Metal Casting Annual Report
Fiscal Year 2003

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry
through improvements in energy and environmental performance

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

Industrial Technologies Program — Boosting the Productivity and Competitiveness of U.S. Industry

Industry consumes 33 percent of all energy used in the United States. By developing and adopting more energy efficiency technologies, U.S. industry can boost its productivity and competitiveness while strengthening national energy security, improving the environment, and reducing emissions linked to global climate change.

The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) works in partnership with U.S. industry to increase the efficiency of energy and materials use, both now and in the future. Through an innovative strategy known as Industries of the Future (IOF), EERE's Industrial Technologies Program (ITP) seeks to improve the energy intensity of the U.S. industrial sector through a coordinated program of research and development (R&D), validation, and dissemination of energy efficiency technologies and operating practices. ITP develops, manages, and implements a balanced portfolio that addresses industry requirements throughout the technology development cycle. The primary long-term strategy is to invest in high-risk, high-return R&D. Investments are focused on technologies and practices that provide clear public benefit but for which market barriers prevent adequate private-sector investment.

The IOF strategy maximizes the energy and environmental benefits of ITP's process-specific technology investments by forming collaborative partnerships with energy–intensive industries. These collaborations aim to effectively plan and implement comprehensive R&D agendas and help disseminate and share best energy management practices throughout the United States. The IOF public-private partnerships also facilitate voluntary efforts, such as the President's Climate VISION initiative, to encourage industry and government to reduce greenhouse gas emissions. ITP focuses its resources on a small number of energy-intensive materials and process industries that account for over 75 percent of industrial energy consumption:

- Aluminum
- Chemicals
- Forest Products
- Glass
- Metal Casting
- Mining
- Petroleum Refining
- Steel

ITP also conducts R&D projects on enabling technologies that are common to many industrial processes such as industrial energy systems, combustion, materials, and sensors and process control systems. In addition, ITP funds technical assistance activities to stimulate near-term adoption of best energy-saving technologies and practices within industry. These activities include plant assessments, tool development and training, information dissemination, and showcase demonstrations.

New technologies that use energy efficiently also lower emissions and improve productivity. By leveraging technical and financial resources of industry and government, the IOF partnerships have generated significant energy and environmental improvements that benefit the nation and America's businesses. Energy-intensive industries face enormous competitive pressures that make it difficult to make the necessary R&D investments in technology to ensure future efficiency gains. Without a sustained commitment by the private and public sectors to invest in new technology R&D and deployment, the ability to close the gap between U.S. energy supply and demand will be severely compromised.

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EXECUTIVE SUMMARY

The metal casting industry purchases an estimated 328 trillion Btu annually to manufacture components for the transportation, aerospace, medical, and many other manufacturing industries. Energy-intensive processes include melting, moldmaking, coremaking, and post-casting operations. Because metal casting is a small business industry — 80 percent of the 2,950 metal casters operating in the United States employ fewer than 100 people — most metal casters cannot assume the high cost and risk associated with research and development (R&D) — particularly long-term R&D. ITP's Metal Casting IOF cost-shares precompetitive research to improve energy efficiency in this vital industry. It fosters research partnerships — emphasizing university-based R&D — and has been credited as the driving force behind many significant technical advances that have helped to improve energy efficiency by an estimated 16.83 trillion Btu in 2010.

Broad industry and university participation (over 325 active R&D partners) in the Metal Casting IOF is facilitated through the Cast Metals Coalition, which is composed of the American Foundry Society (AFS), the North American Die Casting Association (NADCA), and the Steel Founders' Society of America (SFSA). Collectively, this coalition represents 80 percent of the U.S. metal casting industry. To guide research, metal casting stakeholders developed a vision that established long-term future goals and a roadmap for charting the R&D pathways to achieve these goals. These documents have formed the basis for open and competitive R&D solicitations that address the energy efficiency goals outlined in the *National Energy Policy*, as well as industry research priorities.

This successful government-industry partnership is now focusing on developing high-impact research projects to make revolutionary improvements in the energy efficiency of metal casting processes. As the Metal Casting IOF's portfolio transitions into the FY 2004, it has organized its portfolio into three categories: Advanced Melting, Innovative Casting Processes, and R&D Integration and Analysis. The following provides a snapshot of the research portfolio and summarizes the major highlights and accomplishments during FY 2003.

Research Portfolio Highlights

- The FY 2003 portfolio of 47 metal casting research projects (see Exhibit 11, p. 10) is performed in partnership with 325 university, industry, and national laboratory partners across the United States. The involvement of industry on the ground floor accelerates technology transfer and dissemination of research results. Involvement of universities is exposing hundreds of students to the field of metal casting and enabling the industry to gain access to the technical expertise available at the universities. It is also helping to sustain vital casting-related curricula at U.S. universities.

- The FY 2003 portfolio addresses priorities outlined in the *Metal Casting Technology Roadmap*, with 66 percent of research funding focused on improvements in manufacturing processes where the greatest opportunities for energy savings exist. Additional research funding is devoted to improving material performance, thereby reducing scrap and increasing yield, as well as addressing environmental needs such as recycling spent sand.

- Beyond the Metal Casting IOF research funding of $18 million received between FY 1998-FY 2003, EERE has leveraged an additional $19 million on current research and technical assistance relevant to metal casters.

Project Successes

- New feeding distance rules for risering and pressurization of risers have been developed that reduce shrinkage and improve yield in steel castings by 10 to 25 percent, thereby reducing melting requirements. ITP estimates that these new rules will save approximately 30 trillion Btu and $154.27 million in energy costs per year in 2020.

- Researchers have developed cost-effective non-incineration techniques that will significantly reduce Volatile Organic Compound (VOC) emissions from foundries. This research has shown that benzene and other VOC emissions can be reduced by 10 to 75 percent, sand system pre-mix consumption can be reduced by 15 to 42 percent, and foundry smoke can also be reduced. This technology is scalable for small, medium, and large foundries. This technology will have an energy cost savings of approximately $57.33 million and 10.16 trillion Btu per year in 2020.

- Steel foundries are making improvements in gating systems, including shrouded pouring. They are reducing scrap and heat treatment requirements in the production of castings, with some R&D partners saving 5 percent of the energy used in steel casting manufacturing. ITP estimates that these improvements will save approximately 4 trillion Btu and $19.5 million in energy costs per year in 2020.

- Researchers have developed a database explaining the effects of key elements on the properties of the die cast product, permitting a tailoring of alloy components to optimize die castings for specific applications. This permits a tailoring of alloy compositions to optimize die castings for specific applications. ITP estimates this project will save 3.21 trillion Btu resulting in an energy cost savings of $15.90 million in 2020.

- Researchers have developed a computational tool for systematically designing Expandable Polystrene (EPS) pattern molds used in the lost foam process — enabling higher-quality patterns with reduced lead-time and expenses. This tool is expected to reduce defects, resulting in yield improvements of about 10 percent with an equal reduction in melting requirements. ITP estimates that the tool will result in an annual energy savings of 1.72 trillion Btu and $3.20 million in energy cost savings per year in 2020.

- Research has led to modifications of die steel chemical composition and heat processing, resulting in die life improvements of 20 to 30 percent and higher. The level of improvement can result in $150,000 less die steel purchased and heat treated each year, a 5 percent scrap reduction, and 0.5 percent productivity improvement, plus a 1 percent decrease in downtime for repair. ITP estimates that the results will have an energy savings of 4.6 billion Btu annually.

IOF Accomplishments

- Through the CMC, the metal casting industry has updated its long-term vision. The new vision became the basis for the new technology roadmap that will be made available late in 2003.

- EERE's BestPractices and Industrial Assessment Centers provide hands-on technical assistance that metal casters can apply immediately, saving them millions of dollars annually. For example, a plant-wide assessment at the AMCAST Wapakoneta, Ohio plant identified recommendations that would result in an average annual energy savings of $6 million.

- In conjunction with Eppich Technologies and industry, the Metal Casting IOF initiated the U.S. Metal Casting Industry's Energy Footprint Study. This study will benchmark energy use in the various types of metal casting facilities. In addition, in April 2003, KERAMIDA Environmental, Inc. began a study in support of DOE to evaluate energy requirements for various metal casting processes.

