Mining

Mining 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 Industries of the Future (IOF) strategy was designed to foster public-private partnerships in economically imperative, energy-intensive U.S. industries, including mining. The Industries of the Future (Aluminum, Chemicals, Forest & Paper, Glass, Metal Casting, Petroleum, and Steel) represent the base of the U.S. industries vital to our economy and our national security.

The Department of Energy, Energy Efficiency and Renewable Energy (EERE), Industrial Technologies Program (ITP) has established numerous successful partnerships between private industry and the federal government. In mining, the initial emphasis has been to develop technologies for recovery and processing minerals and materials. The mining partnership leverages resources from related R&D efforts in chemicals, steel, and metal casting as well as from crosscutting R&D efforts in materials, sensors, and automation. Finally, the Mining partnership has also shared technical information with the EERE Geothermal Program and the Office of Fossil Energy.

All ITP industry partnerships are driven to meet the needs of industry within the framework set by the mission of the U.S. Department of Energy. Industry and government work together through these partnerships on pre-competitive technology R&D to enhance energy security, minimize environmental impacts from production (including "greenhouse" emissions), and promote economic well-being.

Industry participation in the Mining IOF is coordinated by the National Mining Association (NMA). To guide the research, the industry developed visions and roadmaps, established long-term goals for the future, and charted the R&D pathways to achieve those goals. The roadmaps have formed the basis for open and competitive solicitations for pre-competitive, cost-shared R&D addressing the energy efficiency goals outlined by industry. This successful public-private partnership has now evolved to a point where the focus is on high-impact R&D to make revolutionary improvements in energy efficiency in mining.

The following provides a snapshot of the Mining IOF's research portfolio and briefly summarizes major highlights and accomplishments during 2003.

Research Portfolio

- In cooperation with the National Mining Association, the Mining IOF funded a diverse portfolio of research focused on materials, sensors, alternate fuels, modeling, processing, excavation, and communications in FY 2003.

- The current portfolio of mining research is being performed by 123 industry, university, and national laboratory partners in 24 states across the United States.

- The Mining IOF has awarded $18.3 million in research with an additional $24.4 million provided by industry cost-share over the period of 1999 to the present.

2003 - Highlights and Accomplishments

- The mining industry is applying the results of cutting-edge IOF research (see pages 9-14). Examples are listed below:

  – Researchers have developed and implemented an advanced in-line and on-line system for machine condition diagnostics and prognostics based on analysis of lubricating oils and hydraulic fluids.

  – Researchers have developed a two-way, real-time, wireless communications system for use in underground mines.

  – Researchers have developed a set of engineering tools that will improve the efficiency of dense-medium cyclones used to separate coal or minerals from waste rock.

- EERE BestPractices and Industrial Assessment Centers are providing hands-on technical assistance that the mining industry can apply immediately. In Nevada, 11 BestPractices training sessions and 11 assessments were conducted on compressed air, pumps, motors, and process heating.

- The *Energy and Environmental Profile of the U.S. Mining Industry* was posted on the Mining IOF Web site. The profile benchmarks the energy and environmental characteristics of the key technologies used in the major processes of the mining industry.

- ITP is working in partnership with the U.S. mining industry through the National Mining Association (NMA) to implement activities in support of NMA achieving its Climate VISION commitment. A Climate VISION workplan has been developed where NMA will be collaborating with the federal government on near-term energy efficiency activities, cross-sector projects, and R&D to develop and commercialize advanced technology (see Climate VISION Web site – www.climatevision.gov).

INDUSTRY OVERVIEW

Minerals are essential to practically every aspect of our lives and our economy; however, they are scarcely noticed by most of us. In the United States, minerals have for decades been so readily available that most of us never give a thought to how our lives would be without them. As individuals, we make little, if any, direct use of mineral commodities. Instead, we buy finished goods made of minerals. We may never actually see minerals as they emerge from underground and surface mines, as they pour molten-hot from furnaces, or as they come off the line at processing plants. Yet, without minerals, civilization as we know it could not exist. Everything that we use in our homes and offices and for transportation, communications, and national defense requires minerals. They are the source of all the metals in buildings, cars, airplanes, and household products. They are also a major source of the raw materials for the building and chemical industries. Even in the information age, minerals play an important part in the production of telephones, computers, and televisions. In fact, 30 different minerals are needed to make a television or a computer, and a telephone is made from as many as 42 different minerals including aluminum, beryllium, coal, copper, gold, iron, limestone, silica, silver, talc, and wollastonite.

Materials Mined

- **Coal** - Coal is defined as a combustible rock containing more than 50 percent by weight and more than 70 percent by value of carbonaceous materials, including inherent moisture. Coal is formed from compaction and induration of various kinds of plant remains.

- **Metals** - A metal is an opaque lustrous elemental substance that is a good conductor of heat and electricity. Metals are also malleable and ductile, possess high melting and boiling points, and tend to form positive ions and chemical compounds.

- **Industrial Minerals** - Industrial minerals are rocks and minerals not produced as sources of metals and exclude mineral fuels such as coal. Industrial minerals include crushed stone, sand, and gravel.

