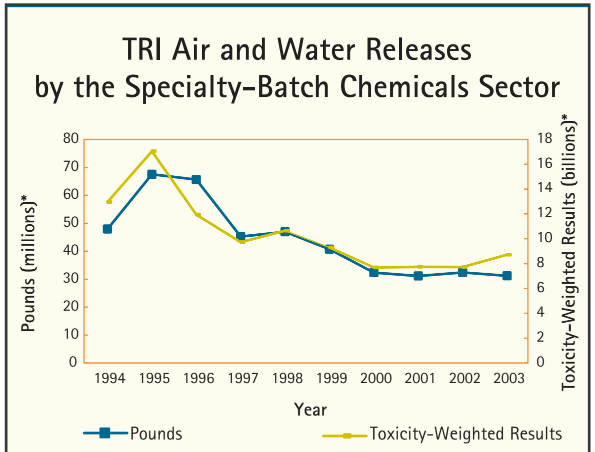
The *TRI Air and Water Releases* line graph presents trends for the sector's air and water releases in both reported pounds and toxicity-weighted results. When weighted for toxicity, the sector's normalized air and water releases decreased by 33% between 1994 and 2003, despite an increase in 2003.



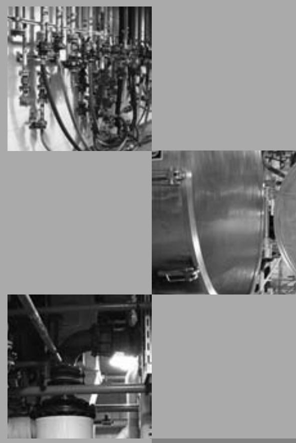
Source: U.S. EPA, 2003.



* Normalized by annual value of shipments for all of SIC code 28.
Sources: U.S. EPA, U.S. Census Bureau.



* Normalized by annual value of shipments for all of SIC code 28.
Sources: U.S. EPA, U.S Census Bureau.



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. More than 98% of the sector's toxicity-weighted results were attributable to air releases, while discharges to water accounted for less than 2%. 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 (98%)	WATER RELEASES (<2%)
Chlorine	Diaminotoluene
Diisocyanates	1,2,3-Trichloropropane
Sulfuric Acid	Certain Glycol Ethers
Diaminotoluene	Copper
Manganese	Lead
Nickel	
Dicyclopentadiene	
1,3-Butadiene	
Propyleneimine	
Polycyclic Aromatic–Compounds	
Aniline	
Bromine	
Naphthalene	
Hydrochloric Acid	
Toluene Diisocyanate	Source: U.S.EPA

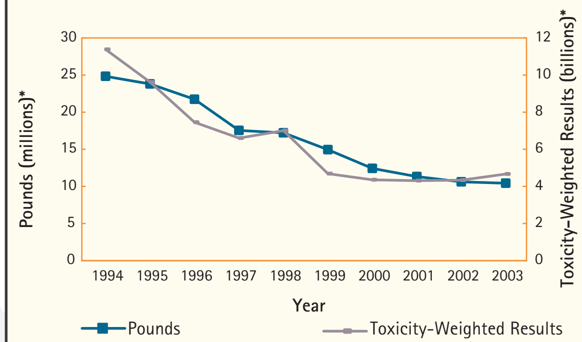
For air releases, chlorine, diisocyanates, and sulfuric acid have consistently been the sector's top-ranked chemicals based on toxicity-weighted results. These three substances accounted for 68% of the sector's toxicity-weighted results for air releases in 2003. From 2000 to 2003, normalized releases to air of chlorine, diisocyanates, and sulfuric acid increased by 11%, 9%, and 84% respectively.[9]

Reducing Air Emissions The specialty-batch chemical sector releases both air toxics and criteria air pollutants. Although 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.

In 2003, 270 facilities in the sector reported air toxics releases of 12 million pounds. As shown in the *TRI Air Toxics Releases* line graph, normalized air toxics releases decreased by 59% from 1994 to 2003, including continued declines in recent years.[10] Toxicity-weighted results for air toxics releases showed a similar decline over the 10-year period.[11]

TRI Air Toxics Releases by the Specialty-Batch Chemicals Sector



* Normalized by annual value of shipments for all of SIC code 28.
Sources: U.S. EPA, U.S. Census Bureau.

Criteria Air Pollutants EPA's National Emissions Inventory estimates that, in 1999, the specialty-batch chemical sector released 44,260 tons of sulfur dioxide, 42,399 tons of nitrogen oxides, 24,201 tons of carbon monoxide, and 22,438 tons of volatile organic compounds.[12]

Managing and Minimizing Waste

EPA hazardous waste data on large quantity generators, as reported in the *National Biennial RCRA Hazardous Waste Report*, indicate that the specialty-batch manufacturing sector accounted for 9% of the hazardous waste generated nationally in 2003.