INDUSTRY OVERVIEW

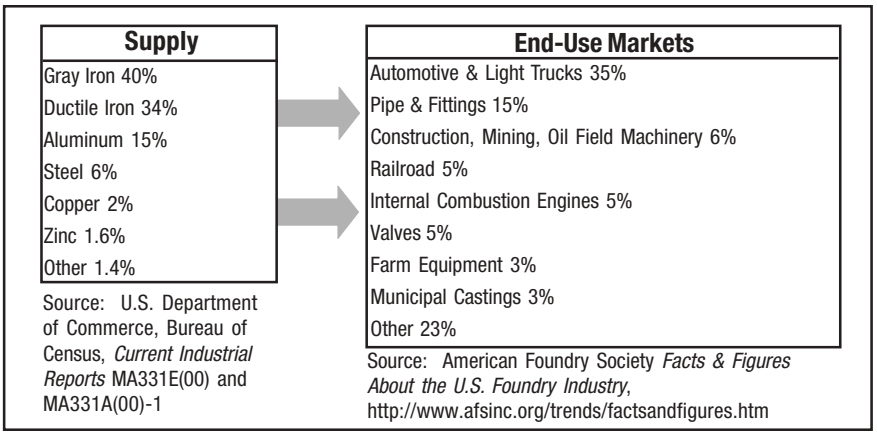
Everyday tasks such as turning on a light, starting a car, or using a computer would not be possible without metal casting. The metal casting industry has been integral to U.S. growth and has helped the United States become the world benchmark in fields such as manufacturing, science, medicine, and aerospace. This industry dominated by small businesses continues to fuel the nation's prosperity and national defense into the 21st century.

The metal casting industry consists of 2,950 facilities located throughout all 50 states. Eighty percent of these facilities employ fewer than 100 people, 14 percent employ between 100 and 250 people, and only 6 percent employ more than 250 people.[1] The industry employed approximately 217,000 people, providing $10.0 billion in wages.[2]

Metal Casting In Brief

Metal casting enables the production of simple and complex parts that meet a wide variety of needs. Nearly all manufactured goods contain one or more cast components. Major end-uses include power generation equipment, defense systems and machinery, motor vehicles, transportation equipment, oil field machinery, pipelines, industrial machinery, construction materials, and other products vital to our economic and national security. Oil field machinery and equipment sales alone represent $259 million in casting sales per year.[3] Exhibit 1 illustrates raw material supplies and end-use markets for metal castings.

Exhibit 1
Metal Casting Supply and End-Use Markets



Source: U.S. Department of Commerce, Bureau of Census, *Current Industrial Reports* MA331E(00) and MA331A(00)-1

Source: American Foundry Society *Facts & Figures About the U.S. Foundry Industry*, http://www.afsinc.org/trends/factsandfigures.htm

The basic metal casting process consists of pouring or injecting molten metal into a mold or die containing a cavity of the desired shape. The most commonly used method for small- and medium-sized castings is green sand molding, accounting for approximately 60 percent of castings produced. Other methods include die casting, shell molding, permanent molding, investment casting, lost foam casting, and squeeze casting.

Markets for metal castings are increasingly competitive and casting customers are placing greater emphasis on high-quality, competitively priced castings. There is increasing demand for lighter-weight, high-strength ferrous and nonferrous cast metal components and castings that meet demanding design specifications. Casting processes must continually evolve and improve to remain competitive in today's marketplace.

Metal Casting Industry Shipments

As shown in Exhibit 2, in 2001, the metal casting industry shipped a total of 12.2 million short tons of castings valued at $16.9 billion. This was a 13 percent decrease in total tonnage shipped and an 11 percent decrease in the value of castings shipped from the previous year. Over the period 1996-2001, there has been an average annual decline of 3 percent in casting shipments.[4]

[1] American Foundry Society, *AFS Trends Facts and Figures* www.afsinc.org/Trends/FactsandFigures.htm
[2] U.S. Department of Commerce, Bureau of Census, *Annual Survey of Manufactures 2000*, Table 3 NAICS code 3315.
[3] Lessiter, Michael J. *Modern Casting* "Oil Field Equipment & Machinery," November 2002, pg. 36.
[4] U.S. Department of Commerce, U.S. Census Bureau, *Current Industrial Reports*, Iron and Steel Castings 2000, MA331A(00)-1, Table 3; Non-Ferrous Castings 2000, MA331E(00)-1, Table 1.

Exhibit 2
U.S. Producers' Shipments of Nonferrous and Ferrous Castings (short tons)

Nonferrous Castings	1996	1997	1998	1999	2000	2001	Avg. % change (96-01)
Aluminum and aluminum-based alloy	1,521,081	1,593,876	1,921,137	1,976,343	2,037,213	1,817,283	4%
Copper and copper-based alloy	284,560	276,480	286,360	310,449	273,739	250,170	-2%
Magnesium and magnesium-based alloy	25,724	19,257	20,741	21,956	29,599	24,346	1%
Zinc and zinc-based alloy	221,543	228,933	239,169	225,058	225,528	191,601	-3%
Sub-Total Nonferrous	2,052,908	2,118,546	2,467,407	2,533,806	2,566,079	2,283,400	3%
Ferrous Castings	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**Avg. % change (96-01)**
Ductile iron	4,312,000	4,325,000	4,583,000	4,658,000	4,599,000	4,161,000	-1%
Gray iron	6,198,000	5,938,000	6,047,000	5,955,000	5,606,000	4,813,000	-5%
Malleable iron	263,000	272,000	247,000	207,000	186,000	135,000	-12%
Steel[1]	1,271,000	1,218,000	1,325,000	1,202,000	972,000	778,000	-9%
Sub-Total Ferrous	12,044,000	11,753,000	12,202,000	12,022,000	11,363,000	9,887,000	-4%
Total Nonferrous and Ferrous	**14,096,908**	**13,871,546**	**14,669,407**	**14,555,806**	**13,929,079**	**12,170,400**	**-3%**

Exhibit 3
Value of Shipments of Nonferrous and Ferrous Castings ('000 dollars)

Nonferrous Castings	1996	1997	1998	1999	2000	2001	Avg. % change (96-01)
Aluminum and aluminum-based alloy	$4,724,290	$5,172,590	$5,669,532	$5,556,386	$6,028,183	$5,428,376	3%
Copper and copper-based alloy	983,955	991,974	1,053,833	1,120,292	1,089,881	1,001,316	1%
Magnesium and magnesium-based alloy	272,842	225,685	256,852	245,677	256,274	203,325	-5%
Zinc and zinc-based alloy	809,127	818,963	914,648	928,341	873,831	765,108	-1%
Sub-Total Nonferrous	$6,790,214	$7,209,212	$7,894,865	$7,850,696	$8,248,169	$7,398,035	2%
Ferrous Castings	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**Avg. % change (96-01)**
Ductile iron	$3,971,500	$4,148,900	$4,428,400	$4,299,000	$4,381,100	$3,928,800	0%
Gray iron	4,463,000	4,719,500	4,635,100	4,446,000	4,406,200	3,817,900	-3%
Malleable iron	266,100	272,400	257,900	238,000	229,400	176,300	-7%
Steel[1]	2,295,600	2,343,500	2,499,000	2,161,000	1,806,800	1,587,200	-7%
Sub-Total Ferrous	$10,996,200	$11,484,300	$11,820,400	$11,144,000	$10,823,500	$9,510,200	-3%
Total Nonferrous and Ferrous	**$17,786,414**	**$18,693,512**	**$19,715,265**	**$18,994,696**	**$19,071,669**	**$16,908,235**	**-1%**

[1] Does not include steel investment castings.
Sources: U.S. Department of Commerce, U.S. Census Bureau, *Current Industrial Reports*, Iron and Steel Castings, MA331A(01)-1, and Non-Ferrous Castings, MA331E(01)-1.