Types of Mining

Surface and underground mining are the two mining methods. The method selected depends on a variety of factors including the nature and location of the deposit, as well as the size, depth, and grade of the minerals. Both surface and underground mining are used widely in the extraction of coal. In 2001, the total amount of coal produced was 1.13 billion tons. Of this, 381 million tons or 34 percent came from underground mines, and the remaining 745 million tons or 66 percent came from surface mines.[1] Of the 1.2 billion tons of crude metal ore produced in the United States in 2001, 1.1 billion tons or 92 percent came from surface mining.[2] Most of the industrial minerals in the United States are extracted by surface mining. In 2001, the total amount of crude industrial ore mined in the United States was 3.3 billion tons. Of this, 3.1 billion or 94 percent came from surface mines.[3]

Economic Profile and Trends

In the course of a lifetime, each American will use 3.5 million pounds of minerals, metals, and fuels. Mining plays a vital role in our national economy, national security, and in the life of each individual. Each year, nearly 47,000 pounds of materials must be mined for each person in the United States to maintain his/her standard of living. Processed materials of mineral origin account for nearly 5 percent of U.S. gross domestic product. Nearly 270,000 people work directly in mining throughout the United States. Employment in industries that support mining, including manufacturing, engineering, and environmental and geological consultants, accounts for nearly 3 million jobs. The average miner makes $49,000 per year in salary, not including overtime, bonuses, and benefits.[4]

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[1] U.S. Department of Energy, Energy Information Administration. *Annual Coal Report 2001*.
[2] U.S. Department of the Interior, U.S. Geological Survey. *Mining and Quarrying Trends*. 2001.
[3] U.S. Department of the Interior, U.S. Geological Survey. *Mining and Quarrying Trends*. 2001.
[4] National Mining Association, Fast Facts About Minerals, http://www.nma.org/statistics/pub_fast_facts_2.asp

Coal

U.S. electricity costs are among the lowest in the world due to the availability of low-cost coal. In fact, coal accounts for 50 percent of all electric power generated in the United States. Coal production in 2002 dropped 33.9 million tons or 3 percent from 2001. Production in 2002 is similar to production in 1997; however, both Appalachian and Interior coal production has decreased over time while Western coal production has increased. Of the 1 billion tons of coal produced in 2002, 91 percent went to electric generation and power producers. The United States is a coal exporter, however, since 1997 coal exports have decreased, the number of mines has decreased by 19 percent, and the number of mine workers has decreased 6 percent.

Exhibit 1
Coal Statistics

Category	1997	2000	2001	2002 e/
Production (million short tons)	*1,090.0*	*1,073.6*	*1,127.7*	*1,093.8*
Appalachian	467.8	419.4	431.1	396.0
Interior	170.9	143.5	146.9	146.1
Western	451.3	510.7	547.9	549.9
Consumption (million short tons)	*1,007.8*	*1,080.9*	*1,052.6*	*1,062.7*
Electric Utilities	900.4	859.3	806.3	777.3
Other Power Producers	21.6	123.3	150.6	195.4
Coking	30.2	28.9	26.1	22.5
Other Industrial	71.5	65.2	65.3	63.1
Residential/Commercial	6.5	4.1	4.4	4.4
Trade (1,000 short tons)				
Exports	83.5	58.5	48.7	39.6
Imports	7.5	12.5	19.8	16.9
Net Exports	*76.0*	*46.0*	*28.9*	*22.7*
Number of Mines	*1,828*	*1,453*	*1,478*	*1,480*
Underground	874	707	719	720
Surface	954	746	759	760
Number of Workers	*81,516*	*72,748*	*76,900*	*76,000*
Underground	52,487	43,172	44,897	44,000
Surface	29,029	29,576	32,003	32,000
Total Value ($ billion)	19.8	18.0	19.6	19.2

e/ estimated
Source: National Mining Association, Most Requested Statistics - U.S. Coal Industry, April 2003.

Metals

Metals production has decreased 21 percent since 1997 with a large decrease in 2001. However, 2002 production increased 7 percent. Consumption of metals in the United States has also fallen since 1997 by 23 percent, with a 12 percent drop in 2001 and a 10 percent drop in 2002 from previous years. The United States is an importer of metals, however the imports have been dropping while exports remain constant. The number of mines has decreased over time and the number of workers has dropped 40 percent since 1997.

Exhibit 2
Metals Statistics

Category	1997	2000	2001	2002 e/
Production (million short tons)	72.9	72.6	53.8	57.6
Consumption (million short tons)	93.9	91.0	80.1	72.2
Trade (million short tons)				
Exports	7.8	7.5	7.3	7.6
Imports	20.7	17.6	12.1	11.3
Net Exports	*-13.0*	*-10.0*	*-4.8*	*-3.7*
Number of Mines/Companies	179	151	142	125
Number of Workers	42,202	34,092	29,576	27,230
Total Value ($ million)	9,064.4	7,835.2	6,519.5	6,383.7

e/ estimated
Source: U.S. Geological Survey, Summary of 12 Metal Mineral Commodity Summaries

Industrial Minerals

Industrial mineral production increased between 1997 to 2002 by 13 percent. Consumption also increased during that time by the same amount. The United States is an importer of industrial minerals with the trade number remaining close from year to year. There was an increase in mines and workers in the industrial mineral sector.

