

# steel

## Steel — Industry of the Future



The U.S. steel industry is building a strong future by developing and demonstrating advanced, energy-efficient technologies through active participation in the Industries of the Future partnership.



Office of Industrial Technologies



Office of Energy Efficiency and Renewable Energy  
U.S. Department of Energy

# partnership

## Working together toward common goals

### A powerful partnership

*Participating in the Industries of the Future strategy has been good for the U.S. steel industry. The partnership has generated*

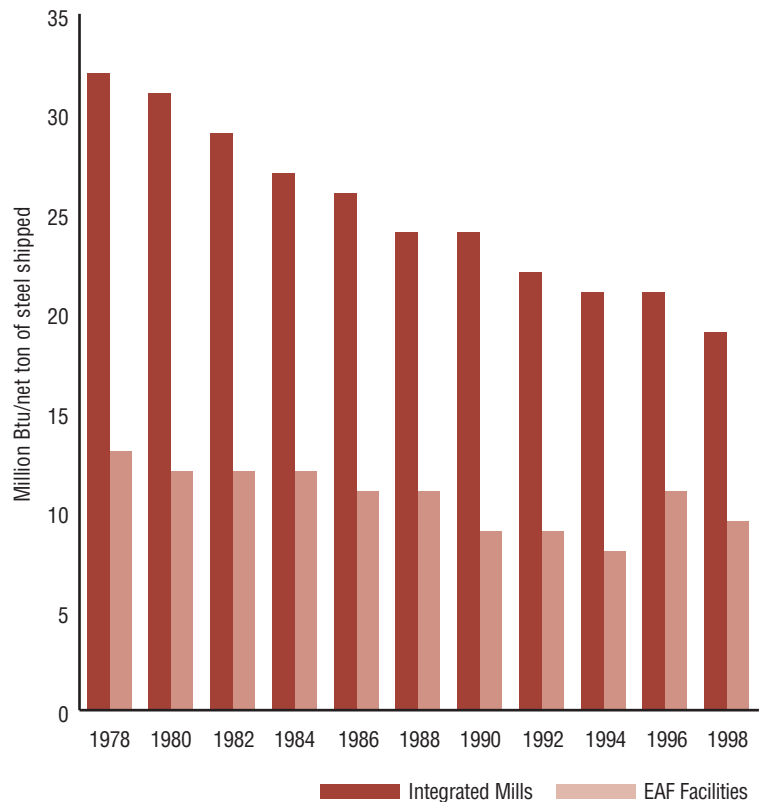
- *An industry-defined vision for the future*
- *Clearly articulated industry goals and priorities*
- *Increased cooperation and problem-solving among companies*
- *Augmented R&D resources*
- *Easier access to the DOE national laboratories*
- *Enhanced understanding of opportunities*
- *Accelerated development and deployment of advanced technologies and processes for greater productivity*

The steel industry is vital to U.S. economic competitiveness and national security. It employs over 150,000 people in well-paying jobs and is among the most productive, efficient, and technologically sophisticated industries in the world. For example, many grades of steel in use today could not have been made even 10 years ago. Traditionally valued for its impressive strength, steel has also become the most recycled material, with 55 percent of U.S. steel now produced from scrap.

Since energy represents about 15 percent of the total manufacturing cost for steel, steelmakers are highly motivated to reduce energy intensity. In 1995, industry leaders joined the U.S. Department of Energy's Office of Industrial Technologies (OIT) in a unique partnership known as Industries of the Future. This innovative partnership strategy aligns public and private R&D resources to address some of the industry's toughest technological challenges. This strategy is helping the U.S. steel industry prepare for success in tomorrow's global markets while advancing national goals for energy efficiency and the environment.

### Energy Intensity in the Steel Industry

*The steel industry has made significant progress in reducing energy intensity, but still accounts for about 2% of all U.S. energy use.*



Source: AISI unpublished survey.