2001 World Casting Production

As shown in Exhibit 4, the United States dropped to second in world ferrous casting production, with 16 percent of the world market. China leads the world in ferrous casting production with 24 percent of the world market. In 2000 and 2001, China experienced a 10 percent and 7 percent growth in ferrous casting shipments respectively, while the United States experienced nearly a 10 percent decline in casting shipments in 2001.[5]

As shown in Exhibit 5, the United States was the leader in nonferrous castings across nearly all alloy types with 24 percent of the world market, down slightly from 27 percent during 2000. Japan followed the United States with 12 percent of the world market. Aluminum represented 90 percent of Japan's nonferrous casting shipments, whereas the United States was more diversified with aluminum accounting for 68 percent of the nonferrous casting shipments. China held 11 percent of the world market. Mexico continued to have strong nonferrous production with 8 percent of the world market. This is a significant increase from 1995 when Mexico held only 2.9 percent of the world market.[6]

Although the United States is one of the largest producers of metal castings, its manufacturing sector is dependent upon imports to meeting casting demand. It is estimated that in 2003 the United States will rely on imports to meet 15 percent or 2.2 million tons of its total casting demand. The United States will rely on imports to supply 20.3 percent of its gray iron casting demand, and 13.6 percent of steel casting demand. Moreover, the United States will rely on imports to meet 17.5 percent of its total demand for aluminum castings and 18.6 percent of its requirements for bronze castings.[7]

Exhibit 4
2001 World Ferrous Casting Production
(Share of Tonnage Produced)

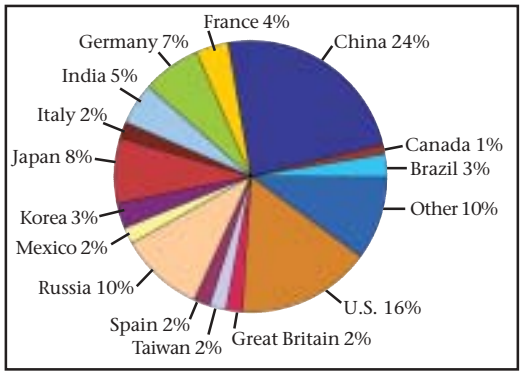
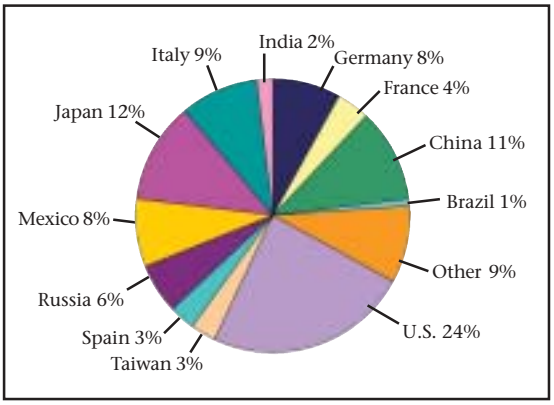


Exhibit 5
2001 World Nonferrous Casting Production
(Share of Tonnage Produced)



[5] Staff Writer, "36th Census of World Casting Production - 2001" *Modern Castings*, December 2002 p. 23.
[6] Ibid.
[7] Kirgin, Kenneth H. "Casting Imports: What to Expect in 2003" *Modern Castings*, September 2002 p. 24.

Energy Use in Metal Casting

The metal casting industry requires more than 460 trillion Btu annually.[10] This includes an estimated 328 trillion Btu consumed in metal casting operations and an estimated 132 trillion Btu lost as off-site power generation and distribution losses. Non-captive foundries consume 70 percent of the energy and captive foundries consume the remaining 30 percent. [Note: A "captive" foundry is one where the cast products are consumed on-site by the company, usually as the parts are incorporated into higher value-added products.] The major energy-consuming processes in metal casting include melting of metal, coremaking, moldmaking, heat treatment, and post-cast activities.[11] The industry spent $1.2 billion in 2001 on purchased fuels and electricity. Energy purchases equalled about 10 percent of the material cost and 4 percent of the value of shipments. Energy costs were highest in iron foundries (12 percent of material costs) and lowest in nonferrous die casting foundries (6 percent of material costs). Purchased fuels and electricity on average represented about 6 percent of the value of shipments for 2002.[12] The amount of energy that is consumed by the typical casting foundry is equivalent to the energy consumption of 100 residential homes per year.[13] Exhibit 6 shows the industry's energy use by fuel type and electricity. A majority of the industry's on-site energy (73 percent) is supplied by fuels (83 percent natural gas, 16 percent coke and breeze, and 1 percent other fuel sources). Electricity provides the remaining 27 percent of the industry's on-site energy needs with 89 trillion Btu being consumed.[14] The on-site electric energy demand requires nearly 221 trillion Btu of which nearly 132 trillion Btu are needed for the generation and transmission of power to the industry.

[10] Using *AFS 2002 Metalcasting Forecast & Trends*, the ratio of metal casting shipments (NAICS 3315) to captive foundry casting production was calculated. This ratio was applied to industry energy consumption for NAICS 3315, *1998 Manufacturing Consumption of Energy Report,* U.S. Department of Energy, Energy Information Administration Tables N.11.1, to estimate energy consumption in captive foundries. The tacit energy was then calculated based on EIA tacit energy conversion factors.

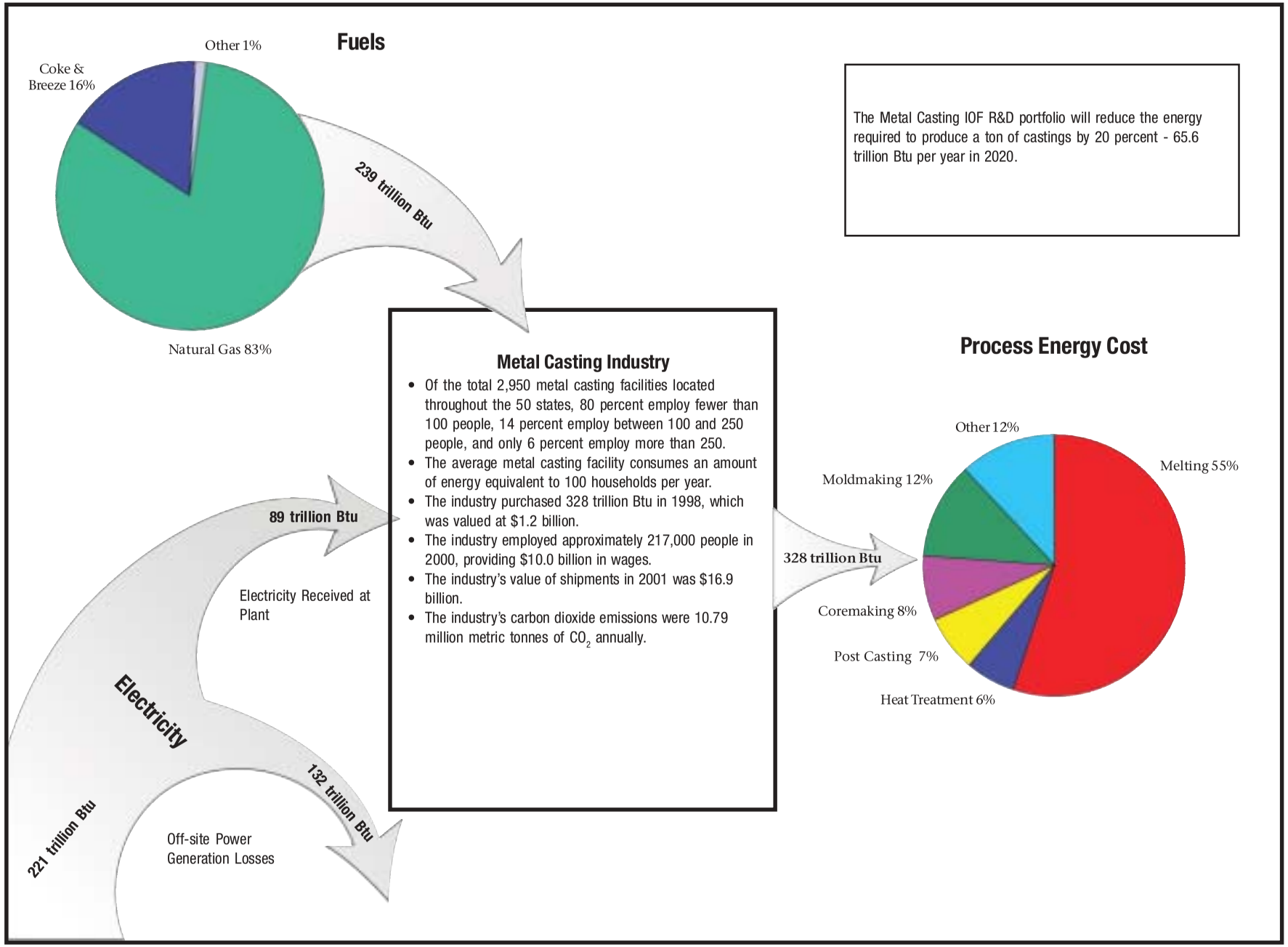
[11] U.S. Department of Energy, Energy Efficiency and Renewable Energy, Office of Industrial Technologies, Metal Casting Industry of the Future, *Energy and Environmental Profile of the U.S. Metal Casting Industry*, 1999, pg. 10.

[12] U.S. Department of Commerce, U.S. Census Bureau, *2000 Annual Survey of Manufactures*, Manufacturing Industry Series, Tables 2 and 4, *Detailed Statistics by Industry: 2000* for NAICS codes 3315, 331511, 331512, 331513, 331524, 331525, 331528, 331521, and 331522.

[13] Used the U.S. Department of Energy, Energy Information Administration, *Residential Energy Consumption Surveys*, to find the average Btu consumption in a year per house. Divided the number of foundries by the annual Btu consumption and found the average Btu consumption in a foundry. Calculated the ratio of number of houses to energy consumed in average foundry.

