Supporting Industries

Supporting Industries 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 U.S. Department of Energy's (DOE) Industrial Technologies Program (ITP) Supporting Industries (SI) portfolio seeks to assist U.S. supporting industries in reducing energy consumption and waste generation in their respective industries, while these industries strive to improve their own global competitiveness. To achieve this goal, several supporting industries were identified that contribute substantial energy, environmental, and product quality benefits to the IOF. These SI were derived from the entire chain of manufacturing industries consisting of raw materials, basic manufacturing, forming and finishing, and end-use industrial sectors. The seven SI currently recognized by the ITP are process heating, heat treating, welding, advanced ceramics, forging, powder metallurgy and particulate materials (PM2), and carbon products. These SI have an estimated energy consumption of 5.94+ quadrillion Btu annually.

The SI portfolio strategy is designed to foster government-industry partnerships in the economically imperative, energy-intensive industries, including the seven recognized supporting industries. The SI initiative has fostered industry partnerships and created the impetus for industry to develop long-term visions and roadmaps. The portfolio maximizes its limited resources to develop and deploy projects parallel to the nation's energy plan objectives. In doing so, SI utilizes resource leveraging and cost-sharing opportunities to reduce the SI energy consumption and help improve the SI global competitiveness.

Research Highlights

There are nine active SI projects. Four of these projects offer comparatively large energy savings. These projects have been funded to Advanced Joining Technologies, Worcester Polytechnic Institute, and Ohio State University representing welding, powder metallurgy, heat treating, and forging sectors and hold an annual combined potential energy saving of up to 35 trillion Btu.

The Advanced Joining Technologies project, "*Superior Joining and Energy-Efficient Manufacturing Through Friction Stir Welding,"* proposes to develop and deploy friction stir welding (FSW) as a superior method to join steels and aluminum alloys. The project is structured into four main tasks including FSW process development, material characterization, predictive numerical simulation of FSW and industrial application deployment and validation. Estimated energy-saving potential for this project is 12.8 trillion Btu per year.

The Worcester Polytechnic Institute project, "*Development of Continuous, Direct-Feedback Control Systems for Sintering of Metallic Composites,"* focuses on the development and field testing of a continuous, direct-feedback system for optimization of powder metallurgy components that has a potential annual energy saving of 2.4 trillion Btu.

Another project with Worcester Polytechnic Institute, "*Materials and Process Design for High Temperature Carburizing Billets,"* integrates optimization of process and materials to enable a broad usage of high-temperature carburization in order to reduce cycle times. Both vacuum and plasma methods are covered to ensure broadest availability of commercial heat treatment processes. The unique capabilities of high-temperature carburizing will be exploited to access new levels of steel performance including the distortion-free, high-performance bearing and gear materials for the transportation sector. Emphasis is placed on creation of a new class of thermally stable, ultra-durable, case-hardened tool and die steels enabling major productivity gains in the forging and die casting of aluminum and steel. This project will allow accelerated replacement of conventional steels with a new class of carburizing steels with greatly broadened applications. U.S. annual energy consumption for carburizing will go from 80 trillion Btu to 20-24 trillion Btu with a reduction in greenhouse gases, and reduced scrap and elimination of the need for hard chromium plating in several applications.

The Ohio State University's (OSU) project, "*Innovative Die Material and Lubrication Strategies for Clean and Energy Conserving Forging Technology,"* aims to develop and implement innovative die material and surface-coating strategies, such as composite dies and self-lubricating coatings, which will reduce energy consumption and costs and improve quality of forged parts to prevent rejection. A fully equipped forging cell at OSU will be the first of its kind in the United States. Project partners will use it to carry out research on industrial-sized equipment.

Benefits of this project include an increased die life, reduced energy (electricity and natural gas) input by 90 percent and energy cost per piece by 50 percent, reduced particulate emissions from lubricants by 90 percent, the creation of wear and failure data to determine preventive maintenance and repair schedules, and targeted quality improvements of 25 parts per million rejection rates.

SUPPORTING INDUSTRIES OVERVIEW

As part of its IOF strategy, DOE's Industrial Technologies Program (ITP) works with energy-intensive industries to improve efficiency, reduce waste, and increase productivity. These IOFs – aluminum, chemicals, forest products, glass, metal casting, mining, petroleum and steel – rely on several supporting industries that supply materials and processes necessary to form and finish the products that the industries create before they are marketed to end-use industries. These supporting industries, in many cases, also provide great opportunities for realizing energy efficiency gains in the IOF processes. Certain supporting industries, such as powder metals and carbon products, produce parts, components, and products for specific end-use applications by using alternative manufacturing processes that are either faster and more cost-effective, or utilize waste materials.

ITP examined supporting industries in the United States that traditionally and significantly contribute to the global competitiveness of the products of eight energy-intensive basic U.S. manufacturing industries. As a result, the following seven supporting industries were identified. These industries contribute substantial energy, environmental, and product quality benefits to the aforementioned basic manufacturing industries.

· Process Heating
· Heat Treating
· Welding
· Advanced Ceramics
· Forging
· Powder Metallurgy and Particulate Materials
· Carbon Products

ITP works with these industries in much the same way it does with the IOFs, funding cost-shared R&D that addresses industry-defined priorities as well as national goals for energy and the environment. In many cases, projects focus on potentially high-payoff technologies that are too risky or too costly to attract the magnitude of private funding necessary to achieve breakthroughs.

Supporting Industries Shipments and Market Share

The economic data published for SI includes process heating, heat-treating, welding, advanced ceramics, forging, powder metallurgy, and carbon products. Based on these industries, the total SI value of shipments was $3.85 trillion while employment was over 16 million. The largest number of these jobs are found in the process heating industry. Below is an overview of each of the SI markets. Exhibit 1 illustrates what each industry supplies in terms of annual shipments as well as each industry's estimated employees.

Process Heating - With its wide and varied industrial use, process heating directly and indirectly affects the employment of an estimated 16 million people in the United States at more than 300,000 establishments with a total annual sales and shipments of $3.8 trillion.

Heat Treating - The heat-treating industry is directly related to metal producing and secondary processing industries, and accounts for $20 billion in the United States annually and $75 billion worldwide. In the United States, approximately 5,000 facilities operate roughly 55,000 furnaces, 66 percent of which are gas-fired and the remainder electrically heated.