Exhibit 3
Industrial Minerals Statistics

	1997	2000	2001	2002 e/
Production (million short tons)	2,381.8	3,200.2	3,200.5	3,213.1
	2,885.9	3,266.0	3,253.7	3,247.1
Trade (million short tons)				
Exports	17.6	22.3	22.4	22.2
Imports	48.6	51.8	56.2	54.4
Net Exports	*-31.0*	*-29.4*	*-33.8*	*-32.1*
Number of Mines/Companies	10,651	11,161	11,096	10,903
Number of Workers	42,202	173,384	171,610	170,270
Total Value ($ million)	21,630.4	23,556.4	23,577.8	24,089.5

e/ estimated
Source: U.S. Geological Survey, Summary of 23 Industrial Mineral Commodity Summaries

Energy Use in Mining

Energy used in mining operations accounted for approximately 1,258 trillion Btu.[5] In 1997, the mining industry spent $3.6 billion on energy, representing about 24 percent of the total cost of supplies. This is a slight increase from 1992 when the mining industry spent $3.5 billion on energy, representing about 16 percent of the total cost of supplies. Major energy sources include fuel oil, electricity (purchased and produced on-site), coal, and natural gas.[6]

Exhibit 4 shows 50 percent of fuels are met by fuel oil followed by natural gas at 32 percent. Coal and motor gasoline supply the balance. Major energy requirements include electricity for ventilation systems, water pumping, and crushing and grinding operations. In total, 753 trillion Btu are generated for the mining industry, 243 trillion Btu are used on-site, while 505 trillion Btu are lost due to off-site generation losses. Diesel fuel is used for hauling and other transportation needs. Although the mining industry is a significant energy user, it continues to make strides in improving productivity and energy efficiency.

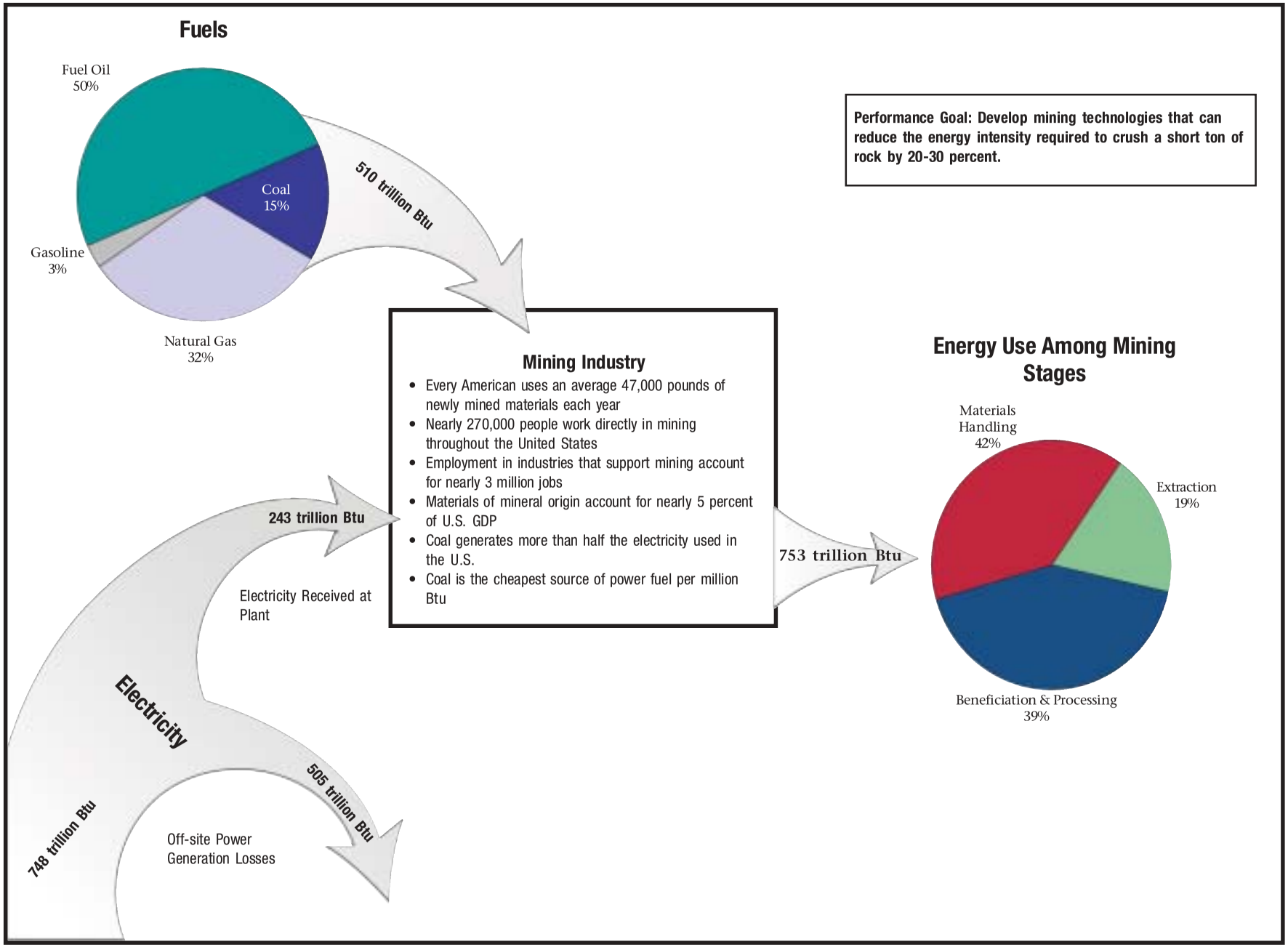
The mining industry is a capital-intensive industry. Total supply costs for minerals received, machinery, fuels, and electricity were $18,961 billion in 1997. The purchase of minerals and machinery accounted for 81 percent in 1997 or over $15.3 billion. Purchased fuels accounted for over $1.5 billion dollars and purchased electricity accounted for over $2 billion for the remaining 19 percent.[7]