[14] U.S. Department of Energy, Energy Information Administration, 1998 Manufacturers Energy Consumption, Table N1.2. "First Use of Energy for All Purposes," NAICS code 3315; 331511; 331521; 331524.

Exhibit 6
Energy Use in Metal Casting



THE CHALLENGE

The metal casting industry is critical to the U.S. economy, as 90 percent of all manufactured goods contain one or more cast metal components. Metal castings are integral in U.S. transportation, energy, aerospace, manufacturing, and national defense. Metal casting is also one of the only major U.S. manufacturing industries that is dominated by small businesses. Moreover, the industry is widely dispersed throughout the country, limiting opportunities for geographic-based, intra-industry coordination. These unique characteristics have helped drive the need for public-private R&D collaboration.

The U.S. metal casting industry is diverse, employing a variety of casting processes and alloys to make a wide range of products. Because the majority of metal casters are small businesses, many lack the resources to perform high-risk, high-impact research on their own. Public-private research partnerships, such as the Cast Metals Coalition (CMC), have proven vital for performing long-term research needed to maintain a productive and healthy U.S. metal casting industry.

The U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy (EERE), Industrial Technologies Program (ITP), supports these partnerships by sponsoring cost-shared R&D funding to improve energy efficiency in metal casting. This partnership is encouraged by ITP's Metal Casting Industry of the Future (IOF) in collaboration with the CMC. The CMC is composed of the American Foundry Society (AFS), the North American Die Casting Association (NADCA), and the Steel Founders' Society of America (SFSA). Collectively, this coalition represents approximately 80 percent of the U.S. metal casting industry.

The partnership emphasizes university-based research with strong industry participation. This strategy taps the technical resources of our nation's educational institutions and positions industry partners to quickly apply the results of metal casting research — thereby saving energy and improving U.S. competitiveness in world markets. The involvement of industry in the early R&D stages helps to speed the pace of technology transfer.

Strong industry involvement ensures direct application of research results and gives evidence to the importance of this cost-shared research partnership. The Metal Casting IOF research partners represent the diversity of the metal casting industry, including suppliers, end-users, designers, ferrous and nonferrous foundries, and die casters. The partnership is also introducing hundreds of students to the industry and helping to sustain vital casting-related curricula at U.S. universities. Ensuring a well-educated and well-trained workforce is imperative for the metal casting industry to remain innovative and competitive in world markets.

Key Pathways

The Industries of the Future strategy was designed to foster government-industry partnerships in economically imperative, energy-intensive U.S. industries, including metal casting. This strategy has fostered industry partnerships and created the impetus for industry to develop long-term visions and roadmaps. Visions establish long-term goals for the future, while roadmaps outline the R&D pathways to achieve vision goals. The Metal Casting vision and roadmap have been the pillars for open and competitive solicitations for pre-competitive R&D that addresses both energy efficiency goals outlined in the *National Energy Policy* as well as industry research priorities. This successful government-industry partnership has now evolved to a point where it is focusing upon high-impact research to make revolutionary improvements in the energy efficiency of the metal casting process.

The Metal Casting IOF has been successful in improving energy efficiency and market competitiveness in the industry. For example, research in lost foam casting, co-funded by the Metal Casting IOF and in partnership with the Lost Foam Casting Consortium, has resulted in significant improvements in the lost foam process, and results have been implemented throughout the industry. The Metal Casting IOF is now targeting additional opportunities for high-impact research. The Metal Casting IOF is conducting in-depth analyses to map energy consumption in the industry by evaluating energy demand in each of the various processes and technologies used in metal casting. Further analysis will reveal the theoretical minimum energy use that may be achievable in the industry. The results of these analyses will assist the Metal Casting IOF in

identifying future areas of focus for high-impact research, setting the groundwork for a Grand Challenge research solicitation.

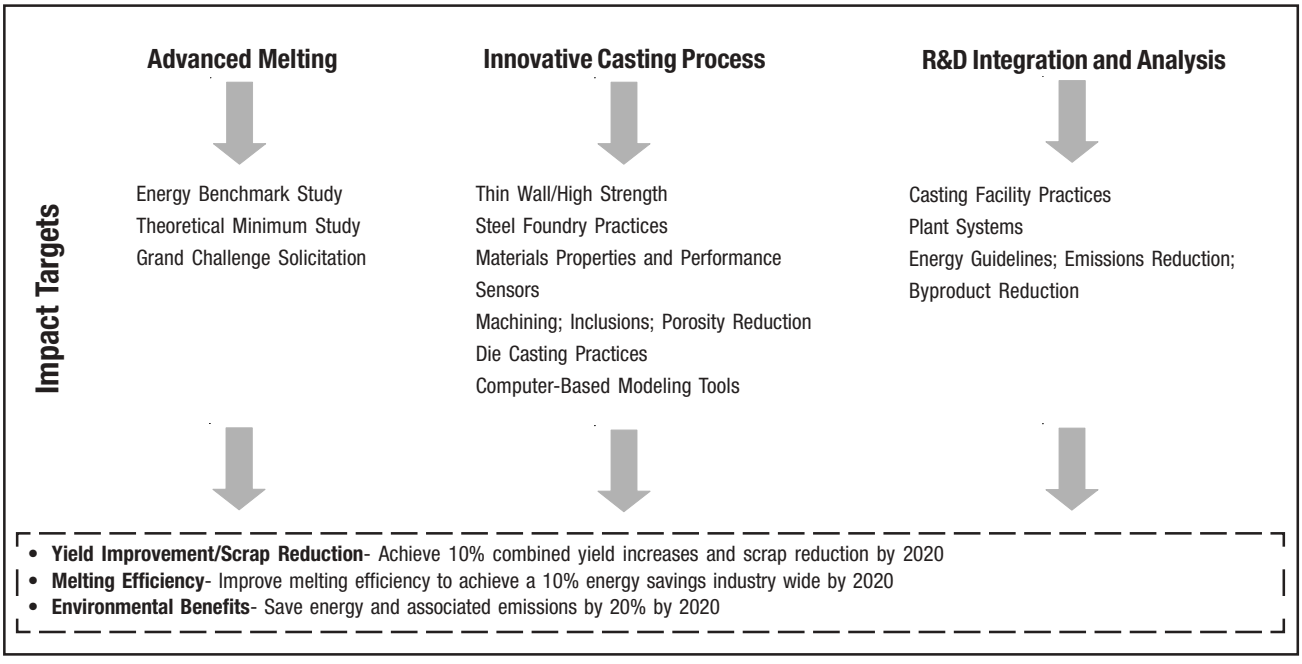
The Metal Casting IOF is organizing its research portfolio in three categories: Advanced Melting, Innovative Casting Processes, and R&D Integration and System Analysis in preparation for FY 2004. Exhibit 7 shows the target areas of each of these research categories. "Advanced Melting" and "Innovative Casting Process" formed the basis for the Metal Casting IOF solicitation offered in March 2003. Awards are expected by fall 2003.

Research Categories of the Metal Casting IOF

The success of the Metal Casting IOF is the result of a strong partnership between the Cast Metals Coalition (CMC) and EERE. In the future, this partnership will direct its efforts to address high-impact research to make revolutionary improvements in energy efficiency in metal casting. Research is grouped into three categories:

- **Advanced Melting:** Research to establish new melting technology processes and practices and significantly improve the energy efficiency of melting.
- **Innovative Casting:** Research that advances energy-efficient casting processes and practices that will increase yield and reduce scrap, thereby reducing remelting requirements.
- **R&D Integration and System Analysis:** Integration of applicable ITP technologies for improving energy efficiency and reducing emissions in metal casting practices.

Exhibit 7
Process & Technology Improvements Target Energy Efficiency



2003 HIGHLIGHTS & ACCOMPLISHMENTS

The Metal Casting Industry of the Future supports a diverse portfolio of cost-shared, pre-competitive research. Research projects address high-risk/high-impact needs that have broad application throughout the metal casting industry.

All metal casting research projects are selected through a competitive review process. Metal Casting IOF research must address both the priorities outlined in the *Metal Casting Industry Technology Roadmap* as well as DOE's national energy efficiency goals. Solicitations are announced in trade society publications and meetings, the *Commerce Business Daily, FedBizOpps*, the Metal Casting IOF Web site, and industry Web sites. In FY 2004 and beyond, the metal casting portfolio will transition to fewer research projects (with higher impact per project) that will have the opportunity to produce revolutionary improvements in metal casting energy efficiency.