Welding - Welding expenditures represent a substantial contribution to the U.S. economy. Many industries that employ welding processes provide the backbone for our nation's defense, infrastructure, and economic well-being. Revenue from these industries totaled over $3.1 trillion in 2000, representing roughly one-third of the total U.S. Gross Domestic Product (GDP). Energy consumption for the industry is estimated at approximately 129 trillion Btu annually. This characterization is shown not to state that welding is a major source of GDP, but rather that welding is ubiquitous in manufacturing.

Advanced Ceramics - The United States currently accounts for $8.5 billion, or 35 percent of the global advanced ceramics market. Forecasts project a global market growth of 8 percent per year between 2000 and 2005, totaling $11.7 billion in 2005. Within the U.S. market, electronics account for 64.7 percent of advanced ceramics applications, followed by chemical and environmental applications (18.7 percent), ceramic coatings (10.2 percent), and structural ceramics (6.4 percent).

Forging - The total forging industry output in North America is estimated to exceed $6 billion annually, achieved by some 25,000 workers mostly in facilities processing iron and steel. The forging industry consumes approximately 1.67 billion kWh of electricity each year, a relatively low amount compared to other technologies producing finished or semi-finished parts.

Powder Metallurgy and Particulate Materials (PM2) - The PM2 industry in the United States is commonly divided into categories of powder producers (the value of U.S. shipments was near $2 billion in 2000; worldwide production exceeding 1 million tons annually), tooling and equipment makers (approximately 100 U.S. companies accounting for $300 million in sales annually), and component and product producers (estimated 250 U.S. producers accounting for $5 billion in sales annually). The PM2 industries consume 16 trillion Btu each year.

Carbon Products - A large portion of the carbon products industry is built on recovering and processing byproducts from other primary operations. The estimated value of shipments of carbon products in 2001 totaled approximately 2.8 billion. Purchased energy for 2001 totaled approximately 2 billion kWh.

Exhibit 1 Economic Data for the Currently Addressed Supporting Industries

Supporting Industries	Value of Shipments ($ billion)	Number of Employees
Process Heating	3,800.0	16,000,000
Heat Treating	20.0	ND
Welding	4.0	18,300
Advanced Ceramics	8.5	ND
Forgings	6.0	36,000
PM2	7.3	40,000
Carbon Products	2.8	11,000
Total	**3,850**	**16,105,300**

ND: No data available
Compiled from *Supporting Industries Energy and Environmental Profile*

THE CHALLENGE

The SI portfolio seeks to assist U.S. supporting industries in reducing energy consumption and waste generation in their respective industries, while they strive to improve their own global competitiveness. The portfolio seeks to accomplish improvement through the integration of SI advanced technology research with that of ITP IOF and crosscutting initiatives. This integration will be aimed to improve the quality and productivity of the finished products and parts while keeping their costs competitive in their end-use markets. The SI goals are to:

- Identify coincident targets of SI, IOFs, and professional associations consistent with IOF goals.
- Encourage collaborative research efforts to reach coincident targets by forming SI alliances.
- Continue to explore opportunities for integrating SI research efforts with those of the IOFs and cross cutting ITP initiatives, consistent with IOF missions and goals.
- Assess and communicate energy, environmental, productivity, and product improvement benefits of the ITP-supported SI research to attract Congressional interest. Target a 20 percent increase in energy efficiency and 30 percent reduction of energy use for each SI by 2010.
- Explore ways to increase the commercialization success rate of SI-sponsored technologies.
- Continuously improve the communication of information on project portfolio, emerging technologies, and best practices, and the process of tracking and reporting technical successes, commercial successes and deployment of the SI-sponsored technologies.
- Successfully manage the schedule, cost, and performance of a balanced portfolio of projects.

Energy Use in Supporting Industries

Supporting industries account for a significant amount of energy consumption within the chain of raw materials, forming and finishing, and end-use industrial sectors. For the seven supporting industries currently addressed by the SI portfolio, total estimated energy consumption is 5.94 quadrillion Btu per year, indicating prospects for large energy savings.

Process-heating technologies supply heat to nearly all manufacturing processes including basic materials and commodities such as steel, cement, and composites, and the value-added products such as electronics, computer chips, textiles, etc. These heating processes consume about 5.2 quadrillion Btu of energy annually, accounting for nearly 17 percent of all industrial energy use.

Heat-treating processes consume 458 trillion Btu per year. These processes are essential to building automobiles, aircrafts, spacecrafts, computers and other heavy equipment and are closely linked to manufacturing products and parts made of steel, alloys of aluminum, copper, magnesium, nickel, and titanium. The vast majority of heat-treated materials are iron and steel with parts that are cast, forged, welded, machined, rolled, stamped, drawn, and extruded. Other heat-treated materials are brass, bronze, and titanium alloy structures.

Welding processes are divided in two main classes, fusion welding for similar or same family materials, and solid state welding for similar and dissimilar materials, and remainder as brazing and soldering. Welding processes apply to most manufacturing and construction industries including heavy, aerospace, petroleum, and automotive. The total energy consumption of the U.S. welding industry is about 129 trillion Btu per year (54 for heavy industry, 43 for light industry, and 32 for automobile, aircraft, and aerospace industries).

Forging components are used in over 20 percent of the products that comprise the GDP of the United States. Some of these applications include automotive and truck, aerospace, off-highway equipment/railroads, general industrial equipment, shipbuilding, and agricultural machinery and equipment. Forging is a key aspect of the metal manufacturing process. Energy consumption of the forging industry ranges between 9 -18 trillion Btu per year. When system inefficiencies and energy consumed in other areas of a forge shop are included, the forging energy consumption can be 6000 - 8000 Btu per pound which, based on the forging shipments, implies 28 - 37 trillion Btu per year energy consumption for the U.S. forging industry.

The PM2 industry produces near-net-shape components with tight dimensional tolerances at moderate temperatures with minimized finishing operations, cost, and energy use. PM2 components are used in many markets including metal cutting, automotive, tools, motors and controls, aircraft and turbine engines, oil/gas well drilling equipment, tractors, etc. Powder manufacture and sintering are the most energy-intensive steps in the process, consuming an estimated 36.3 billion Btu per ton of parts. By 2000 statistics of a 401,000 ton yield, the total estimated energy consumption of the PM2 industry is about 16 trillion Btu annually.

