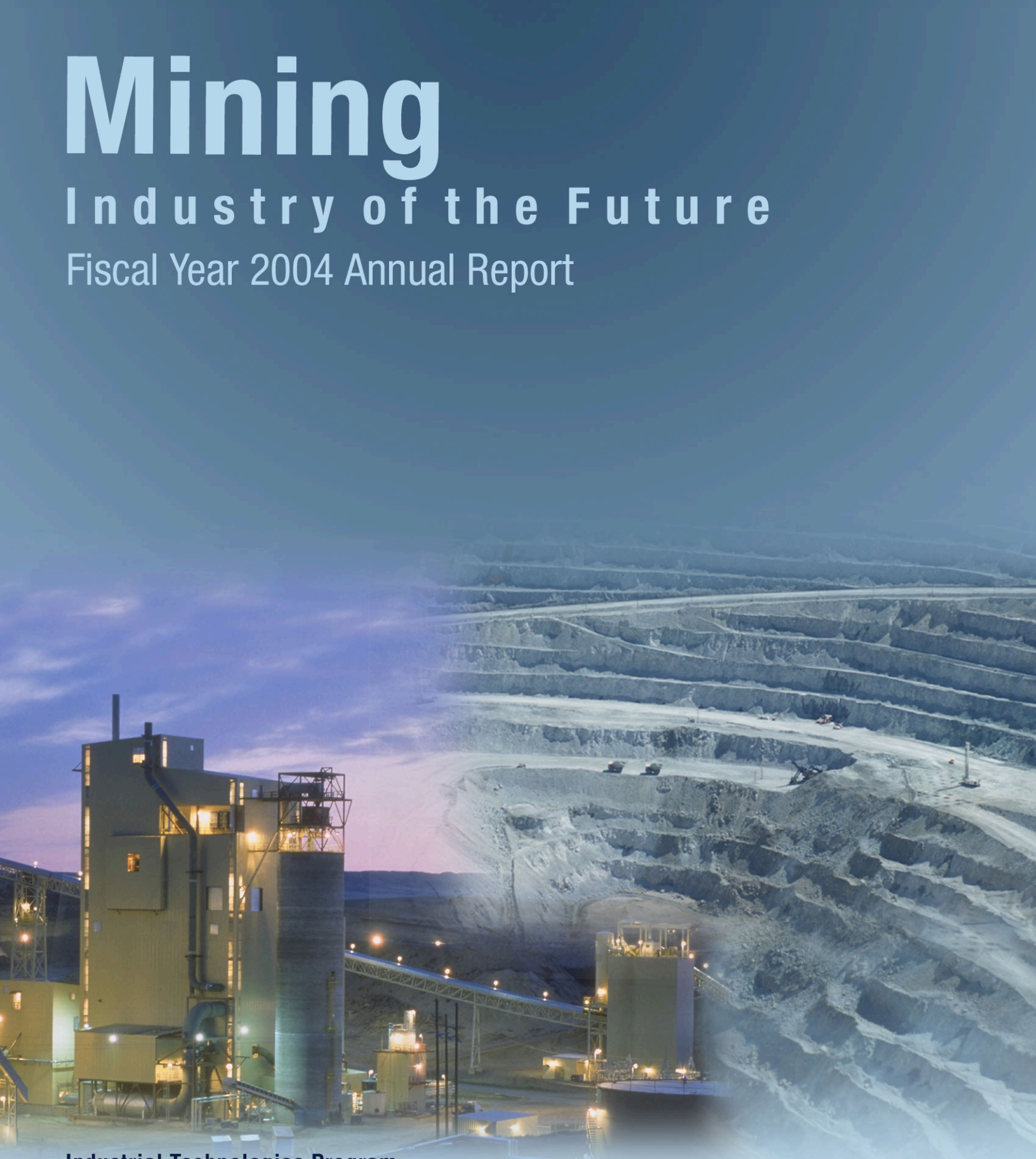
Mining

Industry of the Future

Fiscal Year 2004 Annual Report



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. EERE's Industrial Technologies Program (ITP) is working to build the Industries of the Future through a coordinated program of research and development (R&D), validation, and dissemination of energy efficiency technologies and operating practices to reduce energy intensity in the industrial sector. 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.

ITP focuses its resources on a small number of energy-intensive materials and process industries that account for over 55 percent of industrial energy consumption.

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

ITP uses a leveraging strategy that maximizes the energy and environmental benefits of its process-specific technology investments by coordinating and cooperating with energy-intensive industries. By working closely with the private sector, ITP is able to effectively plan and implement comprehensive R&D agendas and help disseminate and share best energy management practices throughout the United States. ITP's 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 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 ITP 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

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 or 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, environmental and geological consultants—accounts for nearly three million jobs. The average miner makes $49,000 per year in salary, not including overtime, bonuses and benefits.[1]

The mining industry is a capital-intensive industry. Total supply costs for minerals received, machinery, fuels and electricity consumed were $19.0 billion in 1997. The purchase of minerals and machinery accounted for 81 percent of this figure, or over $15.3 billion. Purchased fuels totaled over $1.5 billion dollars, and purchased electricity over $2 billion, accounting for the remaining 19 percent.[2]

Transformational R&D, such as that funded by the U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy (EERE), Industrial Technologies Program (ITP), is critical to maintaining the global competitive position of the U.S. mining industry. Studies sponsored by EERE are quantifying the opportunities for saving energy in the mining industry.