Maintaining a strong and well-balanced portfolio requires careful attention throughout the competitive solicitation, evaluation, and selection process. The FY 2003 Metal Casting IOF research portfolio consists of 47 active projects, addressing the diverse research needs of the industry. Many of the projects in the portfolio have applications across various casting processes and alloys. All projects address the need to improve energy efficiency in the industry.

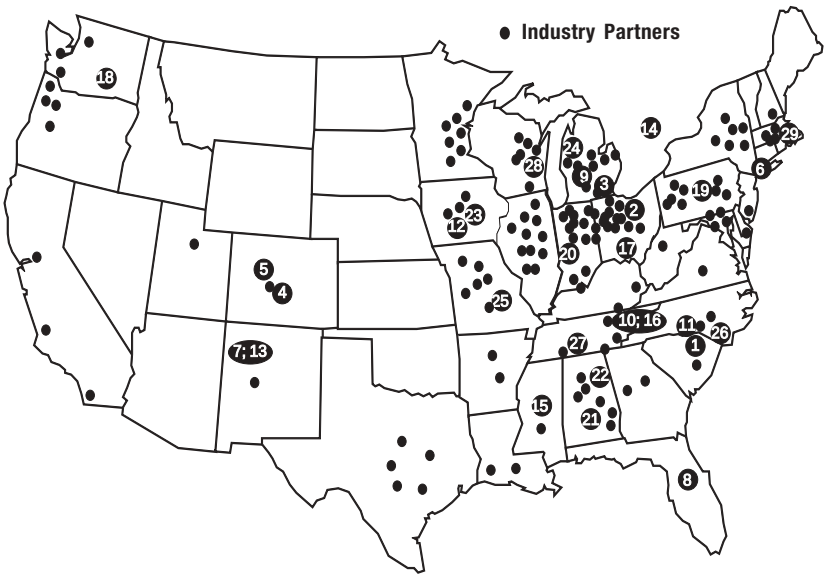
Broad Industry Partnership

One of the strengths of the metal casting research portfolio is the large participation of both industry and universities, providing both cost-share and in-kind support. Currently, the program is partnering with 325 industry, university, and national laboratory partners in 35 states across the United States. The geographic reach of the Metal Casting IOF is illustrated in Exhibit 8.

Exhibit 8
Broad Industry Partnership
Metal Casting Research Performers and Project Partners

Primary Research Performers

1 Advanced Technology Institute
2 Case Western Reserve University
3 Climax Research Services
4 Colorado School of Mines
5 Colorado State University
6 Copper Development Assoc., Inc.
7 Flow Simulation Services, Inc.
8 GKS Engineering Services
9 Hayes Lemmerz
10 Industrial Analytics Corporation
11 Intl. Lead Zinc Research Organization
12 Iowa State University
13 Los Alamos National Laboratory
14 Materials Technology Laboratory
15 Mississippi State University
16 Oak Ridge National Laboratory
17 Ohio State University
18 Pacific Northwest National Laboratory
19 Pennsylvania State University
20 Tri-State University
21 University of Alabama
22 University of Alabama - Birmingham
23 University of Iowa
24 University of Michigan
25 University of Missouri - Rolla
26 University of North Carolina -Charlotte
27 University of Tennessee
28 University of Wisconsin - Milwaukee
29 Worcester Polytechnic Institute

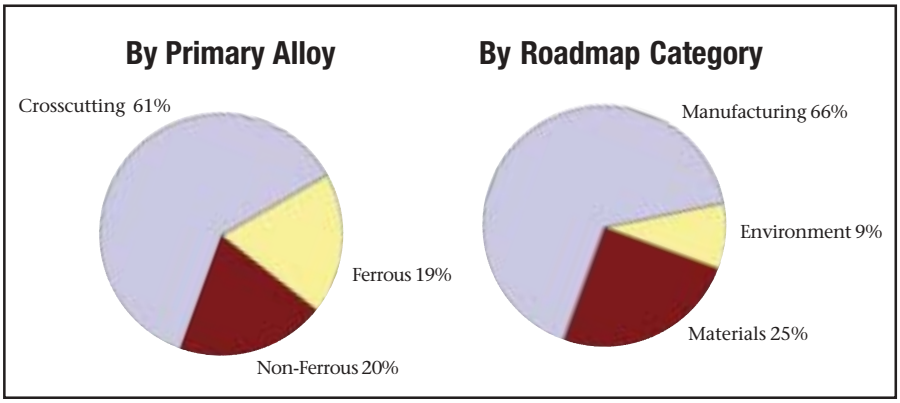


The Metal Casting Industry of the Future is partnering with 325 university, industry, and laboratory partners in 35 states across the U.S.

A Diverse Research Portfolio

Exhibit 9 illustrates program R&D funding by roadmap category and illustrates program funding by alloy. As shown, the portfolio addresses each of the key areas of the *Metal Casting Industry Technology Roadmap* — manufacturing, materials, and environment. Because many of the key opportunities for improving energy efficiency are in the area of manufacturing technologies, a larger portion of program funding goes to research in this category. It should be noted that although projects are categorized by the primary roadmap category they address, the majority of projects have crosscutting applications and respond to research priorities in multiple roadmap categories. The program also maintains a healthy balance of research targeted to both ferrous and nonferrous alloys as illustrated in the exhibit. Additionally, the majority of research in the program's portfolio crosscuts all alloy types, further leveraging research investments.

Exhibit 9
Research Funding



A list of the current portfolio of metal casting projects, organized by roadmap category, is shown in Exhibit 11 on page 10. Lead research organizations are also shown. Fact sheets for these projects can be found at http://www.oit.doe.gov/factsheets/fact_mc.shtml#metal.

Integrated Assistance for the Metal Casting Industry

The Metal Casting IOF has funded $18 million in research with an additional $23 million provided by industry cost-share over the period of 1997 to the present.

A number of other EERE program activities have performed research related to metal casting. These include NICE^3, Inventions & Innovation, and the Aluminum and Steel IOFs. Combined, they have provided an additional $19 million in funding on current research and technical assistance relevant to metal casters and leveraged an additional $19 million in cost-share.

Exhibit 10
Examples of EERE Technical and Financial Assistance

- **NICE^3:** National Industry Competitiveness through Energy, Environment, and Economics (NICE^3) provides funding to state and industry partnerships (large and small businesses) for projects that develop and demonstrate advances in energy efficiency and clean production technologies.
- **I&I:** Inventions and Innovation (I&I) provides financial assistance for conducting early development and establishing technical performance of innovative, energy-saving ideas and inventions.
- **IAC:** Industrial Assessment Centers enable eligible small and medium-sized manufacturers to receive comprehensive industrial assessments-performed at no cost to the manufacturer.

Beyond the research funding provided by the Metal Casting IOF, many EERE technical and financial assistance programs and services are available to the metal casting industry to improve energy efficiency and competitiveness in casting processes. Exhibit 10 describes several examples of EERE program assistance. Exhibit 12 lists recent examples of research above and beyond that performed through the Metal Casting IOF that is relevant to the metal casting industry.

In addition to those programs listed in Exhibit 10, EERE provides research on cutting-edge enabling technologies, including Sensors & Automation, Industrial Materials, Combustion, and others. The program enables risk-sharing on industry-specific pre-competitive long-term, high-impact research available through the Industries of the Future, such as Aluminum and Steel. The program also provides financial assistance for small businesses through Small Business Innovative Research grants.

In addition, the Metal Casting Industry of the Future is working with Allied Partners to help deploy the results of metal casting research and improve energy efficiency in the industry. Allied Partners are manufacturers, trade associations, industrial service and equipment providers, utilities, and other organizations that agree to promote increased energy efficiency and productivity for those industries that participate in the Industries of the Future strategy. The metal casting industry is working with the

Exhibit 11
Metal Casting Portfolio by Roadmap Category

(Fact sheets are available at http://www.oit.doe.gov/factsheets/fact_mc.shtml#metal)