The carbon products industry supplies critical materials and components to essential U.S. industries including aluminum, steel, chemicals, aerospace, and environment. The industry consumes about 107 trillion Btu of energy per year. Some carbon products include Hall-Heroult anodes, cathodes and sidewalls for aluminum manufacturing, electrodes and carbon blocks for steel furnaces, crucibles, heaters, and filters.

Exhibit 2 Estimated Energy Consumption for Currently Addressed and Additional Supporting Industries (10^{12} Btu)

Process Heating	5,200
Heat Treating	458
Welding	129
Advanced Ceramics	ND
Forging	28-37
PM2	16
Carbon Products	107

ND - No data available
Data compiled from the *Profile of Total Energy Use for U.S. Industry*, Draft August 2003

Key Pathways

The SI portfolio is designed to foster industry partnerships and create the impetus for industry to develop long-term visions and roadmaps. These visions establish long-term goals for the future, while roadmaps outline the R&D pathways to achieve vision goals. For each SI, the common strategic pathway is to develop opportunity assessments and studies, industry workshops, industry roadmaps, and deployment of the ITP BestPractices tools. Also, recommendations created by using the RAND ITP Database Navigator (DBN), which is described under the *"Partnership Efforts"* section, are provided for incorporating the SI roadmap research into IOF solicitations, or to develop joint solicitations. Industry workshops are being planned to determine SI Grand Challenge ideas based on discussions and analysis of various inputs such as the *IES Energy Savings* (IES-ES) *Roadmap* results, the *Manufacturing Chain Energy Profile* results, the RAND study results, roadmap barriers, etc. In addition, the following specific pathways are being used for some of the currently addressed supporting industries to reach their individual goals.

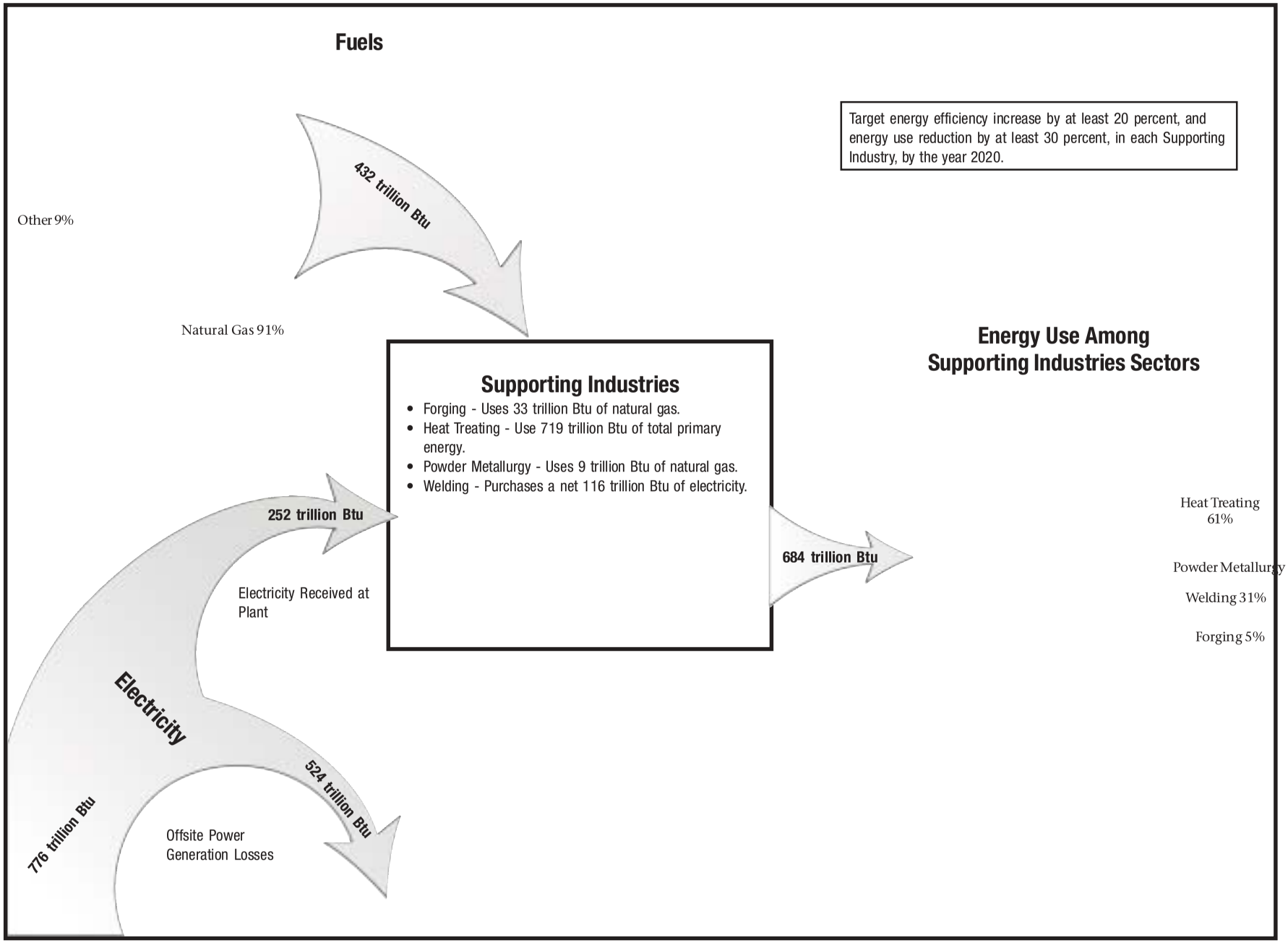
Process Heating - The first step will be to define 2002 Industrial Heating System of the Future and Furnace Grand Challenge (FGC) concepts. The FGC concepts will be based on inputs from I*ES-ES Roadmap*, *Process Heating Roadmap*, furnace demographic study, and the periodic ITP-IHEA furnace user conferences that will be planned. The *IES-ES Roadmap* will examine all IOF energy footprints and profiles and identify energy-saving opportunities (long- and short-term) applied to industrial energy systems. The demographic study will assess process heating industry energy use; types of processes used with their classification in meaningful categories, types of equipment used by different industries, number of heating equipment for different types and age, and current efficiency level for the process categories.