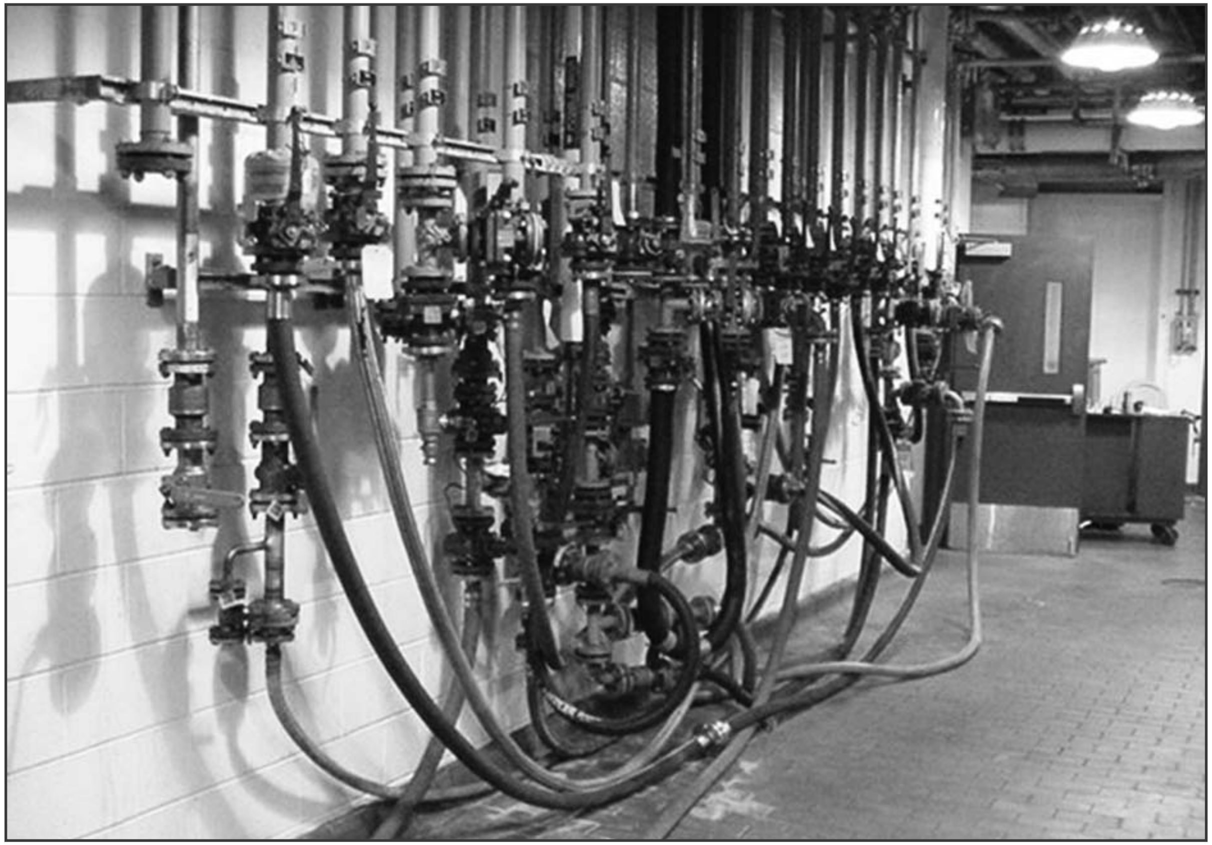
In 2003, 253 specialty-batch chemical facilities reported 2.6 million tons of hazardous waste generated, although one facility accounted for 74% of this total. Approximately 70% of the waste generated by this sector was from manufacturing, production, and maintenance activities. Another 16% of the sector's hazardous waste consisted of residuals from air pollution control devices. The one facility noted above reported that most of its waste was managed by deepwell or underground injection. For all other facilities in the sector, the predominant waste management methods were adsorption and incineration.

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 specialty-batch chemical sector reported 11% of its wastes as individual waste codes. Of the individually reported wastes, the predominant hazardous waste types reported by the sector in 2003 included corrosive waste, benzene, and ignitable and reactive wastes.[13]

The following case study highlights one specialty-batch chemical company's success in finding beneficial reuses for the waste that it generates.

Case Study: Optima Chemical Group's Pollution Prevention Initiatives *Optima Chemical Group, based in Georgia, produces a wide variety of specialty organic chemicals for other manufacturers. When evaluating its manufacturing processes and investigating alternative production methods, the company looks for opportunities to reduce the generation of waste, thereby preventing pollution. Optima also looks for beneficial reuses of the waste that it generates.*

In the past year, Optima's most significant pollution prevention project involved a major production process that generated approximately 40,000 pounds per week of a waste stream with a high pH level due to the presence of sodium hydroxide. After an exhausting study and search, Optima located a facility that could put the material to use as a neutralizing agent in its treatment plant. Optima's proactive efforts effectively reduced the quantity of hazardous waste it needed to dispose by more than 1 million pounds per year.[14]



Appendix A: Endnotes

Preface

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Leadership by Trade Associations

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[6] For more information on Coatings Care®, visit: http://www.paint.org/cc/.

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Beneficial Reuse of Materials

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Energy Consumption by the Cement Sector

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[2] U.S. Department of Commerce, Bureau of Economic Analysis: Industry Economic Accounts, available at: http://www.bea.gov/bea/dn2.htm.

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Top TRI Chemicals Based on Toxicity-Weighted Results

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TRI Air and Water Releases by the Shipbuilding & Ship Repair Sector
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Specialty-Batch Chemicals Charts & Tables References

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Total TRI Disposal or Other Releases by the Specialty-Batch Chemicals Sector
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TRI Air and Water Releases by the Specialty-Batch Chemicals Sector
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Top TRI Chemicals Based on Toxicity-Weighted Results
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TRI Air Toxics Releases by the Specialty-Batch Chemicals Sector
U.S. EPA, TRI, 2003 PDR; and RSEI; and U.S. Census Bureau, ASM, 2003. Data presented include the Clean Air Act hazardous air pollutants that are reported to TRI (182 out of 188 pollutants).

Appendix B: Data Sources

DATA SOURCES: Economic Census/Annual Survey of Manufactures (ASM)/Bureau of Economic Analysis (BEA)

METRIC USED: Annual information on value of shipments/revenue.

PERIOD ANALYZED: 1994–2003.

NEXT DATA RELEASE: In 2006 for 2004 data.