*"The roadmap has allowed us not only to identify but to prioritize the types of things that really make sense for us to work on together."*

*Tom Usher, CEO  
USX Corporation, 1998*



## Industry sets the goals and priorities

Under the leadership of the American Iron and Steel Institute (AISI) and the Steel Manufacturers Association (SMA), the U.S. steel industry is actively engaged in the Industries of the Future strategy. By reaching a consensus on industry-wide goals and R&D priorities, the industry has succeeded in attracting public and private investment for new technology development. Collaborative teams share the costs and risks of R&D to accelerate meaningful technology advances.

### Vision

Led by the American Iron and Steel Institute, the industry reached consensus on broad goals for the future and established a unified research agenda, *Steel: A National Resource for the Future*, to guide collaborative research, development, and demonstration (RD&D).

### Roadmap

In 1998 the industry mapped out the pathway for achieving its vision in the *Steel Industry Technology Roadmap*. This landmark document describes priorities, key milestones, and performance targets for collaborative RD&D. (View the document by visiting [www.steel.org/mt/](http://www.steel.org/mt/))

### Implementation

Guided by industry-defined priorities in the steel roadmap, OIT currently provides funding to nearly 50 steel-specific R&D projects worth a total of roughly \$68 million in public-private investment. OIT provides approximately two-thirds of the cost-share for these competitively awarded projects that also help meet national goals for energy and the environment.

### New Technology Direction

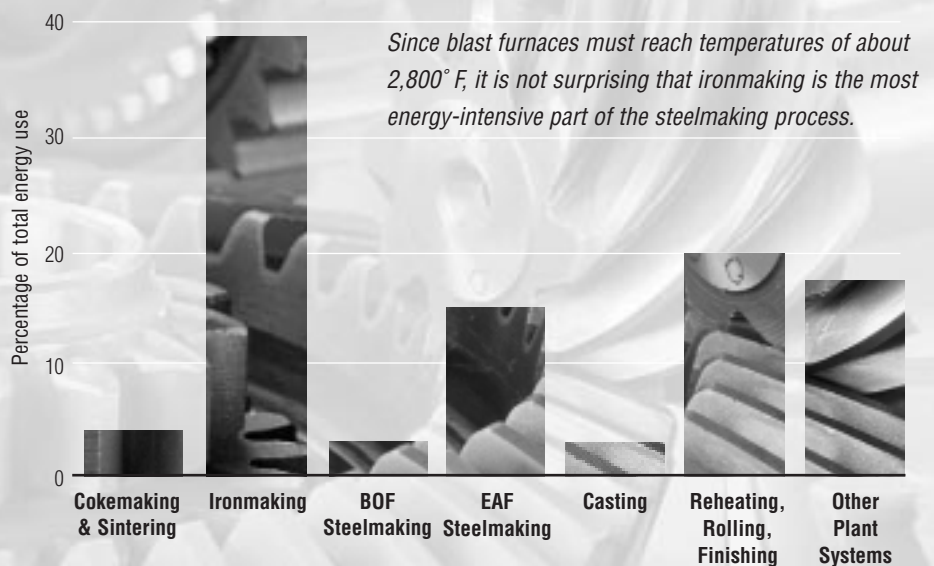
The industry reaffirmed its commitment to the partnership by signing a new compact with OIT in February 1999 and by revising the 1998 roadmap to reflect new developments and priorities. The revised roadmap will guide new public-private R&D investment in improved steel technology. In addition, the new Steel Industry Research Challenge will foster the development of revolutionary steel technologies for the 21<sup>st</sup> century.

## Agreements provide quick start for new steel R&D efforts

In July 1997, AISI signed a cooperative agreement with DOE to provide joint industry-federal funding for research projects that address priority needs identified in the Steel Industry Technology Roadmap. At roughly the same time, AISI completed "pre-negotiated agreements" with a consortium of federal laboratories, establishing the terms and conditions of steel-sponsored work at the federal labs.

"We now have a simple, agile means of implementing the technology roadmap," said Andrew Sharkey, AISI President and CEO. "On the one hand, we have an agreement that provides federal cost-sharing, and on the other, agreements to execute work at the national labs on projects for which that is appropriate."