Heat Treating - The FGC concepts will attempt to address modular and hybrid furnaces. Active projects on heat treatment of castings, carburizing and rapid aluminum billet preheating address prediction software for thermal cycle, microstructure and properties and material distortion, and processes to control mechanical properties.

Welding - Active projects on gas metal arc welding (GMAW) and friction stir welding (FSW) will develop an integrated GMAW model to optimize the welding process, and deploy FSW as a superior method for joining steel and aluminum alloys.

Powder Metallurgy and Particulate Materials (PM2) - An active project on continuous, direct-feedback control systems for sintering metallic composites is focusing on controlling and optimizing the de-lubrication process used during the sintering of powder metallurgy components.

Exhibit 3
Energy Use in the Supporting Industries



FY 2003: HIGHLIGHTS AND ACCOMPLISHMENTS

The SI portfolio received $1.6 million in funding in fiscal year 2003. The portfolio consists of nine active projects. This includes projects from industry, universities, and laboratories.

Broad Industry Partnership

One of the strengths of the SI portfolio is the large participation of industry, associations, universities, and laboratories providing both cost-share and in-kind support. Currently, SI has 45 partners. Partners are mostly concentrated on the East Coast and Midwest but reach as far west as California. Exhibit 4 provides a list of industry partners and their locations throughout the United States.

Exhibit 5 illustrates R&D funding by partner type, most of which are in industry. SI supports several types of partners from industry, universities, laboratories, and associations.

A Diverse Research Portfolio

Following are the nine active SI projects that are related to aluminum alloy forgings, welding processes, die material, and quenching for heat treating, welding, powder metals, and forging industries. Exhibit 6 (page 7) illustrates that the nine SI projects are consistent with the goals for the SI roadmap.

Exhibit 5
Supporting Industries Partners by Sector

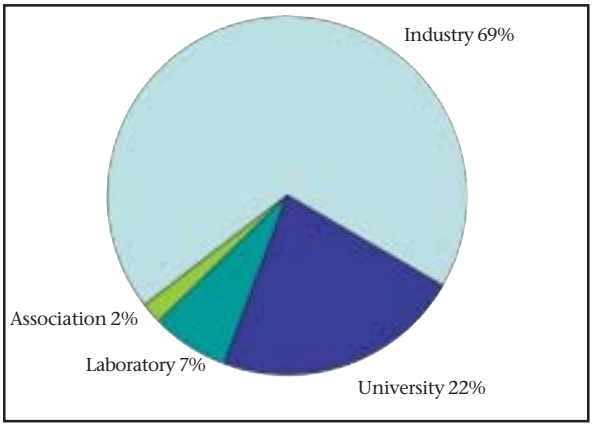


Exhibit 4 Research Performers and Project Partners of Supporting Industries

Advanced Joining Technologies
Advanced Metal Products
Air Products and Chemicals
Akron Steel Treating
Aluminum Company of America
AMCAST Industrial Corporation
Argonne National Laboratory
Bodycote Thermal Processing
Brigham Young University
Case Western Reserve University
Caterpillar, Inc.
Center for Heat Treating Excellence
Deere & Company
Eclipse Combustion
Edison Materials Technology Center
Euclid Heat Treating
Forging Industries Association
General Motors Corporation
Houghton International
Industronics Service Company
IPSEN International
IQ Technologies, Inc.
Kolene Corporation
KomTek
Lincoln Electric Company
Northeastern University
Northwestern University
Pacific Northwest National Laboratory
Pennsylvania State University
Pratt & Whitney
Queen City Forging Company
Sandia National Laboratories
South Dakota School of Mines & Technology
Summit Heat Treating
Surface Combustion
The Boeing Company
Timken Company
Torrington Company
UES Software
University of Connecticut
University of Massachusetts-Amherst
Worcester Polytechnic Institute
Oak Crest Institute of Science
Oak Ridge National Laboratory
Ohio State University

Superior Joining and Energy Efficient Manufacturing Through Friction Stir Welding, Advanced Joining Technologies - This project proposes to develop and deploy friction stir welding (FSW) as a superior method to join steels and aluminum alloys. The project is structured into four main tasks including FSW process development, material characterization, predictive numerical simulation of FSW and industrial application deployment and validation. Estimated energy-saving potential for this project is 12.8 trillion Btu per year.

Development of Continuous, Direct-Feedback Control Systems for Sintering of Metallic Components, Worcester Polytechnic Institute - This project will focus on the development and field testing of a continuous, direct-feedback system for the control and optimization of the de-lubrication process during the sintering of powder metallurgy components. The project has a potential annual energy savings of 2.4 trillion Btu.

Materials and Process Design for High-Temperature Carburizing Integrating and Performance, Worcester Polytechnic Institute - This project will develop a fast, high-temperature carburizing process using the computational materials design approach developed by Northwestern University's Steel Research Group. The project will integrate optimization of process and materials to enable a broad usage of high-temperature carburization in order to reduce cycle times. Estimated annual energy savings is 20 trillion Btu.

Innovative Die Material and Lubrication Strategies for Clean and Energy-Conserving Forging Technology, Ohio State University - This project will develop and implement innovative die material and surface coatings such as composite dies and self-lubricating coatings to increase die life. The project will also decrease process energy input by 15 percent, reduce energy cost per piece by 50 percent, reduce particulate emissions from lubricants by 90 percent and increase die-related uptime to 90 percent.

Fatigue Resistant, Energy Efficient (FREE) Welding, Caterpillar, Inc. - This project will focus on using pulsed waveforms to produce fatigue resistant welds in high-strength steels, structural steels, and aluminum. Estimated annual energy savings is 3.4 trillion Btu.

Intensive Quenching Technology for Heat Treating and Forging Industries, Edison Materials Technology Center (EMTEC) - This project is focused on developing a method of uniformly quenching heated metal parts with a very high cooling rate that is several times greater than conventional quenching processes. Estimated annual energy savings is 600 billion Btu.