Manufacturing

- Development of Computational Fluid Dynamics Tool for Modeling the Blowing and Steaming of Expandable Polystyrene (EPS) Patterns for Lost Foam Castings *(Arena, LLC)*
- Optimization of Squeeze Casting Process for Aluminum Alloy Parts *(Case Western Reserve University)*
- Effects of Die Design & Dimensional Features on Thermal Fatigue Cracking of Die Casting Dies *(Case Western Reserve University)*
- Gating of Permanent Mold Aluminum Casting (Phase II) *(Case Western Reserve University)*
- Integration of RSP Tooling with Rapid Prototyping for Die Casting Applications *(Colorado State University)*
- Quantification and Standardization of Pattern Properties for the Lost Foam Casting Process *(Industrial Analytics Corporation)*
- Ergonomic Improvements for Foundries *(Iowa State University)*
- Reduction in Energy Consumption and Variability in Steel Casting *(Iowa State University)*
- Effects of Applied Pressure During Feeding on the Fatigue Properties of Critical Cast Aluminum Alloy Components *(Mississippi State University)*
- Predicting Pattern Tooling and Casting Dimensions for Investment Casting - Phase II *(Oak Ridge National Laboratory)*
- Control of Soldering and Thermal Fatigue During Die Casting *(Oak Ridge National Laboratory)*
- Sensors for Die Casting *(Oak Ridge National Laboratory)*
- Castability Assessment and Data Integration for Die Casting Design *(Ohio State University)*
- Prediction of Part Distortion in Die Casting (Phase III) *(Ohio State University)*
- Energy Consumption of Die Casting Operations *(Ohio State University)*
- Understanding the Relationship Between Pattern Filling and Part Quality in Die Casting *(Ohio State University)*
- Computer Modeling of the Mechanical Performance of Die Casting Dies *(Ohio State University)*
- Improvements in Sand/Mold/Core Technology: Effects on Casting Finish *(Ohio State University)*
- Investment Shell Cracking *(Tri-State University)*
- Thin Wall Cast Iron: Phase 2 *(University of Alabama)*
- Advanced Lost Foam Casting, Phase V *(University of Alabama - Birmingham)*
- Clean Cast Steel Technology, Phase IV *(University of Alabama - Birmingham)*
- Advanced Steel Casting Technology *(University of Alabama-Birmingham)*
- Yield Improvement and Defect Reduction in Steel Castings *(University of Iowa)*
- Investigation of Heat Transfer at the Mold/Metal Interface in Permanent Mold Casting of Light Alloys *(University of Michigan)*
- Determination of Bulk Dimensional Variation in Castings *(University of North Carolina at Charlotte)*
- Semi-Solid Metals Processing Consortium *(Worcester Polytechnic Institute)*
- Manufacture of Semi-Solid Metals (SSM) Feedstock *(Worcester Polytechnic Institute)*

Materials

- Evaluation of Heat Checking and Washout of Heat Resistant Superalloys for Die Insert *(Case Western Reserve University)*
- Die Materials for Critical Applications and Increased Production Rates *(Case Western Reserve University)*
- Metallic Reinforcement of Direct Squeeze Die Cast Aluminum Alloys for Improved Strength and Fracture Resistance *(Case Western Reserve University)*
- Prevention of Porosity in Iron Casting *(Climax Research Services)*
- Development of a Fatigue Properties Database for Use in Modern Design Methods *(Climax Research Services)*
- Development of Surface Engineered Coatings for Die Casting Dies *(Colorado School of Mines)*
- Grain Refinement of Permanent Mold Cast Copper Base Alloys *(Copper Development Association)*
- Development Program for Natural Aging Aluminum Alloys *(GKS Engineering Services)*
- Creep Resistant Zinc Alloy Development *(International Lead Zinc Research Organization, Inc.)*
- Effects of Externally Solidified Product on Wave Celerity and Quality of Die Cast Products *(Ohio State University)*
- Heat Treatment Procedure Qualification for Steel Castings *(Pennsylvania State University)*
- Age Strengthening of Gray Cast Iron Phase III *(Tri-State University)*
- Metallic Recovery and Ferrous Melting Processes *(Tri-State University)*
- Clean, Machinable, Thin-Walled Gray and Ductile Iron Casting Production, Phase III *(University of Alabama - Birmingham)*
- Service Performance of Welded Duplex Stainless Steel Castings and Wrought Materials *(University of Tennessee)*

Environmental

- Development of Technical Data to Validate Performance of Foundry Byproducts in Hot-Mix Asphalt and Controlled Low-Strength Material *(Pennsylvania State University)*
- Non-Incineration Treatment to Reduce Benzene and V.O.C. Emissions from Green Sand Molding Systems *(Pennsylvania State University)*
- Steel Foundry Refractory Lining Optimization: Electric Arc Furnace *(University of Missouri - Rolla)*

technical societies, state casting associations, research institutes, and others to formalize Allied Partnership agreements. Through Allied Partners, EERE will be better able to deliver the results of research programs and technical assistance.

At present, the Metal Casting IOF and the Metals Processing Institute at Worcester Polytechnic Institute have formed an Allied Partnership. The objectives of this partnership are to increase knowledge and end-user awareness of opportunities in the operation and/or design of metal processing systems leading to improved productivity, energy efficiency, reliability, and reduced life-cycle costs for industrial customers.

Exhibit 12
Additional Industrial Technologies Research Related to Metal Casting

(Fact sheets are available at http://www.oit.doe.gov/factsheets/)

Financial Assistance

- Ceramic Composite Die for Metal Casting (Inventions & Innovation)
- High-Frequency Eddy-Current Separator for Foundry Sand (Inventions & Innovation)
- Computer Process Model for the Cupola Furnace (Inventions & Innovation)
- Casting Quality Measurements for Polystyrene Foam Patterns (Inventions & Innovation)
- A New "Pour In-Mold" (DPI) Technology for Producing Ductile and Compacted Graphite Iron Castings (Inventions & Innovation)
- Demonstration of a Vanadium Carbide Coating/Enhancing Wear Resistance (NICE^3)
- Reducing Foundry Emissions and Green Sand Waste (NICE^3)
- Rapid Heat Treatment of Cast Aluminum Components (NICE^3)
- Enhanced Application Control of Die Casting Lubricants (NICE^3)
- Commercial Demonstration of an Improved Magnesium Thixomolding Process (NICE^3)
- Die Casting Copper Motor Rotors (NICE^3)
- Improvement of the Lost Foam Casting Process (NICE^3)

Crosscutting Applications

- A Bubble Probe for Optimization of Bubble Distribution and Minimization of Splashing/Droplet Formation (Aluminum)
- Continuous Severe Deformation Processing of Aluminum Alloys (Aluminum)
- Coolant Characteristics and Control in Direct Chill Casting (Aluminum)
- Degassing of Aluminum Alloys Using Ultrasonic Vibrations (Aluminum)
- Development of an Innovative Vertical Floatation Melter and Scrap Dryer (Aluminum)
- Development of a Two-Phase Model for the Hot Deformation of Highly Alloyed Aluminum (Aluminum)
- Effect of Impurities on the Processing of Aluminum Alloys in Casting, Extrusion, and Rolling (Aluminum)
- Energy Efficient Isothermal Melting (Aluminum)
- Fundamental Studies of Structural Factors Affecting the Formability of Continuous Cast Aluminum Alloys (Aluminum)
- Gating of Permanent Mold Aluminum Casting Phase-II (Aluminum)
- High Efficiency, Low-Dross Combustion System for Aluminum Remelt Reverberatory Furnaces (Aluminum)
- Improved Energy Efficiency in Aluminum Melting (Aluminum)
- Molten Aluminum Treatment by Salt Fluxing with Low Environmental Emissions (Aluminum)
- Reduction of Annealing Times for Energy Conservation in Aluminum Processing (Aluminum)
- Reduction of Oxidative Melt Loss of Aluminum and its Alloys (Aluminum)
- Selective Absorption of Salts from Molten Aluminum (Aluminum)
- Surface Behavior of Aluminum Alloys Deformed Under Various Processing Conditions (Aluminum)
- Alloys for Ethylene Cracker (Chemicals)
- Improving the Efficiency of Electric Arc Furnace in the United States (Steel)
- Optical Sensors for Post Combustion Control in Electric Arc Steelmaking (Steel)

Technical Assistance

- BestPractices - Plant Assessments and Hands-on Technical Assistance
  - AMCAST
  - Metlab
- Industrial Assessments
  - Over $11.6 million in energy-saving recommendations implemented in the metal casting industry since 1992

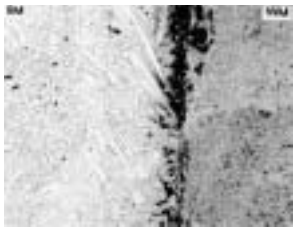
The Metal Casting Industry of the Future posted a number of important accomplishments in 2003 with energy efficiency improvements to be transferred to industry. The following describes accomplishments in several key areas including:

- Applying R&D Results
- Partnership Highlights
- Improving Energy Efficiency Today
- Disseminating Research Results to Industry
- Energy Analysis - Targeting Energy Efficiency

Applying R&D Results

Industry is adopting Metal Casting IOF research results rapidly in their casting operations. The following provides examples of metal casting research developments and applications.