Energy-Savings Opportunities

In 2003, a mining industry energy analysis was completed. This analysis demonstrated that the largest opportunities for energy savings in mining were materials handling, beneficiation and processing, and extraction. Diesel technologies were the largest energy consumers in materials handling, accounting for 87 percent of the energy used. Comminution activities, or crushing and grinding, were the largest energy consumers in beneficiation and processing, accounting for 75 percent of the energy used. Finally, pumping was the largest energy consumer in extraction, accounting for 41 percent. Materials handling and beneficiation and processing consume the largest amount of energy, however, improvements in extraction could reduce downstream materials handling and processing, reducing energy needs.

[5] U.S. Department of Energy, Industrial Technologies Program, *February* 2001.
[6] U.S. Department of Commerce, U.S. Census, 1997 Economic Census, Mining-Subject Series, NAICS 212.
[7] U.S. Department of Commerce, U.S. Census, 1997 Economic Census, Mining-Subject Series, NAICS 212.

Exhibit 4
Energy Use in the Mining Industry



THE CHALLENGE

Mining is one of the most energy-intensive industries in the United States. It is also the supplier of raw materials to the U.S. manufacturing sector. These unique characteristics have helped drive the need for public-private R&D collaboration.

Research Categories of the Mining IOF

The success of the Mining IOF is the result of a strong partnership between the mining industry and EERE. In the future, this partnership will direct its efforts to address high-impact research to make revolutionary improvements in energy efficiency in mining. Research is grouped into three categories:

- **Extraction**
- **Materials Handling**
- **Beneficiation and Processing**

Energy-Intensive Industry

The mining industry consumed an estimated 1,258 trillion Btu in 2001 or 11 percent of the energy consumed by the industrial sector in the United States. Energy-intensive processes in mining include materials handling, beneficiation and processing, and extraction. The Mining IOF is funding research to improve energy efficiency in these processes. This research is improving production, environmental impacts, and health and safety. A 2003 analysis of active mining research projects estimates that the current R&D portfolio will save 5.0 trillion Btu annually in 2010. This is estimated to increase to 56.1 trillion Btu in 2020.

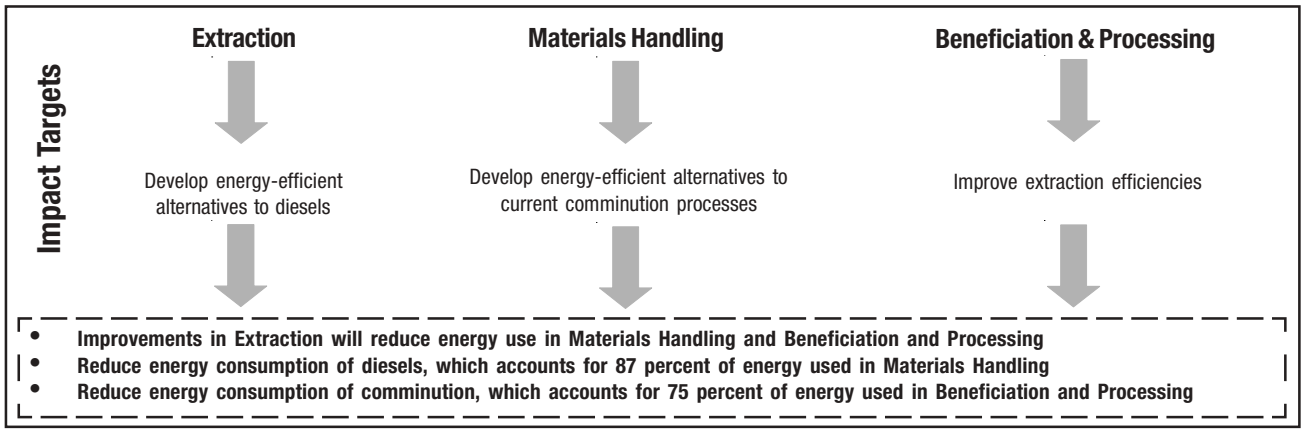
Mining R&D is a component of the overall EERE strategy to improve energy efficiency nationwide and to contribute to the goals outlined in the National Energy Policy. It is contributing to the EERE mission "to strengthen America's energy security, environmental quality, and economic vitality through public-private partnerships that:

1. promote energy efficiency and productivity;
2. bring clean, reliable, and affordable energy technologies to the marketplace; and
3. make a difference in the everyday lives of Americans by enhancing their energy choices and their quality of life." [8]

Important Role in State and Local Economies

The mining industry plays an important role in all 50 states. Minerals occur based on varying geologic conditions, thus the same minerals are not found everywhere, but in very limited areas. As a supplier of coal, metals, and industrial minerals, including sand, stone, and gravel to businesses, manufacturers, utilities, and others, the mining industry is vital to the well-being of communities across the country.