An Energy Savings Model for the Heat Treatment of Castings, Worcester Polytechnic Institute - This project will develop an integrated system of software, databases, and design rules to enable quantitative prediction and optimization of the heat treatment of castings to reduce energy consumption, increase quality, increase productivity, and reduce heat treatment cycle times. Estimated annual energy savings is 6.93 trillion Btu.

Enhancement of Aluminum Alloy Forgings Through Rapid Preheating of Billets, KomTek, Inc. - This project will focus on identifying the mechanisms and rates of rapid preheating billets required to obtain an order of magnitude refinement on grain size. It will also determine improvement in mechanical properties

Exhibit 6 Summary of Potential Annual Energy Savings from the Nine Active Projects

Name of SI Partner	Name of SI Project	Potential Energy Savings
Advanced Joining Technologies	Superior Joining and Energy Efficient Manufacturing Through Friction Stir Welding	12.8 trillion Btu
Caterpillar, Inc.	Fatigue Resistant, Energy Efficient (FREE) Welding	3.4 trillion Btu
Edison Materials Technology Center (EMTEC)	Intensive Quenching Technology for Heat Treating and Forging Industries	600 billion Btu
Worcester Polytechnic Institute (WPI)	Development of Continuous, Direct-Feedback Control Systems for Sintering of Metallic Components	2.4 trillion Btu
WPI	An Energy Savings Model for the Heat Treatment of Casting	6.93 trillion Btu
WPI	Materials and Process Design for High-Temperature Carburizing Integrating and Performance	20 trillion Btu
Ohio State University	Innovative Die Material and Lubrication Strategies for Clean and Energy Conserving Forging Technology	ND
KomTek, Inc.	Enhancement of Aluminum Alloy Forging Through Rapid Preheating of Billets	2.1 billion Btu
The Lincoln Electric Company	Novel Optimization Methodology for Welding Process/Consumable Integration	2.05 million Btu
Estimated Total		**46.164 trillion**

ND-No Data Available

produced by such an improvement, and design, construct, and implement a hybrid rapid preheating technology for rapid preheating billets. Estimated annual energy savings is 2.1 billion Btu.

Novel Optimization Methodology for Welding Process/Consumable Integration, The Lincoln Electric Company - This project will develop a generalized methodology to describe operational characteristics and mechanical property development as a function of welding process variables and alloy composition in an integrated fashion. Estimated annual energy savings is 2.05 million Btu. Associations are adopting the strategy of establishing partnerships and cooperative alliances with the government and academia.

Partnership Highlights

U.S. manufacturing companies and their trade and professional associations are adopting the strategy of establishing partnerships and cooperative alliances with the government and academia. This strategy centers on the development of new, diverse and better materials and products while partners strive to reach coincident goals and targets. Within the SI portfolio, several technology roadmaps have been completed and several partnerships and alliances have been formed. These roadmaps are used as the basis to identify opportunities for collaborative research to leverage technical and financial resources.

Partnership Efforts and Successes for Supporting Industries

ITP has created many leveraging opportunities for the supporting industries. Several supporting industries began to leverage their limited R&D resources by forming long-term alliances and short-term partnerships with the technical societies, trade and professional associations, academia and government through which they can pool their knowledge and specialized facilities.

Process Heating Steering Committee (PHSC) - Established with the sponsorship of ITP. Membership consists of Industrial Heating Equipment Association (IHEA) member companies executives, IOF executives (steel, aluminum, glass, forging) and ITP staff. Through teleconferences and periodic meetings, members provide input on their industry needs, possibilities of collaborative efforts, and steps to advance technologies for improving their process heating equipment (furnaces, process heaters, kilns, dryers, etc.). Its subcommittees in materials, systems protocol, sensors and controls, and research and development are active in identifying Grand Challenge projects and collaborating with the national laboratories.

The Center for Heat Treating Excellence (CHTE) - The alliance between the industrial sector and university researchers was established in 1999. Through a member-driven portfolio, this alliance addresses short and long-term needs of the heat treating industry by applying fundamental research to solve industrial problems and to advance technologies.

Materials Treating Institute (MTI) - The heat treating, forging and welding industries collaborate with MTI to enter into partnership with the ITP Chemical IOF for developing unique and special purpose materials for the chemical industries.

Partnership Efforts by the Forging Industries Association (FIA) - FIA, in coordination with ITP, carried out tasks to form several industry-university alliances which led to various roadmap implementation projects. These four alliances are listed below.

1. Joint Activities Discussions - Advanced Steel Processing and Products Research Center (an industry-university cooperative dedicated to ferrous metallurgy) and the Watervliet Arsenal and Benet Research Laboratories.

2. Center of Excellence in Forging Technology (CEFT) - Located at The Ohio State University, CEFT will work closely with the Center for Heat Treating Excellence (CHTE) at the Worcester Polytechnic Institute.

3. Forging Defense Manufacturing Consortium - This $15 million R&D project is demonstrating readiness improvements in the forging supply chain. It is a 6 - year project that will produce multi-attribute dies for forging and die-casting industries.

4. Joint Industry Alliance (JIA) - American Iron and Steel Institute's (AISI) Bar and Rod Market Development Group, FIA, and ASM Heat Treatment Society, formed the JIA with the sponsorship of the Steel IOF. The Alliance seeks to carry out cross-cutting, pre-competitive research to resolve industrial developmental issues and to produce a database that could be used to compare product conditions before and after forging and heat treating operations. Constituencies include members from associations, suppliers, end-users, and the federal government. Efforts are under way to extend JIA to The Center for Powder Metallurgy Technology, end-use industries, and DOC-NIST.

Plant-Wide Assessments - Plant-Wide Assessments (PWA) investigate overall energy use in industrial facilities which can account for 10 percent or more of an industry's total operating costs, and highlight opportunities for best energy management practices for industry, including the adoption of new, efficient technologies. BestPractices works with supporting industries to characterize finding and document savings that can be replicated in other facilities and other industries for multipled savings. Companies that participate in assessments can expect to realize a minimum of $1 million savings annually from energy costs, waste reduction, and increased productivity, usually with a payback of less than 18 months. Exhibit 7 shows four ongoing PWAs for supporting industries.