- ***Clean Cast Steel Technology*** - Researchers at the University of Alabama- Birmingham developed a method to improve casting product quality by removing or minimizing oxide defects and allowing the production of higher-integrity castings for high-speed machining lines for gating systems, including shrouded pouring. By reducing scrap and heat treatment requirements, an estimated 5 percent savings of the energy used in steel casting could be achieved as a result of this research. ITP estimates that these improvements will save approximately 4 trillion Btu and $19.5 million in energy costs per year in 2020. Currently, three steel foundries — Falk Corporation, Atlas Foundry & Machine, and Harrison Steel Casting — have implemented the results of this study. To learn more, please visit http://www.oit.doe.gov/factsheets/metalcast/pdfs/uab_cleansteel.pdf.



Weld fusion boundary pitting corrosion-sensitive material ASTM A890-4A (2205 type).

- ***Service Performance of Welded Duplex Stainless Steel Castings and Wrought Materials*** – Research at the University of Tennessee has revealed that the corrosion performance of the solution-treated cast materials is equivalent to that of their wrought counterparts across the full range of compositions. This project increases yield, thus saving the energy associated with remelting. ITP estimates that this project will save approximately 700 million Btu and $470 thousand in energy cost savings in 2020. A specification for cast duplex stainless steel is balloted for inclusion in ASTM A923. For more information, please visit http://www.oit.doe.gov/metalcast/factsheets/ut_welded_duplex.pdf.

- ***Yield Improvement and Defect Reduction in Steel Casting*** - Researchers at the University of Iowa have developed new feeding distance rules for risering and pressurization of risers that will reduce shrinkage and increase yield in steel castings. This research program is also forming the basis for a new set of radiographic standards for steel castings. The results of this research are expected to improve yield by 10 to 25 percent with an equal reduction in melt energy requirements. These new rules will save approximately 30 trillion Btu and $154.27 million in energy costs per year in 2020. To learn more, please visit http://www.oit.doe.gov/metalcast/factsheets/ui_yield_def.pdf.

- ***Development of a Computational Fluid Dynamics Tool for Modeling the Blowing and Steaming of Expandable Polystyrene (EPS) Patterns for Lost Foam Casting*** - Researchers at Flow Simulation Services, Inc. have developed a mathematical tool that will allow, for the first time, an analytical approach to systematically design EPS pattern molds that will produce higher-quality patterns with reduced lead-time and expense. These tools are being used by a major automobile manufacturer to solve manufacturing bottlenecks. This research is expected to achieve significant defect reductions resulting in yield improvements of about 10 percent with an equal reduction in melting requirements. ITP estimates that this research will save 1.72 trillion Btu and $3.20 million in energy cost savings in 2020. To learn more, please visit http://www.arena-flow.com.

- ***Non-Incineration Treatment to Reduce Benzene and VOC Emissions for Green Sand Molding System*** - Researchers at Pennsylvania State University have been researching methods to develop a cost-effective, non-incineration technique that will significantly reduce VOC emissions from green sand foundries. The research has shown that Benzene and VOC emissions can be reduced by 10 to 75 percent; sand system pre-mix consumption can be reduced by 15 to 42 percent; foundry smoke

Box Pattern Filling

is reduced; and Advanced Oxidation (AO) Technology is scalable for small, medium, and large foundries. This technology will have an energy cost savings of approximately $57.33 million and 10.16 trillion Btu per year in 2020. For more information, please visit http://www.oit.doe.gov/metalcast/factsheets/voc_psu.pdf.

AO Technology has reduced smoke, odor, and emissions in foundries.

- ***Investigation of Heat Transfer at the Mold-Metal Interface in Permanent Mold-Casting of Light Alloys*** - Researchers at the University of Michigan have focused their work on improving the design functions supporting production of light alloy castings produced by permanent mold casting processes. This work provides the basis for the production of casting walls that are thinner, lighter weight, higher integrity, and with improved mechanical properties. Their research has developed and experimentally verified a new approach to estimating interfacial heat transfer in Indirect Squeeze Casting and Low Pressure Permanent Mold Casting. Accurate modeling of the heat transfer will reduce scrap rates, production lead-time, tooling costs, and delivery times. ITP estimates an energy savings of 8 percent or 2.61 trillion btu and an energy cost savings of $15.96 million in 2020 for this project. For more information, please visit http://www.oit.doe.gov/metalcast/factsheets/cda_grain_refinement.pdf.

- ***Iron Fatigue Design Properties*** - Researchers at Climax Research Services (CRS) have developed a first-of-its-kind listing of 22 cast irons (gray, ductile, austempered ductile, and compacted gray iron) strain controlled fatigue properties along with the structure that is found in typical sections that are common in the metal casting industry. This database is available to original equipment designers and enables the production of lighter-weight castings that require less melting, thus reducing the energy required. To learn more, please visit http://www.oit.doe.gov/metalcast/factsheets/crs_fatigue.pdf.

- ***Simple Visualization Techniques for Die Casting Part and Die Design*** - Research conducted at Ohio State University has helped the die casting industry identify and resolve die casting design problems while still in the design phase. The software, *CastView,* is intended to help minimize flow-related problems, thermal problems in the die casting die, and solidification-related defects in the cast part. Reports by users of this software say that they have experienced scrap reduction of 20 percent and first-time successes have been made. To learn more, please visit http://www.oit.doe.gov/metalcast/factsheets/vistool.pdf or http://www.diecasting.org/.

- ***Effects of Composition and Processing of High Performance Die Steels*** - Research conducted at Case Western Reserve University indicated that specifically processed die steels of selected compositions are superior in performance to other die steels that have been employed in the past. Modification of die steel chemical composition and heat treatment processing have resulted in die life improvements of 20 to 30 percent and higher, significantly reducing energy use associated with die replacement and testing as well as reducing die replacement costs. In one case, a new steel composition yielded an improvement of 30 percent over Premium Grade H-13 resulting in gains of $150,000, and a 5 percent scrap reduction. Researchers estimate that results from this project will have an energy savings of 4.6 billion Btu annually. To learn more, please visit http://www.oit.doe.gov/metalcast/factsheets/cwru_die_life_optimal_comp.pdf.

- ***A Study of Aluminum Alloy Microstructure Performance Interaction*** - The results of this study have been compiled by NADCA in *Microstructures and Properties of Aluminum Die Casting Alloys*. Die Casters can now access a database explaining the effects of key elements on the properties of the die cast product. This permits a tailoring of alloy compositions to optimize die castings for specific applications. Die casters have utilized the information to improve heat sinks by enhancing the thermal capability of an alloy and to increase the strength of an alloy. For more information about the publication, please visit http://www.diecasting.org/.

- ***RSP Tooling*** – The Rapid Solidification Process (RSP™) was developed at the Idaho National Engineering and Environmental Laboratory to allow die casters to build production tooling in the time it usually takes to make prototype tooling. The technique eliminates the need for any CNC milling, sink EDM, benching, polishing, engraving, and heat treatment. This technology is projected to save 5.4 trillion Btu in 2020. The invention received an *R&D 100 Award* in 1998 and the *Federal Laboratory Consortium Award* in 2001. In 2002, RSP™ Tooling, LLC was formed to design, build, use, and sell machines that manufacture tooling using this process. To learn more, please visit http://www.oit.doe.gov/metalcast/factsheets/csu_rsp_tooling.pdf.

Partnership Highlights

A New Roadmap for the Future - In July 2002, the Cast Metals Coalition (CMC) published its new vision, *A Vision for the U.S. Metal Casting Industry 2002 and Beyond*. In January 2003, the CMC, working with DOE and industry, held a workshop to develop a technology roadmap for achieving goals set forth in the vision. The publication will be available to the public in November 2003 and will be on-line at: www.oit.doe.gov/metalcast/pdfs/mcvision.pdf.

Improving Energy Efficiency Today

Within ITP there are other services that help industry save energy today. These include software tools, training, and energy-saving resources from EERE BestPractices and Industrial Assessment Centers. Recommendations by these groups have the potential to save metal casters millions of dollars annually. For example, a plant-wide assessment performed by the BestPractices program for AMCAST Industrial Corporation in Wapakoneta, Ohio, identified 12 plant and process modifications that would result in an annual savings of $3.7 million per year. The actual savings experienced by the plant were close to $6 million per year. In addition, AMCAST has embarked on a program to replicate the projects at their other North American facilities. This ambitious action will result in a total corporate savings of $36 million. To learn more, visit: http://www.oit.doe.gov/bestpractices/factsheets/amcast.pdf.