Sector chapters presenting data:

- Construction
- Forest Products
- Metal Finishing
- Paint & Coatings
- Ports
- Shipbuilding & Ship Repair
- Specialty-Batch Chemicals

DATA SOURCE DESCRIPTION: The U.S. Census Bureau's Economic Census profiles American businesses every five years, in years ending in 2 and 7, from the national to the local levels. The Bureau's Annual Survey of Manufactures provides sample estimates of statistics for all manufacturing establishments with one or more paid employees in each of the four years between the Economic Census. These data were used for two purposes: (i) for normalizing environmental data and (ii) for characterizing the "Sector At-a-Glance" tables.

DATA SOURCE CONSIDERATIONS: Aspects of the Census influence the use of these data for EPA's Sector Strategies Program.

- *Nonmanufacturing sectors not included.* Although the Economic Census includes data on all sectors, the ASM for intermittent years is restricted to manufacturing sectors only. Revenue data for nonmanufacturing sectors, specifically, colleges & universities, construction, and ports are not included.
- *Changes to the ASM.* In 2003, the ASM collapsed specific 6-digit North American Industry Classification System (NAICS) codes to the 5-digit NAICS level due to budget cuts. For 2003 and preceeding years, data for these sectors will be collected and presented at the 5-digit NAICS level. Unless further budget cuts occur, the Economic Census (conducted every five years) will continue to maintain the 6-digit NAICS detail. The collapse to 5-digit codes affects two Sector Strategies Program sectors: forest products and metal finishing. For these sectors, defined at the 6-digit NAICS detail, using a 5-digit NAICS code would over-include additional sectors. For 2003 onward, this data source cannot be used for these sectors. As an alternative, data on revenue and value of shipments can be accessed from the U.S. Department of Commerce's Bureau of Economic Analysis. BEA uses and presents annual data on the value of shipments sourced from the Census Bureau. To maintain the 6-digit NAICS level, BEA extrapolates these data by applying 6-digit NAICS weights from the most current Economic Census year to the 5-digit NAICS data in annual survey years. BEA will continue to do so for preceeding years.

DATA PROCESSING STEPS:

- Data and documentation from the U.S. Census Bureau are available at www.census.gov/econ/census02 and www.census.gov/mcd/asmhome.html.
- Data and documentation from the U.S. Bureau of Economic Analysis are available at www.bea.doc.gov.
- For most sectors, value of shipments/revenue was used for normalizing data. These data are extracted from the ASM, Economic Census, and BEA. For the following manufacturing sectors, production data was used from other sources: cement and iron & steel (U.S. Geological Survey) and metal casting (American Foundry Society). For colleges & universities revenue data were used from the National Center for Education Statistics.
- For value of shipments/revenue data, relevant sector assignments were based on 6-digit NAICS codes for all sectors but specialty-batch chemicals. This sector was normalized using the chemical manufacturing sector's value of shipments.

DATA SOURCE: Manufacturing Energy Consumption Survey (MECS)

ENVIRONMENTAL METRIC USED: Quadrennial energy consumption by the manufacturing industry.

PERIOD ANALYZED: 1994, 1998, and 2002.

NEXT DATA RELEASE: 2006 data release schedule to be determined.

Sector chapters presenting data:

- Forest Products
- Iron & Steel
- Metal Casting

DATA SOURCE DESCRIPTION: MECS data are maintained by the U.S. Department of Energy's statistical agency, Energy Information Administration (EIA). Data are available by manufacturing industry and region and by value of shipments and employment size category and region (e.g., Northeast Census region). MECS data are collected quadrennially for a sample size through mailed questionnaires and then extrapolated to represent the manufacturing universe. For example, in 2002, a sample size of approximately 15,500 establishments was drawn from a sample frame representing 97% to 98% of the manufacturing payroll.

DATA SOURCE CONSIDERATIONS: Aspects of MECS influence the use of these data for EPA's Sector Strategies Program.

- *Detail of data.* MECS energy consumption estimates for the manufacturing industry are available for all manufacturing sectors at the 3-digit NAICS code level and select manufacturing sectors at the 6-digit NAICS code level. For the Sector Strategies Program sectors, 2002 data at the 6-digit level are available for the cement, forest products, iron & steel, and metal casting sectors.

- *Small businesses are not included.* MECS does not include small establishments, including those with fewer than 5 employees or those with 5 to 20 employees with certain minimum annual payrolls and shipments

DATA PROCESSING STEPS:

- Data and documentation are available at www.eia.doe.gov/emeu/mecs.

- Sectors are defined based on 3-, 4-, 5-, and/or 6-digit NAICS code combinations.

- Energy consumed for all purposes (first use) was totaled for relevant sectors. Other potential available metrics include: energy consumed as a fuel, as a nonfuel (for purposes other than for heat, power, and electricity generation), and offsite-produced fuel consumed.

- Energy consumption data presented are normalized based on the sectors' productivity (as measured by changes in value of shipments/revenue or production), with 1994 as a baseline year.

- Units of measure are maintained in trillion British thermal units (Btus).

DATA SOURCE: National Biennial RCRA Hazardous Waste Report (hereafter, National Biennial Report)

ENVIRONMENTAL METRICS USED: Biennial information on hazardous waste generation, management, and final disposition.

PERIOD ANALYZED: 2001 and 2003.

NEXT DATA RELEASE: 2005 data release schedule to be determined.

Sector chapters presenting data:

- Cement
- Colleges & Universities
- Construction
- Forest Products
- Iron & Steel
- Metal Casting
- Metal Finishing
- Paint & Coatings
- Shipbuilding & Ship Repair
- Specialty-Batch Chemicals

DATA SOURCE DESCRIPTION: EPA's Office of Solid Waste (OSW) biennially collects information on the generation, management, and final disposition of hazardous waste from large quantity generators (LQGs) and treatment, storage, and disposal facilities (TSDFs) and compiles a National Biennial Report. OSW first collected Biennial Reporting (BR) data using a national standardized form in 1989. The Toxicity Characteristic rule in 1990 added more waste types and required more stringent analysis of waste constituents.