Exhibit 7: Plant-Wide Assessments for the Supporting Industries

Company Name and Plant location	Date Awarded
Jernberg Industries, Chicago, IL	December 2001
Metaldyne, Royal Oak, MI	September 2002
Metlab, Philadelphia, PA	June 2000
Utica Corporation, Utica, NY	June 2000

Allied Partners - The Allied Partnership is a key element of IOF BestPractices. Allied Partners work to provide energy efficiency information, products, services, and support to industrial manufacturers. An Allied Partner agreement represents a shared, voluntary commitment to promote industrial energy efficiency. Four allied partners who have signed to work with SI include Industrial Heating Equipment Association (IHEA), Forging Industries Association (FIA), Metal Powder Industries Federation (MPIF), and Center for Heat Treating Excellence (CHTE).

RAND ITP Database and Navigational Tool - Under the sponsorship of the ITP SI initiative, an "ITP Database & Navigational Tool" was developed to define multiple-application/ multiple-industry research projects. By using this tool, advanced technologies could be developed that will not only yield larger overall energy savings but also greater chances for commercial success due to widened industry participation. This tool can be used to identify the crosscutting industry research needs, and the opportunities for developing multiple-industry research proposals.

Integrated Assistance for the Supporting Industries

Beyond the research funding provided by SI, many EERE technical and financial assistance resources and services are available to SI to improve energy efficiency and competitiveness in the included industries.

In addition to the nine SI technology roadmap projects (TRP), the SI portfolio supports and tracks directly related and relevant projects funded through the other IOF areas. Exhibits 8 (page 10) and 9 (page 11) show these relationships and projects based on their respective sector.

Exhibit 8 Directly Related Project Highlights

Funding Portfolio: Steel IOF
- Advanced Control of Operations in the Blast Furnace
- An Optical Sensor for Post-Combustion Control in Electric Arc Furnace Steelmaking
- Development and Demonstration of a High-Efficiency, Rapid-Heating, Low-NOx Alternative to Conventional Heating of Steel Shapes
- Development and Demonstration of Novel Low-NOx Burners for Boilers in the Steel Industry
- Dilute Oxygen Combustion System
- Hot Oxygen Injection into the Blast Furnace
- Improving Refractory Service Life and Recycling Refractory Materials in EAF Steel Production
- Minimizing NOx Emissions from By-Product Fuels in Steelmaking
- Nitrogen Control in Electric Arc Furnace Steelmaking by Direct Reduced Iron Fines Injection
- Optical Sensors and Controls for Improved Basic Oxygen Furnace Operations
- Optimizing of Post Combustion in Steelmaking

Funding Portfolio: Chemicals IOF
- High-Efficiency, Ultra Low-Emission, Integrated Process Heater System
- Funding Portfolio: Petroleum IOF
- Dilute Oxygen Combustion (DOC) System
- High-Efficiency, Ultra Low-Emission, Integrated Process Heater System
- NOx Emission Reduction by Oscillating Combustion
- Online Sensors for Emissions Monitoring (Petroleum, Phase II)
- Rotary Burner Technology Demonstration (Phase I)
- Thermal Imaging Control of High-Temperature Furnaces
- Very Low Emissions: Forced Internal Recirculation

Funding Portfolio: Combustion
- Process Heat Combustion System
- Super Boiler: Packed Media/Transport Membrane Boiler Development and Demonstration

Funding Portfolio: Aluminum IOF
- Dynamic Expert System Controls for Optimal Oxy-fuel Melter Performance
- High-Efficiency, High-Capacity, Low-NOx Aluminum Melting Using Oxygen-Enhanced Combustion
- High-Efficiency, Low-Dross Combustion System
- Innovative Energy-Efficient High-Temperature Gas-Fired Furnace
- Nickel Aluminide Heat Trays and Furnace Fixtures
- Rotary Burner Technology Demonstration (Phase 1)
- Very Low Emissions: Forced Internal Recirculation (FIR) Burner
- Diagnostics and Control of Natural Gas-Fired Furnaces via Flame Image Analysis (Glass)
- Diagnostics and Modeling of High-Temp Corrosion of Superstructure Refractories in Oxy-fuel Glass Furnaces
- Diode Laser Sensor for Combustion Control (Steel)
- Glass Furnace Combustion and Melting User Research Facility
- High-Luminosity, Low-NOx Burner

Funding Portfolio: Sensors and Automation
- Development of a Versatile Laser Ultrasonic System and Application to Online Measurement for Process Control
- Diagnostics and Control of Natural Gas Fired Furnaces via Flame Image Analysis (Glass)
- Integrated Industrial Process Sensing and Control System Applied to and Demonstrated in Cupola Furnaces
- Real-Time Gas Composition Analyzers for Online Process Control (Aluminum, Ceramic, Chemical, Forest Products, Glass, Metal casting, Steel)
- Thermal Imaging Control of High-Temperature Furnaces (Steel)
- Tunable Diode Lasers Sensors for Monitoring and Control of Harsh Combustion Environments

Exhibit 9: Relevant Project Highlights

Process Heating
- An Optical Sensor for Post-Combustion Control in Electric Arc Furnace Steelmaking
- Technology of Low Coal Rate and High Productivity of Rotary Hearth Furnace Iron making
- Pulverized Coal Injection
- Quantifying the Thermal Behavior of Slags
- Temperature Measurement of Galvanneal Steel
- NOx Emission Reduction by Oscillating Combustion
- Innovative Vertical Floatation Melter (VFM) and Scrap Dryer
- Energy Conserving Tool for Combustion-Dependent Industries
- Energy Efficient Isothermal Melting Process (ITM)
- Improving Energy Efficiency in Aluminum Melting
- Reduction of Oxidative Melt Loss
- Demonstration of a High-Temperature, Corrosion-Resistant Coating (NICE^3)
- Rapid Heat Treatment of Cast Aluminum Components (NICE^3)
- Development and Validation of a Coupled Combustion Space/Glass Bath Furnace Simulation
- Waste Heat-Driven Ammonia Absorption Chiller (Combustion)
- Solid-State Chemical Sensors for Monitoring Hydrogen
- Sensor Fusion for Intelligent Process Control (Glass)

Welding
- Hybrid Integrated Model for Gas Metal Arc Welding
- Materials and Process Design for High-Temperature Carburizing
- Study of Deformation Behavior of Lightweight Steel Structures Under Impact Loading
- Development of Appropriate Spot Welding Practice for Transformation Hardened Steel