Exhibit 5
Process & Technology Improvements Target Energy Efficiency



[8] U.S. Department of Energy, Assistant Secretary for Energy Efficiency and Renewable Energy, *Organization Mission and Functions*, 2002, pg.1

Mining operations are often the leading employers in their communities. Nearly 270,000 people work directly in mining throughout the United States. Employment in industries that support mining, including manufacturing, engineering, environmental and geological consulting, account for nearly 3 million jobs.[9] The average miner earns $49,000 per year in salary, not including overtime, bonuses, and benefits.[10]

[9] National Mining Association, Fast Facts About Minerals, http://www.nma.org/statistics/pub_fast_facts_2.asp
[10] National Mining Association, Fast Facts About Minerals, http://www.nma.org/statistics/pub_fast_facts_2.asp

2003 HIGHLIGHTS & ACCOMPLISHMENTS

The Mining IOF supports a diverse portfolio of cost-shared, pre-competitive research. Research projects address high-risk/high-impact needs that have broad application throughout the mining industry.

All the mining research projects are selected through a competitive review. Mining IOF research must address both the priorities outlined in the related technology roadmap as well as DOE's national energy efficiency goals. Solicitations are announced in the *Commerce Business Daily*, *FedBizOpps*, the DOE's *E-Center*, and the Mining IOF Web site. In 2003, the mining portfolio started to transition to fewer, larger projects that will have the opportunity to produce revolutionary improvements in mining energy efficiency.

Maintaining a strong and well-balanced portfolio requires careful attention throughout the competitive solicitation, evaluation, and selection process. The 2003 Mining IOF research portfolio consists of 26 active projects, addressing the diverse research needs of the *Crosscutting Technologies Roadmap* and the *Mineral Processing Technologies Roadmap*. Many of the projects crosscut the coal, metals, industrial minerals, and sand and gravel industries. All projects address the need to improve energy efficiency in the industry.

Broad Industry Partnerships

One of the strengths of the mining research portfolio is the large participation of industry, universities, and national laboratories, providing expertise, cost-share, and in-kind support. Currently there are 123 industry, university, and national laboratory partners in 27 states across the United States. The geographic reach of the IOF's partnership is illustrated in Exhibit 6.

The involvement of industry on the ground floor accelerates technology transfer and dissemination of research results. Industry partners represent the diversity of the mining industry and include mines, plants, manufacturers, and suppliers. The IOF's portfolio also enables the industry to have direct access to technical expertise available at universities and national laboratories.

Exhibit 6
Broad Industry Partnerships
Mining Research Performers and Project Partners

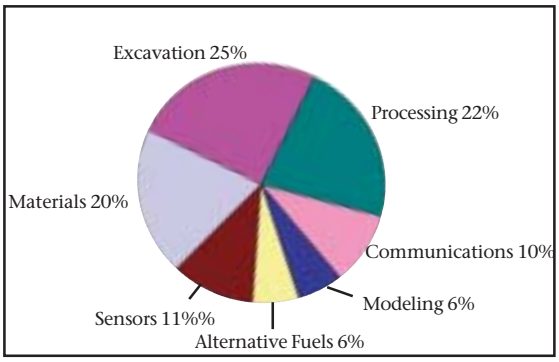
Primary Research Performers

1 Advanced Ceramics Research, Inc.
2 AdvR, Inc.
3 Caterpillar Inc.
4 CQ, Inc.
5 Minerals and Coal Technologies, Inc.
6 Stolar Horizon, Incorporated
7 Transtek, Inc.
8 Argonne National Laboratory
9 Idaho National Engineering and Environmental Laboratory
10 Lawrence Berkeley National Laboratory
11 Los Alamos National Laboratory
12 Pacific Northwest National Laboratory
13 Sandia National Laboratory
14 Michigan Technological University
15 The University of Alaska
16 Virginia Polytechnic Institute and State University
17 West Virginia University
18 University of Kentucky
19 University of Utah

The Mining Industry of the Future is currently funding 26 cost-shared projects with 123 project partners including 12 from academia.

Exhibit 7 illustrates mining R&D funding by portfolio category. As shown, the portfolio addresses each of the key areas highlighted in the technology roadmaps. Many of the key operating practices and opportunities for energy savings are in the areas of processing and excavation, therefore they account for the largest portion of funding at 47 percent. A current portfolio of mining projects organized by portfolio categories is shown in Exhibit 8.

Exhibit 7
Research Funded by Portfolio Area



Integrated Technical Assistance for the Mining Industry

The Mining IOF has funded $14.8 million in research with an additional $16.7 million provided by industry cost-share over the period from 1999 to the present. A number of other EERE portfolios have performed research related to mining. These include NICE[3], Inventions and Innovation, and the Aluminum, Metal Casting, Steel, and Chemical IOFs. Combined, they have provided approximately $28.6 million in funding on current research and technical assistance relevant to mining and leveraged an additional $38.7 million in cost-share.