Data Source Considerations: Setup of the data system and changes to the last three reporting cycles influence the use of these data by EPA's Sector Strategies Program for years prior to 2001.

- *Smaller generators are not included.* Only LQGs (facilities that meet minimum thresholds for reporting, such as those that generate 1,000 kilograms or more of hazardous waste per month or 1 kilogram or more of acutely hazardous waste per month) and TSDFs are required to submit a biennial Hazardous Waste Report; other generators are not.

- *Changes to the National Biennial Report.* In 1997, OSW began to exclude wastewater from its report to improve consistency, accuracy, and reliability of data collected across the program. This change was initiated in 1997 but fully implemented during the 1999 reporting cycle. Inconsistencies exist in the inclusion and exclusion of wastewater in the primary generated waste values making it inadvisable to compare 1997 and 1999 data with data collected in earlier and subsequent reporting years.

- *Improvements implemented during the 2001 reporting cycle.* States and regions were delegated the responsibility for determining inclusion or exclusion of data from the National Biennial Report. This resolved issues of translating state and regional codes to national codes needed to determine wastewater exclusion. Because states and regions have a better understanding of the waste reported under the state waste codes, they are able to improve data quality by more accurately identifying wastewater. Additionally, reporting national source codes that determine whether waste is deemed primary or secondary became mandatory. This is expected to improve the population of the primary generated waste variable analyzed. Based on these changes, it was determined that data from reporting year 2001 onward could be included in the 2006 Sector Strategies Performance Report. Although this change was initiated in 2001, it was fully implemented during the 2003 reporting cycle.

Data Processing Steps:

- Data and documentation can be found at www.epa.gov/epaoswer/hazwaste/data/biennialreport.

- For most sectors, data are compiled based on the primary 3-, 4-, 5-, and/or 6-digit NAICS codes reported in the National Biennial Report. For the cement, iron & steel, and specialty-batch chemicals sectors, the sector BR data are extracted based on a predetermined list of facilities. The count of the number of facilities reporting hazardous waste data is a total of the number of unique RCRA identification numbers (IDs) with the sectors' NAICS codes. This may overestimate facility counts, as one facility may have multiple RCRA IDs.

- Only data flagged for inclusion in the National Biennial Report are included.

- Waste associated with source code G61 and management code H141 are excluded from this analysis to avoid double counting of stored wastes. This is consistent with the National Biennial Report methodology.

- Units of measure are maintained in tons.

Data Source: National Emissions Inventory (NEI)

Environmental Metrics Used: Emission estimates of specific criteria air pollutants (CAP). Pollutants analyzed: sulfur dioxide, nitrogen oxides, particulate matter (<2.5 microns and <10 microns), and volatile organic compounds.

Period Analyzed: 1996–2002 (preliminary).

Next Data Release: February 2006 for final 2002.

Sector chapters presenting data:

- Cement
- Metal Casting
- Paint & Coatings
- Shipbuilding & Ship Repair
- Specialty-Batch Chemicals

Data Source Description: EPA's Emission Factor and Inventory Group within the Office of Air Quality Planning and Standards (OAQPS) prepares a national database of CAP emissions based on input from numerous state, tribal, and local air pollution control agencies; industry-submitted data; data from other EPA databases; as well as emission estimates. State and local emissions inventories are submitted to EPA once every three years for most point sources contained in NEI. Through the 1999 NEI, EPA estimated emissions for any jurisdiction that did not submit an emissions inventory and where data were not available through industry submissions or other EPA databases. Gaps in data for the years between submissions are filled with emission estimates modeled using sources such as sector-level economic data and supplemental emissions information. As a result of the Consolidated Emissions Reporting rule, NEI updates for 2002 and beyond are expected to include data uploads from all jurisdictions.

Data Source Considerations: Several changes to NEI influence the appropriate use of these data for EPA's Sector Strategies Program.

- *Addition of $PM_{2.5}$.* In 1997, OAQPS established National Ambient Air Quality Standards for particulate matter less than 2.5 micrometers in diameter. As a consequence, NEI began to collect $PM_{2.5}$ emissions estimates as of the 1999 inventory.

- *Improved methodology and regulatory amendments.* As a result of the Consolidated Emissions Reporting rule, NEI updates for 2002 and beyond are expected to include data uploads from all jurisdictions. If so, the need to estimate missing emissions data will be reduced.

- *Changes in "Trends" Report Methodology for PM.* In the 2002 Trends Report, OAQPS restructured certain source categories under the PM pollutant codes. Some source classification codes (SCCs) previously captured under the "Miscellaneous" category (Tier 1–14) were moved to the "Other Industrial Processes" category (Tier 1–7). The change in tier structure was made for the years 1990 and 1996 to 2002. Specifically, this increases the cement sector's PM emissions estimates as presented in the 2004 Sector Strategies Performance Report, which falls within the "Other Industrial Processes" category.

- *NEI Hazardous Air Pollutant (HAP) data.* NEI also includes hazardous air pollutant (HAP), or air toxics data. Air toxics are identified as 188 chemicals that cause serious health and environmental effects, as designated by the Clean Air Act Section 112b. The 2006 Sector Strategies Performance Report presents air toxics data from the Toxics Release Inventory rather than NEI, primarily because TRI allows for annual trends analyses. Currently, the 1990 and 1996 NEI databases are not recommended for use due to unusable format or data quality concerns, and the final version of the 2002 data is not available. Consequently, NEI air toxics data are only available for 1999 within the timeframe for completing this report, limiting the ability to use these data for trends analyses. Following the release of the 1990 and 2002 databases, EPA will evaluate the suitability of NEI to perform trends analyses for the next Performance Report.