Heat Treating
- Integrated Heat Treatment Model for Aluminum Castings
- Effects of Residuals in Carbon Steel
- Controlled Thermo-Mechanical Processing of Tubes and Pipes for Enhanced Manufacturing and Performance
- Removal of Residual Elements in the Steel Ladle by a Combination of Top Slag and Deep Injection
- Research Related to Automated Steel Cleaning Analysis (ASCAT)

Powder Metallurgy
- A HotEye-Based Coordinate Measuring Machine for the Forging Industry
- Continuous Severe Plastic Deformation (CSPD) Processing of Aluminum Alloys

Advanced Ceramics
- Development of Submerged Entry Nozzles that Resist Clogging
- CastCon Process for Mining Applications Led by Michigan Technological University
- Fibrous Monolithic Composites as Wear-resistant Components for mining Led by Advanced Ceramics Research, Inc.
- Selection and Development of Metallic and Refractory Materials for Black Liquor and Biomass Gasification

Improving Energy Efficiency Today

BestPractices, an initiative of the U.S. DOE's ITP, works with supporting industries to identify plant-wide opportunities for energy savings and process efficiency. Through the implementation of new technologies and systems improvements, companies across the United States are achieving immediate savings results. Involvement in BestPractices allows companies to join the ranks of forward-thinking U.S. industrial manufacturers who are saving energy and money, reducing pollution and emissions, and increasing productivity right now.

The Metals Processing Laboratory Users Facility (MPLUS) is a DOE, EERE, and ITP user facility designated to assist research in key industries, universities, and federal laboratories in improving energy efficiency, improving environmental aspects, and increasing competitiveness. The goal of MPLUS is to provide access to the specialized technical expertise and equipment needed to solve metals processing issues that limit the development and implementation of emerging metals processing technologies. The scope of work can also extend to other types of materials. MPLUS enables industry and academia access to unique DOE laboratory capabilities to address key industrial materials issues. MPLUS can help SI primarily in the area of advanced ceramics. SI is fully aware of the potential opportunities that exist in the future where MPLUS can provide key research activities within the seven SI areas. MPLUS has four primary User Centers including:

· Processing – casting, powder metallurgy, deformation processing (extrusion, forging, rolling), melting, thermomechanical processing, high-density infrared processing

- Joining – welding, monitoring and control, solidification, brazing, bonding
- Characterization – corrosion, mechanical properties, fracture mechanics, microstructure, nondestructive examination, computer-controlled dilatometry, and emissivity
- Materials/Process Modeling – mathematical design and analyses, high performance computing, process modeling, solidification and deformation, microstructure evolution, thermodynamic and kinetic, and materials databases

Disseminating Research Results to Industry

The SI initiative performs various outreach activities to disseminate R&D results and enable industry to implement energy-saving practices and technologies. This includes participating in conferences and maintaining an up-to-date Web site that highlights SI activities. In addition, SI sponsored the pilot project *"Translating Paper-Based Roadmaps to Digital Form"* for the PM2 industry. Pennsylvania State University (PSU) developed a Web site that offers users a digital version of the PM2 roadmap that can be updated via user comments to individual elements on the Web site. The information in the Web site will be used to develop and modify respective technology roadmaps with expert input. This Web site is able to organize information about the roadmapping process and provide information about resources for professionals. This concept could be used to increase details of technical needs identified in the existing IOF roadmaps, link roadmaps across multiple industry sectors to identify common needs and critical barriers, and integrate critical barriers into cohesive R&D funding scenarios. If proven successful, PSU will seek other industry sponsors to digitize their roadmaps.

Energy Analysis - Targeting Energy Savings for Supporting Industries

SI is targeting national energy savings, by year 2020 (and 2010), as follows:

Process Heating Industry Energy-Saving Potential – The U.S. process heating industry consumes about 5.2 quadrillion Btu of energy annually. The efficiency level of process heating (PH) equipment is 15-80 percent. By 2020, advancements in technologies and operating practices will contribute significantly to achieving the energy and environmental performance targets of the vision industries, by offering the potential to reduce energy consumption in PH by an additional 5-25 percent. The industry expects to achieve this by improving performance of high-temperature materials; and developing predictive PH system models; heavy oil burner with gas emission profile; methods for stabilizing low-emission flames; advanced combustion technologies; and low-cost, low-temp heat recovery. These advancements will translate to a total U.S. process heating industry energy-savings potential of 26 trillion Btu per year to 1.3 quadrillion Btu per year (average 0.8 quadrillion Btu/yr).

Heat Treating Industry Energy-Saving Potential – The U.S. heat-treating industry consumes 458 trillion Btu annually. Industry's goal is to reduce energy consumption by 80 percent. Operating efficiencies of heat-treating processes are 5-70 percent for gas furnaces, and 15-100 percent for electric furnaces. It can be assumed that the potential for energy savings exist as 40 percent for gas-fired furnaces and 30 percent for electric furnaces. The heat-treating industry expects to achieve this potential by developing new furnace designs and implementing better combustion controls and heat recovery, translating to a total U.S. heat-treating industry energy-saving potential of 180 trillion Btu per year.

Welding Energy Industry Energy-Saving Potential – The U.S. welding industry consumes about 129 trillion Btu annually. Welding energy efficiency depends on which technique is used. Processes with high-energy density, such as laser welding and high power source efficiency, have lower energy input. The typical power source efficiency is in the 75-85 percent range. The industry vision proposes to reduce welding energy by 50 percent. It expects to achieve this target by increasing productivity through decreased pre- and post-heating operations, advanced lower heat input welding processes and filler materials, alternate energy sources, and automation and robotics, which will translate to a total U.S. welding industry energy-savings potential of 64 trillion Btu per year.

Advanced Ceramics Industry Energy-Saving Potential - The United States Advanced Ceramics Association (USACA) is working in cooperation with the ITP to explore ways in which advanced ceramics can reduce

energy consumption and pollution in energy-intensive industries. By 2020, advanced structural ceramics will be the cost-effective preferred materials that will exceed performance of other materials due to reliability, high-temperature capability, and other unique properties. Products will be initially designed for ceramic materials, with confidence, using established standards and design tools. Automation and other advanced fabrication processes will optimize cycle times and yield, ensure predictable and controllable production, and eliminate the need for post-process inspection.