Exhibit 8
Mining Portfolio by Primary Category and Project Leadership
(Fact sheets are available at http://www.oit.doe.gov/mining/portfolio.shtml)

Materials
- Fibrous Monolithic Composites as Wear Resistant Components for Mining
- Advanced Processes for Abrasion Resistant Metal-Matrix Composites and Thermal Spray Coating for Earth Moving Machines

Sensors
- Real-time Coal/Ore Grade Sensor
- Horizon Sensing
- Imaging Ahead of Mining
- 24-Channel Geophone Array for Horizontal or Vertical Boreholes
- Mine Compatible Laser Analysis Instrument for Ore Grading

Alternative Fuels
- Hydride Fuel Cell for Mining Vehicles
- Advanced Power and Control for Fuel Cell Vehicles

Modeling
- Three-Dimensional Simulation of Charge Motion in SAG and Ball Mills for Energy Efficiency
- Comminution Circuit Optimization
- Mapping with Natural Induced Polarization

Communications
- High Temperature Superconductors in Underground Communications
- Wireless Mine-Wide Telecommunications Technology

Processing
- Dense Medium Cyclone Optimization
- Calibration Methods for On-line Analyzers
- Mining By-product Recovery
- Selective Flocculation of Fine Mineral Particles
- Alternate Anodes
- Smart Screening
- Novel Dewatering Aids for Mineral and Coal Fines
- Treatment of Cyanide Solutions and Slurries Using ASH Technology Methods for On-line Analyzers
- Mining By-product Recovery
- Selective Flocculation of Fine Mineral Particles
- Alternate Anodes
- Smart Screening
- Novel Dewatering Aids for Mineral and Coal Fines
- Treatment of Cyanide Solutions and Slurries Using ASH Technology

Excavation
- CastCon Processes for Mining Applications
- Computerized Roof Bolt Design System
- Robotics Technology for Improving Mining Productivity
- Drilling and Blasting Optimization
- Projectile Based Excavation
- Development and Deployment of Automated Machine Fluid Analysis Systems

Exhibit 9
Examples of EERE Technical and Financial Assistance

- **NICE³:** National Industry Competitiveness through Energy, Environment, and Economics (NICE³) 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 have comprehensive industrial assessments performed at no cost to the manufacturer.
- **Plant-Wide Assessments:** Plant-wide energy assessments 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.

In addition to those portfolios listed in Exhibit 9, EERE provides research on leading-edge enabling technologies, including Sensors & Controls, Industrial Materials, and Combustion. The portfolio enables risk-sharing on industry-specific pre-competitive long-term, high-impact research available through other IOF's such as Aluminum, Metal Casting, Chemicals, and Steel. Small Business Innovative Research grants also provide financial assistance for small businesses.

In addition, the Mining IOF is working with Allied Partners to help deploy the results of mining 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 help promote increased energy efficiency and productivity for those industries that participate in the IOF strategy. The mining industry is working with mining associations and companies to formalize Allied Partnership agreements. Through Allied Partners, EERE will be able to deliver the results of research programs and technical assistance.

Exhibit 10
Examples of ITP Research Related to Mining

Financial Assistance

- Magnetic Elutriation Technology For Clean and Efficient Processing of Iron Ore (NICE³)
- Processing Electric Arc Furnace Dust into Salable Chemical Products (NICE³)
- Particulate Briquetting Technology for Steel Industry (NICE³)
- A Microbial Genomics Approach to Resource Exploration and Characterization (I&I)
- Advance Overfire Air System and Design Methodology for Stoker Type Boilers and Furnaces that Burn Biomass, Coal and Other Solid Fuels (I&I)
- An Insoluble Titanium-Lead Anode for Sulfate Electrolytes (I&I)
- Anerobic Bioleaching Technology for Metals Release (I&I)
- Auxiliary Air-Conditioning, Heating, and Engine Warming System for Trucks (I&I)
- Coal-Fired Air Turbine (CAT) Cycle Plant (I&I)
- Cupola Furnace Computer Process Model (I&I)
- Density Separation in Complex-Mode Vibration Fluidized Beds (I&I)
- Development of a Lower pH Copper Flotation Reagent System (I&I)
- Development of an Innovative Energy Efficient High Temperature Natural Gas Furnace (I&I)
- Development of Environmentally Benign Mineral Floatation Collectors (I&I)
- Distributed Optical Fiber Sensor for Continuous Liquid Level Tank Gauging (I&I)
- Duel Fuel Energy Conversion System for Diesel Engines (I&I)
- Filtering Molten Metal (I&I)
- Miniature, Inexpensive, Amperometric Oxygen Sensor (I&I)
- Ramex Tunneler (I&I)
- Tough-Coated Hard Powders: A New Paradigm in Mining and Machining Tool Materials (I&I)
- Ultra Fine Mineral Recovery Pilot Plant (I&I)
- Wireless Telemetry Communications (I&I)
- Variable Wall Mining Machine with Dual Duct Ventilation System (I&I)

Crosscutting Applications

- Advanced Blast Furnace Control (Steel)
- Clog-Resistant Submerged Entry Nozzles (Steel)
- Improving Refractory Service Life and Recycling Refractory Materials (Steel)
- On-Line, Non-destructive Measurement of Mechanical Properties (Steel)
- Oscillating Combustion to Reduce NOx Emissions (Steel)
- Recycling Waste Oxides into Primary Process (Steel)
- Advanced Anodes and Cathodes Utilized in Energy Efficient Aluminum Production Cells (Aluminum)
- Development of Novel Non-Consumable Anode for Electrowinning Primary Aluminum (Aluminum)
- Dynamic Inert Metal Anodes for Primary Aluminum Production (Aluminum)
- Wetted Cathodes for Low-temperature Aluminum Smelting (Aluminum)
- Inter Metal Anode Life in Low Temperature Aluminum Reduction Process (Aluminum)
- Wettable Ceramic-Based Drained Technology for Aluminum Electrolysis (Aluminum)
- Membranes for Corrosive Oxidation (Chemicals)
- Multiphase Fluid Dynamics Research Consortium (Chemicals)
- Recovery of Select Thermoplastics via Froth Flotation (Chemicals)
- Selective Catalytic Oxidative Dehydrogenation of Alkanes to Olefins: Effective Catalysts (Chemicals)
- Solution Crystallization Modeling Tools (Chemicals)
- Performance Data to Increase Reuse of Foundry Byproducts (Metal Casting)