Data Processing Steps:

- NEI CAP data were obtained from OAQPS staff (August 2005) and the Clearinghouse for Inventories & Emissions Factors (CHIEF); documentation available at www.epa.gov/ttn/chief/trends.

- For most sectors, data are compiled based on the facilities' SIC codes as included in the NEI. For the specialty-batch chemicals sector, NEI data are extracted based on a predetermined list of facilities.

- Emissions estimates are totaled by criteria air pollutants for sectors.

- The cement and paint & coatings sectors present 1996 through 2002 emissions. Estimates for 2002 are preliminary, and 2000 and 2001 emissions are projected based on the 1999 inventory.

- The metal casting and shipbuilding & ship repair sectors present 1996 and 2001 emissions.

- The specialty-batch chemicals sector presents 1999 emissions.

- Data are normalized based on a sector's productivity (as measured by changes in value of shipments/revenue or production), with 1996 as the baseline year.

- Units of measure (from the trends source file) were converted from short tons to tons for presentation purposes.

2006

DATA SOURCE: Toxics Release Inventory (TRI)

ENVIRONMENTAL METRICS USED: Toxic chemical releases (including disposal) and waste management.

PERIOD ANALYZED: 1994–2003.

NEXT DATA RELEASE: In 2005 for 2004 data.

Sector chapters presenting data:

- Cement
- Forest Products
- Iron & Steel
- Metal Casting
- Metal Finishing
- Paint & Coatings
- Shipbuilding & Ship Repair
- Specialty-Batch Chemicals

DATA SOURCE DESCRIPTION: The Toxics Release Inventory was established under the Emergency Planning and Community Right-to-Know Act of 1986 and expanded by the Pollution Prevention Act of 1990. Following expansions of the reporting requirements in the past 10 years, TRI now includes facilities with 10 or more employees in the manufacturing sectors (SIC codes 20–39); federal facilities; metal mines; coal mines; electrical utilities that combust coal or oil; commercial hazardous waste treatment facilities; chemical wholesalers; petroleum bulk terminals and plants; and solvent recovery services who use, process, or manufacture more than a threshold amount of any of the more than 600 toxic chemicals. Facilities must report to TRI if they exceed the reporting threshold for manufacture or process (>25,000 pounds) or for other uses (>10,000 pounds) of a listed chemical. Reporting thresholds for persistent bioaccumulative toxic chemicals (PBTs) are lower. In 2003, 23,811 facilities, including federal facilities, reported to EPA's TRI Program. They reported 4.44 billion pounds of onsite and offsite disposal or other releases and 25.8 billion pounds of production-related waste managed.

DATA SOURCE CONSIDERATIONS: There are a number of aspects of TRI data that influence their use for sector-level performance measurement. These issues include:

- *Small businesses not included.* TRI excludes smaller facilities, that is, those with fewer than 10 employees. However, larger facilities meeting reporting thresholds are included, and these facilities are expected to have greater environmental impacts.

- *Comprises a list of reportable chemicals.* Facilities in the TRI-reporting industry sectors must file if they exceed the reporting thresholds for any of the 600+ chemicals. Use of a single list of reportable chemicals is viewed as more suitable for tracking trends over time than data sources where the reportable chemicals may vary across facilities.

- *Multimedia coverage.* TRI reporting covers releases and other disposal to all environmental media (air, water and land) for the same time period each year. Such umbrella reporting is viewed as more suitable for trends analysis than compiling release and disposal data from several data systems.

- *Annual filing.* TRI reports are submitted each year, which is preferable to data systems where information is updated less frequently.

- *Data accuracy.* Facility owners/operators are responsible for TRI reporting using their best available information. The data facilities submit on releases and waste management quantities are calculated using one of the following methods: monitoring or measurement; mass balance calculations; emission factors; or engineering estimates. In practice, some facilities may conservatively overestimate their releases, e.g., chose to use emission factors instead of actual measurements (to avoid any risk of underreporting.) Direct electronic filing of TRI reports may reduce the potential for data processing errors.

- *Changes in best available information.* Facilities are required to complete their TRI forms using their best available information. Industry representatives have pointed out that estimates of releases might change over time as more information becomes available. For example, while conducting measurements required by another regulation, such as emissions testing required by a national emission standard for hazardous air pollutants (NESHAP), a facility may find a TRI-reportable chemical in its releases that it was not aware of previously. As facilities learn of the existence of various chemicals, they are then required to report those releases to TRI. This situation would result in an increased level of reported releases that is not necessarily accompanied by an increase in actual emissions.

DATA PROCESSING STEPS:

- Documentation can be found at www.epa.gov/tri.

- TRI data for reporting years 1994–2003 were provided by the TRI program (Office of Environmental Information) frozen as of December 28, 2004. The frozen data are used to ensure reproducibility and to support later revisions of the analysis.

- Extracted data elements for this 2006 Performance Report include the following data elements from all TRI Form Rs submitted by the sectors:

  Disposal or Other Releases includes:

  Section 5.1: Fugitive air emissions
  Section 5.2: Stack air emissions
  Section 5.3: Discharges to water
  Section 5.4: Land and other onsite disposal
  Section 6.1: Discharges to publicly owned treatment works (POTWs), for metals and metal compounds only
  Section 6.2: Transfers to other offsite locations, for disposal codes only.
  The disposal codes are as follows:

  M10 Storage Only
  M40 Solidification/Stabilization - Metals and Metal Compounds Only
  M41 Solidification/Stabilization - Metals and Metal Compounds Only
  M61 Wastewater Treatment (excluding POTW) - Metals and Metal Compounds Only
  M62 Wastewater Treatment (excluding POTW) - Metals and Metal Compounds Only
  M63 Surface Impoundment
  M64 Other Landfills
  M65 RCRA Subtitle C Landfills
  M66 Subtitle C Surface Impoundment
  M67 Other Surface Impoundment
  M71 Underground Injection
  M72 Offsite Disposal in Landfills
  M73 Land Treatment
  M79 Other Land Disposal
  M81 Underground Injection to Class I Wells
  M82 Underground Injection to Class II–V Well
  M90 Other Offsite Management
  M91 Transfers to Waste Broker - Disposal
  M94 Transfers to Waste Broker - Disposal
  M99 Unknown