Forging Industry Energy-Saving Potential – The U.S. forging industry consumes between 9-18 trillion Btu annually. Targets exist for improving the forging operating efficiency from an average of 60–80 percent to an energy-saving potential of 25 percent. The forging industry expects to achieve this by replacing fossil fuels; heating by induction; and heating for forgings weighing up to 25 tons, which will translate to a total U.S. forging industry energy-saving potential of 8 trillion Btu per year.

Powder Metallurgy and Particulate Materials (PM2) Industry Energy-Saving Potential – The U.S. PM2 industry consumes about 16 trillion Btu annually. Its vision goal is to reduce manufacturing energy by 50 percent by 2010, and by 80 percent by 2020. The industry expects to achieve this by improving the PM2 process efficiency, or its applications, by measures such as manufacturing full-density components using single pressing and sintering; manufacturing advanced materials using nano-scale iron powder; feedback process controls; three-dimensional forming; and improved joining of PM2 components. These advancements will translate to total U.S. PM2 industry energy-savings potential of about 8 trillion Btu per year by 2010, and 13 trillion Btu per year by 2020.

Carbon Products Industry Energy-Saving Potential – The U.S. carbon products industry consumes about 107 trillion Btu annually. The United States Advanced Ceramics Association (USACA) is working in cooperation with the ITP to explore ways in which advanced ceramics can reduce energy consumption and pollution in energy-intensive industries.

Plant-Wide Assessments - Plant-Wide Assessments (PWA) investigate overall energy use in industrial facilities which can account for 10 percent or more of an industry's total operating costs, and highlight opportunities for best energy management practices for industry, including the adoption of new, efficient technologies. BestPractices works with supporting industries to characterize findings and document savings that can be replicated in other facilities and other industries for multiplied savings. Companies that participate in assessments can expect to realize a minimum of $1 million in savings annually from energy costs, waste reduction, and increased productivity, usually with a payback of less than 18 months. Exhibit 11 shows the four ongoing PWAs for supporting industries.

TOOLS, PUBLICATIONS, AND RESOURCES AVAILABLE

The SI initiative offers a wide array of tools and publications to help supporting industries improve their productivity and energy efficiency. These resources are available on-line at the SI site at http://www.oit.doe.gov/related.

BestPractices Tools

ITP's BestPractices team works with the industry to identify plant-wide opportunities for energy savings and process efficiency. Through implementation of new technologies and systems improvements, companies across the United States are achieving immediate savings results. Opportunities for serving these benefits to supporting industries are important because of the various plants involved. Both the ITP's BestPractices and SI initiative work with the supporting industries to identify opportunities to use energy more efficiently through new technology implementation, plant assessments, and system improvements. SI supports the deployment of software tools that assist industry in saving energy. These powerful tools help industry identify and analyze energy system savings opportunities in the plant. The following BestPractices tools help supporting industries realize energy savings:

Process Heating Assessment and Survey Tool (PHAST) - Process Heating Assessment and Survey Tool (PHAST) provides an introduction to process heating methods and tools to improve thermal efficiency of heating equipment. Use the tool to survey process-heating equipment that uses fuel, steam, or electricity, and identify the most energy-intensive equipment. Industry can also perform an energy (heat) balance on selected equipment (furnaces) to identify and reduce non-productive energy use, and compare performance of the furnace under various operating conditions and test "what-if" scenarios. Software for the PHAST tool can be downloaded at http://www.oit.doe.gov/bestpractices/process_heat.

Steam Systems Assessment Tool - The Steam System Assessment Tool (SSAT) allows users to assess potential savings from individualized steam-system improvements. Users input data about their plant's conditions, and the SSAT generates results detailing the energy, cost, and emissions savings that various improvements could achieve. Software can be downloaded at http://www.oit.doe.gov/bestpractices/steam/tools.shtml.

Steam System Scoping Tool - The Steam Scoping Tool guides an evaluation of a how a company manages a steam system against well-documented industry best practices. The user employs an MS Excel spreadsheet to respond to questions regarding operation and maintenance practices for his or her steam system. The spreadsheet calculates a rating score to indicate how the user's system compares to a high industry standard. Software can be downloaded at http://www.oit.doe.gov/bestpractices/steam/tools.shtml.

NOx Scoping Tool - The NOx scoping tool is designed to assist the development of a cost-effective, plant-wide strategy and plan for NOx reduction and energy efficiency improvements. This tool includes a method of taking inventory of NOx sources, information on NOx reduction, and information on commonly used methods of energy efficiency improvements and NOx reduction.

Publications

Process Heating
- Industrial Applications of Laser Ultrasonics

Heat Treating
- Research & Development Plant to Achieve Vision 2020
- Heat Treating Industry Vision 2020
- Report of the Heat Treating Technology Roadmap Workshop

Welding
- Vision for the Welding Industry
- Welding Technology Roadmap

Advanced Ceramics

- Advanced Ceramics Technology Roadmap
- Advanced Ceramics in Glass Production: Needs and Opportunities
- Applications for Advanced Ceramics in Aluminum Production: Needs and Opportunities
- Opportunities for Advanced Ceramics to Meet the Needs of Industries of the Future

Forging

- Forging Industry Vision of the Future
- Forging Industry Technology Roadmap
- Ohio State University Program

Powder Metallurgy and Particulate Materials (PM2)

- Powder Metallurgy and Particulate Materials Industry Vision and Technology Roadmap

Carbon Products

- The Carbon Products Industry Vision for the Future: A World of Carbon Products

Fact Sheets

The SI initiative disseminates information on current and past projects through project fact sheets. The information provided each fact sheet includes the objective, accomplishments, benefits, principal investigator, and project partners. All SI fact sheets are available on-line at http://www.oit.doe.gov/related/port_sitrp.shtml.

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 For More Information

Learn about all EERE Programs - http://www.eere.energy.gov
Visit the SI Web site: http://www.oit.doe.gov/related

Ask an Expert - The Industrial Technologies Program's 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 6 p.m. PST).
Phone: 1-800-862-2086
Fax: 360-956-2214
Email: clearinghouse@ee.doe.gov

For print copies of DOE, EERE, and ITP Publications, contact -
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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

Supporting Industries

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

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

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