Disseminating Research Results to Industry

The Metal Casting IOF performs various outreach activities to disseminate R&D results and enable the U.S. metal casting industry to implement energy-saving practices and technologies. This includes participating in trade shows and maintaining an up-to-date Web site that highlights Metal Casting IOF activities. In addition, through trade publications such as *Die Casting Engineer* and *Modern Casting,* research funded by the Metal Casting IOF is often highlighted, exposing metal casters to research that can save them energy and reduce their costs. Examples of trade shows in which the Metal Casting IOF participates include:

- CastExpo hosted by AFS (www.afsinc.org)
- Die Casting Congress & Exposition hosted by NADCA (www.diecasting.org)
- Technical and Operating Conference hosted by SFSA (www.sfsa.org)

Energy Analysis - Targeting Energy Efficiency

The Metal Casting IOF is performing an Energy Footprint Study of the U.S. Metal Casting Industry. This study will benchmark energy use in the various types of metal casting facilities, and measure the effectiveness of the processes and technology improvements in energy savings. The study will assist the Metal Casting IOF and the CMC to direct efforts to high-impact, revolutionary processes research. Also in February 2003, the Metal Casting IOF began a study to evaluate energy requirements for various metal casting processes for the Metal Casting IOF. This study is evaluating the theoretical minimum and practical potential for reducing energy requirements to produce 1 ton of molten metal in metal casting operations. These reports will be available at: http://www.oit.doe.gov/metalcast/tools.shtml.

TOOLS, PUBLICATIONS, AND RESOURCES AVAILABLE

The Metal Casting Industry of the Future offers a wide array of tools and publications to help metal casters improve productivity and energy efficiency. These resources are available on-line at the Metal Casting Web site at http://www.oit.doe.gov/metalcast/tools.shtml.

Tools and Publications

The tools and publications available from the Metal Casting IOF include:

- ***A Vision for the U.S. Metal Casting Industry: 2002 and Beyond***: This document outlines the broad goals and challenges identified by industry leaders that must be addressed over the next 20 years. Achieving the goals set forth in the vision will improve productivity and energy efficiency in the industry and quicken the development and application of advanced, clean technologies in metal casting processes.

- ***Metal Casting Industry Technology Roadmap (1997)***: The Metal Casting Industry Technology Roadmap establishes the industry's R&D priorities, performance targets, and milestones for attaining the goals set forth in the vision. A new roadmap is currently under development.

- ***Gateway to Metal Casting Resources***: This application is available both on-line and in CD-ROM form. It provides abstracts of Metal Casting IOF projects along with links to both fact sheets and technical reports of these projects. Projects are categorized by alloy, casting method, and step in the casting process. This application provides both links to the technical societies and other resources available from DOE.

- ***The Metal Casting Industry of the Future Annual Report 2002***: The report gives a snapshot of the Metal Casting IOF during 2002. It provides industrial trends in shipments and production, energy use, and employment. The report also provides information on Metal Casting IOF accomplishments and a synopsis of each Metal Casting IOF-funded project.

- ***Energy and Environmental Profile of the Metal Casting Industry***: This detailed report benchmarks the energy and environmental characteristics of the key technologies used in the major processes of the metal casting industry.

To view these documents and application, please visit: http://www.oit.doe.gov/metalcast/tools.shtml.

Fact Sheets

The Metal Casting IOF disseminates information on current and past projects through project fact sheets. The information provided in each fact sheet includes the objective, accomplishments, benefits, principal investigator, and project partners. All metal casting fact sheets are available on-line at: http://www.oit.doe.gov/factsheets/fact_mc.shtml#metal and on the *Gateway to Metal Casting Resources*.

HOW TO GET INVOLVED AND CONTACT INFORMATION

Partnership Information

Public-private partnerships are the foundation of ITP's technology delivery strategy. ITP includes its partners in every phase of the technology development process to focus scarce resources where they can have the greatest impact on industrial energy efficiency. To learn more, please visit our Web site at www.eere.energy.gov/industry.

- Collaborative, **cost-shared research and development** projects are a central part of ITP's strategy. Annual solicitations provide technology development opportunities in a variety of energy-intensive industries.

- **Industries of the Future Partnerships** increase energy efficiency in the most energy-intensive industries. In addition to cost-shared research and development projects, industry partners participate in the development of vision and roadmap documents that define long-term goals, technology challenges, and research priorities.

- **Allied Partnerships** provide an opportunity for ITP to reach a broad audience of potential customers by allying with corporations, trade associations, equipment manufacturers, utilities, and other stakeholders to distribute industrial energy efficiency products and services. By becoming an Allied Partner, an organization can increase its value to clients by helping them achieve plant efficiencies.

- **State energy organizations** work with ITP in applying technology to assist their local industries. ITP assists states in developing IOF partnerships to mobilize local industries and other stakeholders to improve energy efficiency through best practices, energy assessments, and collaborative research and development.

- **EERE's technical programs** (of which ITP is one of eleven) give manufacturers access to a diverse portfolio of energy efficiency and renewable energy technologies and bring advanced manufacturing technology to the renewable energy community. For more information, access the EERE home page at www.eere.energy.gov.

- The President's **Climate VISION** (Voluntary Innovative Sector Initiatives: Opportunities Now) effort also offers opportunities for manufacturers to pursue cost-effective actions that will reduce greenhouse gas emissions. See www.climatevision.gov for details.

Access to Resources and Expertise

The Industrial Technologies Program provides manufacturers with a wide variety of industrial energy efficiency resources to help your company cut energy use right away. Visit our site at www.eere.energy.gov/industry or call the EERE Information Center at 877-337-3463 to access these resources and for more information.

- ITP offers **energy management best practices** to improve energy efficiency throughout plant operations. Improvements to industrial systems such as compressed air, motors, process heat, and steam can yield enormous savings with little or no capital investment.

- Our suite of powerful system optimization **software tools** can help plants identify and analyze energy-saving opportunities in a variety of systems.

- **Training sessions** are held several times per year at sites across the country for companies interested in implementing energy-saving projects in their facilities. DOE software tools are used as part of the training sessions.

- ITP's qualified **industrial energy specialists** will work with your plant personnel to identify savings opportunities and train staff in the use of ITP software tools.

- Our extensive library of **publications** gives companies the resources they need to achieve immediate energy savings.

- **Plant-wide energy assessments** are available to manufacturers of all sizes interested in cutting their energy use. Cost-shared solicitations are available each year for plant-wide energy assessments. In addition, no-cost, targeted assessments are provided to eligible facilities by teams of engineering faculty and students from 26 university-based Industrial Assessment Centers around the country.

- The **DOE Regional Offices** provide a nation-wide network of capabilities for implementing ITP's technology delivery strategy. Regional Offices are located in Atlanta, Boston, Chicago, Denver, Philadelphia, and Seattle. Visit www.eere.energy.gov/rso.html for more information.

Where to Go to Get More Information

Visit our Web site - http://www.oit.doe.gov/metalcast/

Learn about all EERE Programs - http://www.eere.energy.gov/

Ask an Expert - The Office of Industrial Technologies Clearinghouse is a great way to access ITP's resources. Times available are 9 a.m. to 8 p.m. EST (6 a.m. to 5 p.m. PST).
Phone: 1-800-862-2086

For print copies of DOE, EERE, and ITP Publications, contact -
Energy Efficiency and Renewable Energy Clearinghouse (EREC)
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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and great energy independence for America. By investing in technology breakthroughs today, our nation can look forward to a more resilient economy and secure future.

Far-reaching technology changes will be essential to America's energy future. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a portfolio of energy technologies that will:

- Conserve energy in the residential, commercial, industrial, government, and transportation sectors
- Increase and diversify energy supply, with a focus on renewable domestic sources
- Upgrade our national energy infrastructure
- Facilitate the emergence of hydrogen technologies as a vital new "energy carrier"

The Opportunities

Biomass Program
Using domestic, plant-derived resources to meet our fuel, power, and chemical needs

Building Technologies Program
Homes, schools, and businesses that use less energy, cost less to operate, and ultimately, generate as much power as they use

Distributed Energy & Electric Reliability Program
A more reliable energy infrastructure and reduced need for new power plants

Federal Energy Management Program
Leading by example, saving energy and taxpayer dollars in federal facilities

FreedomCAR & Vehicle Technologies Program
Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle

Geothermal Technologies Program
Tapping the Earth's energy to meet our heat and power needs

Hydrogen, Fuel Cells & Infrastructure Technologies Program
Paving the way toward a hydrogen economy and net-zero carbon energy future

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry through improvements in energy and environmental performance

Solar Energy Technology Program
Utilizing the sun's natural energy to generate electricity and provide water and space heating

Weatherization & Intergovernmental Program
Accelerating the use of today's best energy-efficient and renewable technologies in homes, communities, and business

Wind & Hydropower Technologies Program
Harnessing America's abundant natural resources for clean power generation

To learn more, visit www.eere.energy.gov

Metal Casting Industry of the Future

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry

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

published January 2004