Technical Assistance

- BestPractices - Plant Assessments and Hands-on Technical Assistance
  - — Kennecott Utah Copper
  - — MagCorp
- Industrial Assessments
  - — Industrial Assessments were given to a number of mining companies in Nevada in 2002-2003. Results have not yet been realized.

The Mining IOF achieved a number of important accomplishments in 2003 with energy efficiency improvements to be transferred to and applied by the mining industry. The following describes accomplishments in several key areas:

- Applying R&D Results
- Disseminating Research Results
- Partnership Highlights
- Energy Analysis
- Climate VISION

Applying R&D Results

Mining IOF projects continue to make progress and meet project milestones. The following provides examples of major milestones completed in mining R&D projects.

Current R&D with Promising Results

- ***Fibrous Monolith Wear Resistant Components for the Mining Industry*** - This project was selected as a 2002 *R&D 100 Award* winner. A patent has been received for "Aligned Composite Structures and Constructs for Mitigation of Impact Damage and Resistance to Wear in Dynamic Environments" and another is pending. Advanced Ceramics Research Inc. along with team members are designing and testing advanced components for drilling, earth-moving, and crushing equipment that are made out of cellular composite materials.

- ***Imaging Ahead of Mining*** - Radio Imaging Methods (RIM) in-Mining and Down-Hole versions of RIM IV are being produced in small quantity at Stolar Horizon. Sandia National Laboratories and its partners use the Internet, instrumentation advances, and newly developed modeling and analysis software to accurately image the volume of material ahead of mining.

- ***Treatment of Cyanide Solutions Using ASH Technology*** - The team has developed and implemented a health & safety plan that has been accepted industry-wide. The University of Utah and partner researchers are adapting the air-sparged hydrocyclone (ASH) technology for the low-cost recovery or destruction of cyanide.

- ***Horizon Sensing*** - This project has received a 2002 *R&D 100 Award*. In a recent demonstration for an audience of MSHA technical representatives, a wall of salt was used to simulate a coal seam. The Horizon Sensor successfully proved it could detect air voids through 23 feet of salt blocks. Stolar Horizon, with its partners, is testing remote sensing and imaging technology on the cutting-edge of mining equipment.

Commercial Technologies

- ***Development of Machine Fluid Analysis System*** - Albany Research Center and team developed and implemented advanced in-line and on-line systems for machine condition diagnostics and prognostics based on analysis of lubricating oils and hydraulic fluids. The technology developed under this project has recently been selected for use in the pulp and paper industry. A system adapted for this application will be installed at the PCA paper mill in Counce, TN. Also, Belhaven has received orders for one or more systems in each of two new configurations, one for marine propulsion diesel and one for a railroad locomotive application.

- ***Wireless Mine Wide Telecommunications System*** - Transtek, Inc., in cooperation with its partners, has developed a two-way, real-time, wireless communications system for use in underground mines. This technology lowers the cost of mining by increasing productivity as well as the safety of miners. A commercial through-the-earth wireless voice communications prototype was built and installed in NIOSH's Lake Lynn underground mine for testing and demonstration with rescue training in early 2002. Transtek has sold and installed five wireless communication systems in underground mines.

- ***Dense Medium Cyclone Optimization*** - Virginia Tech leads a team that has developed a set of engineering tools to improve the efficiency of dense-medium cyclones used to separate coal or minerals from waste rock. These improvements reduce the energy costs associated with the process and increase the amount of valuable materials that are recovered as product. Tracer services are now provided by Precision Testing Laboratories of Beckley, West Virginia. Financial returns have already been realized from tracer tests conducted by Precision Testing Laboratories for the Turris Coal Company. The project software, waiting final approval, will soon be accessible at www.coalprep.org.

Emerging Technologies

- ***Smart Screening Systems for Mining*** - QRDC Inc. and its partners are developing a Smart Screening System that reduces energy use in screening processes by 75 percent. In addition, Smart Screening Systems will reduce maintenance requirements, improve throughput, and increase work safety and health. QRDC has licensed the technology to Smart Screen Systems, Inc. to prepare for commercialization.

Partnership Highlights

BestPractices Training Session and Assessments - In conjunction with the Mining Energy Solutions event conducted on August 26-28, 2003 in Elko, Nevada, ITP's BestPractices initiative conducted a number of training sessions and assessments with the Nevada mining industry highlighting energy-savings opportunities. Results from these sessions were presented at the Mining Energy Solutions event. Also, in cooperation with the National Mining Association's Mining Climate Action Plan (MICAP), BestPractices has performed 12 training sessions in the pumps, motors, compressed air, and process heating areas.