  Note that quantities of chemicals sent offsite for energy recovery, recycling, or treatment were NOT included in the "disposal" quantity. These excluded quantities were any transfers coded as sent offsite for:

  M20 Solvents/Organics Recovery
  M24 Metals Recovery
  M25 Other Reuse or Recovery
  M28 Acid Regeneration
  M50 Incineration/Thermal Treatment
  M54 Incineration/Insignificant Fuel Value
  M56 Energy Recovery
  M69 Other Waste Treatment
  M90 Other Off-Site Management
  M92 Transfer to Waste Broker – Energy Recovery
  M93 Transfer to Waste Broker – Recycling
  M95 Transfer to Waste Broker – Waste Treatment

  Air Releases includes stack and fugitive emissions as reported in sections 5.1 and 5.2 of TRI Form R.

  Water Releases includes discharges to water and to POTWs for metals only as reported in sections 5.3 and 6.1 (metals only) of TRI Form R.

  Air Toxics includes stack and fugitive emissions of air toxics, also called hazardous air pollutants, as designated by the Clean Air Act Section 112b that are reportable to TRI as reported in sections 5.1 and 5.2 of TRI Form R. The act designates 188 chemicals as air toxics, 182 of which are included in TRI. TRI, rather than NEI, was used as the source for sector-level air toxics data primarily because TRI allows for a variety of annual trends analyses that were not possible with NEI.

  Recycling includes the quantity of the toxic chemicals that was either recovered at the facility and made available for further use or sent offsite for recycling and subsequently made available for use in commerce. These amounts are reported in sections 8.4 and 8.5 of TRI Form R.

  Energy Recovery includes the quantity of the toxic chemicals that was combusted in an energy recovery device, such as a boiler or industrial furnace. These amounts are reported in sections 8.2 and 8.3 of TRI Form R.

  Treatment includes the quantity of chemicals destroyed in onsite or offsite operations such as biological treatment, neutralization, incineration, and physical separation as reported in sections 8.6 and 8.7 of TRI Form R.

- For most sectors, data are compiled based on the primary SIC code reported on the TRI Form R. For the cement, iron & steel, and specialty-batch chemicals sectors, the sector TRI data are extracted based on a predetermined list of facilities. The count of the number of facilities reporting to TRI is a total of the number of unique TRI IDs in the sectors' SIC codes. This may overestimate facility counts, as one facility may have multiple TRI IDs.

- TRI releases and disposals were totaled for all chemicals reported by a sector. Absolute pounds are presented for 1994–2003. Absolute pounds of releases to air and water also are presented only for the same 10-year period.
- Data are normalized based on the sectors' productivity (as measured by changes in value of shipments/revenue or production), with 1994 as the baseline year.
- TRI waste managed by management method and ultimate disposition also are presented. Absolute pounds are presented for the most current year of data available.
- Units of measure are maintained in pounds.

DATA SOURCE: Risk Screening Environmental Indicators (RSEI)

ENVIRONMENTAL METRICS USED: Relative toxicity of air and water releases reported to TRI.

PERIOD ANALYZED: 1994–2003 TRI data.

NEXT DATA RELEASE: In early 2006 for 2004 data

Sector chapters presenting data:

- Cement
- Forest Products
- Iron & Steel
- Metal Casting
- Metal Finishing
- Paint & Coatings
- Shipbuilding & Ship Repair
- Specialty-Batch Chemicals

DATA SOURCE DESCRIPTION: Data from TRI allows comparisons of the quantities of chemicals reported year-to-year. Comparisons of the sum of TRI release data of two or more chemicals for a given year to the sum of release data for the same chemicals for different years is a simple and useful way to assess overall environmental loading of pollutants across years. However, the relative toxicity of each chemical is not taken into account. For example, mercury and methanol are both toxic chemicals. However, a pound of mercury released to air is likely to be more harmful to human health than a pound of methanol released to air because the toxic effects of mercury are much more severe and debilitating to humans and can occur at lower levels of exposure. These chemicals are treated equally when all pounds are simply summed. A sector's progress in reducing higher toxicity substances, therefore, is not fully evident when trends are presented by total pounds alone. To consider toxicity, each chemical can be weighted by a relative toxicity weight using EPA's Risk-Screening Environmental Indicators model. The model multiplies the pounds of media-specific releases (e.g., pounds of mercury released to air) by a chemical-specific toxicity weight to calculate a toxicity-weighted result.

DATA SOURCE CONSIDERATIONS: Aspects of RSEI influence the use of these modeled data for EPA's Sector Strategies Program.

- *Comparing RSEI results.* The numeric RSEI output depicts the relative toxicity of TRI releases for comparative purposes and is meaningful only when compared to other values produced by RSEI.
- *Excludes certain chemicals.* RSEI does not provide toxicity weights for all TRI chemicals, although chemicals without toxicity weights account for a very small percentage (<1%) of total reported pounds released and transferred. If there is no toxicity weight available for the chemical, then the toxicity-weighted result is zero.
- *Acute human or environmental toxicity not addressed.* RSEI addresses chronic human toxicity (cancer and noncancer effects, e.g., developmental toxicity, reproductive toxicity, neurotoxicity, etc.) associated with long-term exposure but does not address concerns for either acute human toxicity or environmental toxicity.
- *Currently excludes toxicity weights for chemicals disposed.* An inhalation toxicity weight is used for fugitive and stack air releases. An oral toxicity weight is used for direct water releases and for releases of metals to POTWs. Releases to land and other disposal are not modeled because necessary data on site-specific conditions are lacking; therefore, for screening purposes, the higher of the inhalation or oral toxicity weight is used. As this could overestimate the toxicity-weighted results for disposals, these data have been excluded from the toxicity-weighted results presented in this 2006 Performance Report.