## Energy Use by Process



Source: "Annual Statistical Report 1998," American Iron and Steel Institute, 1999.



# results

## Making a difference

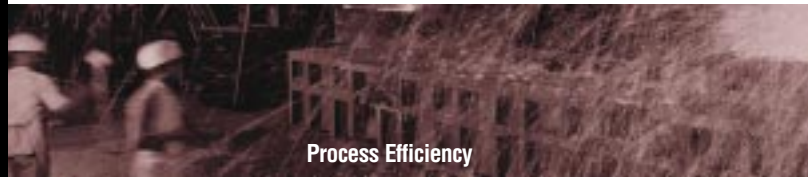
Over the last five years, OIT has committed more than \$50 million to work on over 50 R&D projects in collaboration with the steel industry. Industry has provided nearly \$20 million in additional support. Through these cost-shared projects, DOE and its many R&D partners have jointly commercialized 15 technologies and expanded the base of fundamental knowledge to optimize steelmaking processes and resource efficiency.

The Steel Industry of the Future partnership is already making a significant difference. Two newly developed computer models are improving the energy efficiency of steel production as well as product quality. The first optimizes the operation of hot blast stoves used to preheat air fed to the blast furnace, reducing natural gas consumption in the stoves by 7 percent. The second quantitatively links the mechanical properties of hot-rolled steel to the operational characteristics of the mill, decreasing product variability and optimizing hot rolling operations. Results of other R&D efforts include long-lasting furnace components made from intermetallic alloys, which reduce equipment downtime and improve steel quality, and oxy-fuel burners, which reduce NOx emissions from steel reheating furnaces by 75 percent or more.

### Steel Industry of the Future Portfolio

#### ***Steel compact***

*The steel industry reaffirmed its commitment to the Industries of the Future partnership by renewing its compact with OIT in February 1999. Both parties pledged to work together in pursuing technology R&D in four priority focus areas (shown at right).*



#### **Process Efficiency**

- Hot Oxygen Injection into the Blast Furnace
- Quantifying the Thermal Behavior of Slags
- Dephosphorization When Using Direct Reduced Iron/Hot Briquetted Iron
- Low Coal Rate/High Productivity on Rotary Hearth Furnace Ironmaking
- Optical Sensors and Controls for Improved BOF Operations
- In-Situ, Real-Time Measurement of Melt Constituents
- Development of Intermetallics for the Steel Industry
- Cold Work Embrittlement of Interstitial-Free Steels
- Improved Refractory Service Life and Recycling Refractory Materials
- Submerged Entry Nozzles that Resist Clogging
- Improved Refractories Using Engineered Materials
- Automated Steel Cleanliness Analysis Tool
- Enhanced Inclusion Removal from Steel in the Tundish
- Magnetic Gate for Molten Metal Flow Control
- Clean Cast Steel Technology
- Strip Casting Study
- Hot Strip Mill Transfer Bar Edge Heating
- Versatile Laser-Ultrasonic System for Seamless Pipe
- Controlled Thermo-Mechanical Processing of Tubes and Pipes
- Enhanced Operation of Highly Varying Industrial Loads to Increase Electric Reliability, Quality, Economics
- Temperature Measurement of Galvanneal Steel
- Steel Reheating for Further Processing





## Showcasing success

The steel industry gains a firsthand look at the advanced, energy-efficient technologies and practices emerging from Industries of the Future by attending **showcases**. These popular public events feature presentations by technology developers, briefings on plant-wide assessments, and plant tours highlighting advanced technologies. OIT co-sponsors the showcases with steel mills that run efficient operations and have adopted cutting-edge technologies.

### Burns Harbor Steel Showcase—April 1998

**Bethlehem Steel's** flagship mill in Burns Harbor, Indiana, hosted the first showcase, at which participants learned about advanced processing, sensing, and materials technologies; efficient motor and steam systems; low-NOx combustion; solid waste reduction; and pollution reduction techniques.