Disseminating Research Results to Industry

The Mining IOF performs various outreach activities to disseminate R&D results and enable the U.S. mining industry to implement energy-saving practices and technologies. This includes participating in trade shows and maintaining an up-to-date Web site that highlights the Mining IOF activities. Examples of 2003 outreach include:

- **Society for Mining, Metallurgy, and Exploration (SME) Annual Meeting and Exhibit** - SME hosted a successful meeting in Cincinnati, Ohio from February 24-27, 2003.

- **Mining IOF Web Site** - In 2003, this Web site was visited 32,129 times. It is a valuable resource for Mining IOF activities, and provides updates on research successes. To view the Web site visit: http://www.oit.doe.gov/mining.

Energy Analysis – Targeting Energy Efficiency

The *Energy and Environmental Profile of the U.S. Mining Industry* is complete. Using this document, energy analysis studies have shown that the most energy-intensive stages include extraction, materials handling, and beneficiation and processing. The development of mining technologies that can reduce the amount of material that must be transported, crushed, and processed can achieve significant improvements in mining energy efficiency. The Mining IOF is currently reviewing proposals from its fifth solicitation. This solicitation was focused on exploration and mining. In conjunction with the mining solicitation, there was a solicitation for white papers on revolutionary technologies/processes in mining. The Mining IOF awarded 13 mining white papers and plans to award an estimated three to five mining R&D projects.

The energy analysis study has been completed. This study analyzed the most energy-intensive processes/equipment in the three stages of extraction, materials handling, and beneficiation and processing. The Metals and Mining team will review the results of this study with U.S. mining industry experts and develop criteria for Grand Challenge solicitations in those areas. The energy analysis study, the criteria developed with industry input, and the white papers from the FY 2003 solicitation will be used to issue a Grand Challenge solicitation in FY 2004 or FY 2005.

Climate VISION

On February 14, 2002, President Bush announced a new strategy to address the long-term challenge of global climate change. The President committed to reducing America's greenhouse gas intensity – the ratio of emissions to economic output – by 18 percent in the next decade, and challenged American businesses and industries to undertake broader efforts to help meet the goal. The President's strategy, known as Climate VISION (Voluntary Innovative Sector Initiative: Opportunities Now), is focused on voluntary partnerships between the government and entire industry sectors. These partnerships aim to reduce the projected growth in America's greenhouse gas emissions through research, development, and deployment of energy-saving technologies and processes.

The U.S. Department of Energy, along with other key federal agencies, recognizes that major, energy-intensive sectors of the American economy are undertaking significant initiatives to meet the President's challenge. These initiatives build upon the progress made by the industrial sector in the past decade (from 1990-2001). During this time, the economy grew by almost 40 percent, while greenhouse gas emissions in the industrial sector remained constant. The Industrial Technologies Program (ITP) is working in partnership with the U.S. mining industry through the National Mining Association (NMA) to implement activities in support of NMA achieving its Climate VISION commitment. A Climate VISION workplan has been developed where NMA will be collaborating with the federal government on near-term energy efficiency activities, cross-sector projects, and R&D to develop and commercialize advanced technology (see Climate VISION Web site – www.climatevision.gov).

TOOLS, PUBLICATION, AND RESOURCES AVAILABLE

The tools and publications available from the Mining IOF include:

Publications

Vision and Roadmaps - The industry's unified vision outlines broad goals for the mining industry's future. The roadmaps establish the mining industry's R&D priorities, performance targets, and milestones for attaining the vision goals. The roadmaps for the Mining IOF are:

- *Mining Industry Roadmap for Crosscutting Technologies*
- *Mineral Processing Technologies Roadmap*
- *Exploration and Mining Technologies Roadmap*
- *Education Roadmap for Mining Professionals*

Energy and Environmental Profile of the U.S. Mining Industry - This report benchmarks the energy and environmental characteristics of the key technologies used in the major processes of the mining industry.

RAND Report *New Forces at Work in Mining: Industry View of Critical Technologies* - The report presents the results of a series of in-depth discussions with leading mining industry representatives selected for their prominent position and their ability to think broadly about technology trends. The discussions highlighted the importance of collaborative technology research, development, and implementation strategies and the increasingly critical role of mine personnel in the utilization of new technologies.

Mining Brochure - This 8-page brochure highlights the benefits of partnership in the Mining IOF.

***E*nergy Tips Sheets** - These 2-page tip sheets provide quick advice on how to keep your systems running at their maximum efficiency. They cover topics regarding compressed air systems, motors, steam, and process heating. To learn more, please visit: http://www.oit.doe.gov/bestpractices/technical_publications.shtml#tip.

ITP Catalog - The ITP catalog contains electronic copies of hundreds of publications, and information on software and videos. Search directly for published information on a mining topic of interest to you. To learn more, please visit: http://www.oit.doe.gov/catalog/.

Fact Sheets

The Mining 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 mining fact sheets are available on-line at: http://www.oit.doe.gov/mining/portfolio.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 - www.eere.energy.gov

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 5 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 -
Energy Efficiency and Renewable Energy Clearinghouse (EREC)
P.O. Box 3048
Merrifield, VA 22116
Fax: 703-893-0400
Phone: 800-363-3732
Email: doe.erec@nciinc.com

For questions regarding Mining IOF activities, please contact -
Mike Canty
Industrial Technologies Program
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
1000 Independence Avenue SW
Washington, DC 20585-0121
Phone: 202-586-8119
Fax: 202-586-6507
email: mike.canty@ee.doe.gov

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

Mining 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

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