- *Assumes highest toxicity weight for chemical form.* Metals and metal compounds are assumed to be released in the chemical form associated with the highest toxicity weight because information on the form is not subject to TRI reporting. The form of a chemical compound can affect its bioavailability and, therefore, its toxicity. For example, hexavalent chromium has an oral toxicity weight of 170 and an inhalation toxicity weight of 86,000; whereas trivalent chromium has an oral and inhalation toxicity weight of 0.33. TRI reports on "chromium" do not specify the valence, so all reported pounds of chromium are more conservatively assigned the toxicity weight of hexavalent chromium. In cases where a facility is releasing the chemical in the lower toxicity form, RSEI would overestimate toxicity-weighted results.

- *Results presented do not include a risk perspective.* Although the RSEI model can provide a full risk-related perspective for air and water releases, only the toxicity portion of the model was used in the analysis for the 2006 Performance Report. It is important to note that risk-related factors were not considered in the analysis for this report. These factors that impact the risk potentially posed by a chemical release are a function of chemical toxicity, the fate and transport of the chemical in the environment after it is released, the pathway of human exposure, and the number of people exposed. Readers interested in the risk perspective for a facility or sector can use the publicly available RSEI model to conduct this screening-level risk analysis.

Data Processing Steps:

- RSEI model documentation is available at www.epa.gov/opptintr/rsei.
- For most sectors, data are compiled based on the primary SIC codes reported on the TRI Form R. For the cement, iron & steel, and specialty-batch chemicals sectors, the sector TRI data are extracted based on a predetermined list of facilities.
- TRI air and water releases, weighted for toxicity, were totaled for all chemicals reported by a sector. Both absolute pounds and toxicity-weighted results are presented for a 10-year period.
- Data are normalized based on the sectors' productivity (as measured by changes in value of shipments/revenue or production), with 1994 as the baseline year.
- The chemicals that account for 90% of the sectors' total toxicity-weighted results for air and water releases in 2003 are presented for each sector.

Industry-Supplied Environmental Data

The following data were supplied by industry partners for two sectors.

Sector: Cement

Data Source: Cement kiln dust surveys, March 7, 2005, provided by Garth Hawkins, Portland Cement Association and Portland Cement Association Report on Sustainable Manufactures, February 2005, Chapter 3 – Solid Waste Production.

Environmental Metric Used: Cement kiln dust sent to landfills, in metric tons.

Sector: Forest Products

Data Source: American Forest & Paper Association Environmental, Health, and Safety Verification Program, Year 2002 Report: Issued 2004.

Environmental Metrics Used:

- Sulfur dioxide and nitrogen oxide air emissions from pulp and paper mills, in pounds per ton of production.
- Wastewater discharges (volume, biochemical oxygen demand, and total suspended solids) from pulp and paper mills, in pounds per ton of production.
- Adsorbable organic halides from pulp and paper mills, in kilograms per tonne of production.

Appendix C: Glossary

Acid rain: Air *pollution* produced when acid chemicals are incorporated into rain, snow, fog, or mist. The "acid" in acid rain comes from *sulfur oxides* and *nitrogen oxides*, products of burning coal and other fuels and from certain industrial processes. The sulfur oxides and nitrogen oxides are related to two strong acids: sulfuric acid and nitric acid. When *sulfur dioxide* and nitrogen oxides are released from power plants and other sources, winds blow them far from their source. If the acid chemicals in the air are blown into areas where the weather is wet, the acids can fall to Earth in the rain, snow, fog, or mist. In areas where the weather is dry, the acid chemicals may become incorporated into dusts or smokes. Acid rain can damage the environment, human health, and property.

Air toxics: Air *pollutants* that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental and ecological effects. Examples of toxic air pollutants include benzene, found in gasoline; perchloroethylene, emitted from some dry cleaning facilities; and methylene chloride, used as a solvent by a number of industries.

Beneficial reuse: Use or reuse of a material that would otherwise become a waste.

Biomass: All of the living material in a given area; often refers to vegetation.

Byproduct: Material other than the intended product that is generated as a consequence of an industrial process.

Combustion: Burning. Many *pollutants*, such as *sulfur dioxide*, *nitrogen oxides*, and *particulates* (PM_{10}) are combustion products, often products of the burning of fuels such as coal, oil, gas, and wood.

Co-product: A substance produced for a commercial purpose during the manufacture, processing, use, or disposal of another substance or mixture.

Criteria air pollutant: A group of six widespread and common air *pollutants* regulated by EPA on the basis of standards set to protect public health or the environment. These six criteria pollutants are carbon monoxide, lead, *nitrogen dioxide, ozone, particulate matter,* and *sulfur dioxide*.

Energy efficiency: Actions to save fuels by better building design, modification of production processes, better selection of road vehicles and transport policies, etc.

Energy recovery: Obtaining energy from waste through a variety of processes, including *combustion*.

Environmental management system: (EMS) A systematic approach to managing all environmental aspects of an operation. International Organization for Standardization (ISO) 14001 is a widely recognized international standard for EMS.

Greenhouse gas: (GHG) A collective term for those gases, including carbon dioxide, methane, nitrous oxide, *ozone*, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, which contribute to potential climate change.

Hazardous air pollutant: (HAP) A category of air *pollutants* that may present a threat of adverse human health effects or adverse environmental effects. Includes asbestos, beryllium, mercury, benzene, coke oven emissions, radionuclides, and vinyl chloride.