### Pittsburgh Regional Steel Showcase—May 2000

**U.S Steel's** Edgar Thomson Plant and **Weirton Steel** hosted this two-day event, of presentations, technology-focused plant tours, and a Congressional field hearing. Other sponsors included Bethlehem Steel, Timken Company, the National Energy Technology Laboratory, the Pennsylvania Departments of Environmental Protection and Economic Development, the American Iron and Steel Institute, the Steel Manufacturers Association, and Koppel Steel.

## Analytical steel studies

OIT supports analytical studies that provide the foundation for future energy savings and productivity improvements in the U.S. steel industry. Existing and planned publications include

- *Theoretical Minimum Energy Requirements for Steelmaking*
- *Reasonably Achievable Energy Savings in the U.S. Steel Industry*
- *Alternate Ironmaking Process Study*
- *Value Chain Analysis*
- *Analysis of Incentives, Disincentives, and Alternatives for Steel Industry CO<sub>2</sub> Reductions*

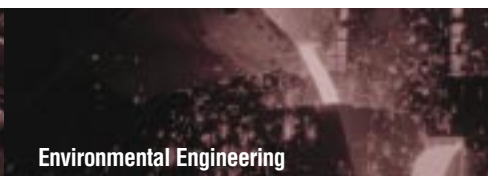
## Cooperative Steel Education Initiative

OIT and the Steel Manufacturers Association are working with steel companies to interest talented undergraduate Engineering and Applied Science students in the industry. Through a joint fellowship program, qualified students are selected to work with industry mentors on projects related to the Steel Industry Technology Roadmap. The students receive constructive project critiques and gain useful work experience.



### Iron Unit Recycling

- Effect of Residuals in Carbon Steels
- Removal of Residual Elements in the Steel Ladle
- Recycling of Waste Oxides in Steelmaking Furnaces
- Sustainable Steelmaking Using Biomass and Waste Oxides
- Novel Method to Process EAF Dust into Saleable Chemical Products
- Regeneration of Acid Pickle Liquor
- Particulate Briquetting for the Steel Industry



### Environmental Engineering

- Dilute Oxygen Combustion
- NOx Emission Reduction by Oscillating Combustion
- Low-Emission Oxygen-Enriched Furnace System
- Low-NOx Boiler Demonstration
- Thermal Imaging Control of Furnaces and Combustors
- Optical Sensor for EAF Post-Combustion Control
- Optimization of Post-Combustion in Steelmaking
- Plant Trial of Non-Chromium Passivation Techniques for Electrolytic Tin Plate



### Production Efficiency

- Intelligent Systems for Induction Hardening
- Cold Work Embrittlement of Interstitial-Free Steels
- Behavior of Multiphase Sheet Steels under High Strain Rate Deformation Conditions
- Variability of High-Strength, Low-Alloy Steels
- Improved Surface Quality of Exposed Automotive Sheet Steels
- Laser-Assisted Arc Welding
- Resistance Spot Welding Practices for Transformation-Hardened Steels
- Development of Steel Foam Materials and Structures
- Deformation Behavior of Lightweight Steel Structures
- Cost-Effective, Energy-Efficient Steel Framing
- Lightweight Steel Containers
- Method of Making Steel Strapping and Strip

To learn more about the projects in the Steel Industry of the Future portfolio, visit [www.oit.doe.gov/steel](http://www.oit.doe.gov/steel)

# resources

## Emerging technologies and best practices for today and tomorrow

OIT's Steel Team supplements its R&D budget by coordinating activities with other OIT programs that can help advance steel industry goals. OIT's Sensors and Controls program, for example, has funded the development of a process for in-situ, real-time measurement of melt constituents, which could increase productivity in steel mills. OIT's Metal Casting Team also funds R&D that can offer carryover benefits for steel casting. The NICE<sup>3</sup> (National Industrial Competitiveness through Energy, Environment, and Economics) program provides financial assistance for demonstrations of emerging steel technologies, such as the Energy-Efficient Process for Hot-Dip Batch Galvanizing.