Hazardous waste: A *byproduct* of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity), or is specifically listed as hazardous by EPA.

Industrial waste: Process waste associated with manufacturing. This waste usually is not classified as either *municipal solid waste* or *hazardous waste* by federal or state laws.

Large quantity generator: (LQG) Generator of 1,000 kilograms per month or more of *hazardous waste*, or more than 1 kilogram per month of acutely hazardous waste. LQGs must submit a biennial hazardous waste report and are subject to other specific regulatory requirements, including requirements regarding waste accumulation, emergency coordination, etc.

Municipal solid waste: Waste discarded by households, hotels/motels, and commercial, institutional, and industrial sources. It typically consists of everyday items such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries. It does not include wastewater.

National Ambient Air Quality Standards: (NAAQS) Standards established by EPA under the Clean Air Act that apply to outdoor air throughout the country. See *criteria air pollutant*.

Net electricity: Net electricity is obtained by summing purchases, transfers in, and generation from noncombustible renewable resources, minus quantities sold and transferred out. It does not include electricity inputs from onsite cogeneration or generation from combustible fuels because that energy has already been included as generating fuel (for example, coal).

Nitrogen dioxide: (NO_2) A *criteria air pollutant* and *smog*-forming chemical formed by the burning of gasoline, natural gas, coal, oil, etc.

Nitrogen oxides: (NO_x) A reddish-brown gas compound that is a product of combustion and a major contributor to the formation of *smog* and *acid rain*.

Non-attainment area: A geographic area in which the level of a *criteria air pollutant* is higher than the level allowed by the federal standards. A single geographic area may have acceptable levels of one criteria air pollutant but unacceptable levels of one or more other criteria air pollutants; thus, an area can be both attainment and non-attainment at the same time.

Non-hazardous waste: Any solid, semi-solid, liquid, or contained gaseous materials discarded from industrial, commercial, mining, or agricultural operations, and from community activities, that is not defined as "hazardous."

Normalization: A process applied to a data set to compare the data against some common measure of annual economic output, such as value of shipments, number of employees, or units of production.

Ozone: A gas which is a variety of oxygen. The oxygen gas found in the air consists of two oxygen atoms stuck together; this is molecular oxygen. Ozone consists of three oxygen atoms stuck together into an ozone molecule. High concentrations of ozone gas are found in a layer of the atmosphere – the stratosphere – high above the Earth. Stratospheric ozone shields the Earth against harmful rays from the sun. *Smog*'s main component is ozone; this ground-level ozone is a product of reactions among chemicals produced by burning coal, gasoline and other fuels, and chemicals found in products including solvents, paints, hairsprays, etc.

Particulate matter: (PM) Solid particles or liquid droplets suspended or carried in the air (e.g., soot, dust, fumes, or mist). $PM_{2.5}$: Particles less than or equal to 2.5 micrometers in diameter. PM_{10}: Particles less than or equal to 10 micrometers in diameter.

Pollutants: (pollution) Unwanted chemicals or other materials found in specific environments – air, water, soil – that are the subject of regulatory concern and activities. Pollutants can harm health, the environment, and property.

Sludge: Solid, semisolid, or liquid waste generated from a municipal, commercial, or industrial wastewater facility.

Solid waste: Nonliquid, nonsoluble materials ranging from municipal garbage to *industrial wastes* that contain complex and sometimes hazardous substances. Solid wastes also include sewage sludge, agricultural refuse, demolition wastes, mining residues, and liquids and gases in containers.

Smog: A mixture of *pollutants*, principally ground-level *ozone*, produced by chemical reactions in the air involving smog-forming chemicals. A major portion of smog-formers come from burning of petroleum-based fuels such as gasoline. Other smog-formers, *volatile organic compounds*, are found in products such as paints and solvents. Smog can harm health, damage the environment, and cause poor visibility. Major smog occurrences are often linked to heavy motor vehicle traffic, sunshine, high temperatures and calm winds, or temperature inversion (weather condition in which warm air is trapped close to the ground instead of rising). Smog is often worse away from the source of the smog-forming chemicals, since the chemical reactions that result in smog occur in the sky while the reacting chemicals are being blown away from their sources by winds.

Stormwater runoff: The portion of precipitation, snowmelt, or irrigation water that does not infiltrate the ground or evaporate but instead flows onto adjacent land or watercourses or is routed into drain/sewer systems.

Sulfur dioxide: (SO_2) A *criteria air pollutant*. Sulfur dioxide is a gas produced by burning coal, most notably in power plants. Some industrial processes, such as production of paper and smelting of metals, produce SO_2. Sulfur dioxide is closely related to sulfuric acid, a strong acid. Sulfur dioxide plays an important role in the production of *acid rain*.

Sulfur oxides: (SO_x) A gas compound that is primarily the product of combustion of fossil fuels and a major contributor to climate change and *acid rain*.

Twenty-foot equivalent unit: (TEU) A measure of containerized cargo equal to one standard 20 ft (length) X 8 ft (width) X 8.5 ft (height) container.

Toxicity weighting: Computation that determines weight given to *pollutants* to aid in the comparison of the relative risks of toxic pollutants. The higher the number – or toxicity weight – the greater the risk that air and water releases pose to people's long-term health.

Value of shipments: The net selling values, exclusive of freight and taxes, of all products shipped by manufacturers.

Volatile organic compound: (VOC) Any organic compound that evaporates readily to the atmosphere, contributing significantly to *smog* production and certain health problems. Volatile organic chemicals include gasoline, industrial chemicals such as benzene, solvents such as toluene and xylene, and tetrachloroethylene (perchloroethylene, the principal dry cleaning solvent). Many volatile organic chemicals are also *hazardous air pollutants*; for example, benzene causes cancer.

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