### Enabling Technologies

OIT's **Industrial Materials of the Future** program works with industry, the national laboratories, academia, and others to develop and commercialize new and improved materials such as intermetallic alloys (including nickel, iron, titanium aluminide, and molybdenum disilicides) to provide superior strength and corrosion resistance in high-temperature industrial environments. The **Combustion** program seeks to improve energy efficiency, reduce emissions, and enhance fuel flexibility by working with the combustion community to develop cost-effective technologies such as the oxy-fuel burner. The **Sensors and Controls** program is working to provide the steel industry with integrated measurement systems for operator-independent control of plant processes. Research is extending sensor reach and accuracy in harsh environments and improving the integration and processing of sensor data to enable on-line, automated assessment and adjustment of system parameters.



### Plant-wide assessment

Crucible Specialty Metals of Syracuse, New York, and six other plants are receiving cost-shared funding from OIT for assessments to evaluate energy efficiency opportunities in such areas as

- Electric motor systems
- Steam systems
- Compressed air systems
- Combined heat and power systems
- Heat exchange networks
- Process modifications
- Adoption of emerging process technology

OIT will share up to half the costs, or up to \$100,000, with each site to conduct the assessments. Each site will gain national recognition for its efforts and will have access to OIT's emerging technologies, tools, and resources.



## BestPractices

OIT offers resources to help steel mills save energy, reduce costs, and cut waste with existing technologies. OIT provides funding, tools, training, advice, and information.

The program offers **plant-wide assessments** to help large steel mills develop a comprehensive strategy for increasing efficiency, reducing emissions, and boosting productivity. Grants of up to \$100,000 in matching funds are awarded through a competitive solicitation process, and a case study helps spread the word on attainable benefits. Alternatively, small to mid-sized manufacturers can take advantage of the **Industrial Assessment Centers**, which provide no-charge assessments through a network of engineering universities.

## Financial Assistance

OIT offers targeted financial assistance to accelerate technology development and adoption. The **Inventions and Innovation** program awards grants of up to \$200,000 to inventors of energy-efficient technologies. Grants are used to establish technical performance, conduct early development, and initiate commercialization activities. The second program, **NICE<sup>3</sup>**, provides cost-shared grants of up to \$500,000 to industry-state partnerships for demonstrations of clean and energy-efficient technologies.

## State Industries of the Future

States are starting Industries of the Future programs to improve competitiveness and bring the energy, environmental, and economic benefits of industrial partnerships to the local level. The Industries of the Future-West Virginia steel industry group, for example, is working closely with the West Virginia Steel Advisory Commission, and a collaborative team (including industry, West Virginia University, and Oak Ridge National Laboratory) is conducting R&D to reduce the corrosion of rollers on continuous galvanizing lines.

**For more information on these and other resources, please contact the OIT Clearinghouse at (800) 862-2086.**

## How to get involved

*Through Industries of the Future partnerships, U.S. steel companies reap the competitive advantages of more efficient and productive technologies and, in turn, contribute to our nation's energy efficiency and environmental quality.*

*To participate:*

- Monitor the OIT Steel Team's Web site and links to related organizations for news and announcements of R&D solicitations, meetings and conferences, and research projects.*
- Team with other organizations and respond to solicitations to strengthen business partnerships for cost-shared research.*
- Begin saving energy, reducing costs, and cutting pollution today by participating in any of the BestPractices programs.*
- Take advantage of OIT's extensive information resources, including fact sheets and case studies, training, software decision tools, searchable CDs, newsletters, and publications catalog.*
- Attend the biennial Industrial Energy Efficiency Symposium and Expo.*

[www.oit.doe.gov/steel](http://www.oit.doe.gov/steel)



For more information on the Steel Industry of the Future,  
contact the OIT Clearinghouse at (800) 862-2086  
or visit [www.oit.doe.gov/steel](http://www.oit.doe.gov/steel)

Please send any comments, questions, or suggestions to [webmaster.oit@ee.doe.gov](mailto:webmaster.oit@ee.doe.gov)



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