The mining industry consumed an estimated 1,258 trillion Btu in 2001, including the off-site losses in electricity generation. Energy-intensive processes in mining include materials handling, beneficiation and processing, and extraction. The Mining portfolio is funding research to improve energy efficiency in these processes. This research is improving production, environmental impacts, health, and safety. A 2004 analysis of mining research projects estimates that the R&D portfolio will save 5.86 trillion Btu annually in 2010. This is estimated to increase to 73.24 trillion Btu in 2020.

A Successful Strategy with Industry

DOE's Office of Energy Efficiency and Renewable Energy (EERE) leads federal development of advanced energy-efficient and environmentally friendly industrial technologies. Mining industry R&D is a component of the overall EERE strategy, contributing to a reduction in energy intensity of industry, a goal outlined in the National Energy Policy.

EERE/ITP is working to build the Industries of the Future through a strategy that is based on multi-year planning, industry involvement and input during the planning process, and careful analysis and data-based decision making. This strategy not only takes into consideration the interests of the industry as described in their R&D Technology Roadmaps, but also consists of an agenda of analytical studies that provide the basis for decision making. For instance, the *Crosscutting Technologies Roadmap*, published in 1999, the *Mineral Processing Technologies Roadmap*, published in 2000, and the *Exploration and Mining Technologies Roadmap,* published in 2002, have provided the basis for focusing the R&D by identifying industry research interests. The *Energy and Environmental Profile of the U.S. Mining Industry*, Bandwidth study and Footprint study were developed using both government and industry data and information, and industry expertise to provide the next level of prioritization for the portfolio. By using these studies, the portfolio is able to design a multi-year R&D plan based on the focus area, barrier, and pathway approach. In this approach, a limited number of critical technology focus areas are identified along with the technical barriers preventing their successful implementation. A multi-year plan (called a "Pathway") is then developed that will guide the R&D activities leading to a successful development of the focus area technology. The "Pathways" are then the basis for solicitations of pre-competitive R&D that addresses both energy efficiency goals outlined in the National Energy Policy and mining industry research priorities. This successful strategy has now evolved to a point where it provides focus on potentially high-impact research to make revolutionary improvements in the U.S. mining industry.

1 National Mining Association. *Fast Fact About Minerals*, http://www.nma.org/statistics/pub_fast_facts_2.asp

2 U.S. Department of Commerce, U.S. Census, *1997 Economic Census*, Mining-Subject Series, NAICS 212.

Achieving Energy Savings: Portfolio Strategy

The following briefly summarizes major highlights and accomplishments during FY 2004 and provides a snapshot of Mining's research portfolio.

- The Mining portfolio funds a diverse portfolio of research focused on extraction, beneficiation and processing, and materials handling.

- The current Mining R&D portfolio involves 104 industry, university, national laboratory, and government agency partners in 34 states across the United States.

- The Mining portfolio has awarded $25.3 million in research to 43 cost-shared projects, with an additional $37.4 million provided by industry cost-share since 1999.

FY 2004 Highlights

The mining industry is currently applying the results of several cutting-edge research technologies (see pages 10-11). Examples are listed below:

- Underground communications are key to mining productivity, safety and health. Researchers at the Los Alamos National Laboratory (LANL) are developing a compact, sensitive, wideband receiver for low-frequency underground communications signals using a high-temperature SQUID (Superconducting Quantum Interference Device). Pyott-Boone has been selected as an exclusive licensee for mining applications of the underground radio.

- The Smart Screening Systems are expected to reduce the energy requirements for screening by 75 percent and significantly reduce noise/vibration levels for workers. Since 2002, the ITP's Mining portfolio has been funding research in Smart Screening Technologies, led by QRDC, Inc. To date, 11 Smart Screening Systems have been sold to mining plants in Minnesota. Six more systems will be installed in taconite plants in 2004. The Minntac plant will save an estimated $7 million when they convert to the Smart Screening System. Thirty-two magnet-based systems have been sold to mining plants in Minnesota. Smart Screening Systems can also be used in many crosscutting applications. Eriez Manufacturing, Inc., one of the leaders in vibrating machines for food and chemical plants, is negotiating a license to manufacture and sell Smart Screening Systems.

- Providing imaging ahead of mining can result in higher quality product, downstream energy savings, and improved safety and health. Researchers at Stolar Research Corporation are demonstrating two advanced technologies critically needed by the coal mining industry: (1) crosswell imaging of a coal seam in advance of mining, via horizontal boreholes, and (2) real-time measurement-while-drilling (MWD) for guidance and navigation of drillstrings during horizontal drilling operations applicable to both short and long holes.

- EERE BestPractices and Industrial Assessment Centers are providing hands-on technical assistance that the mining industry can apply immediately. In October 2003, the National Mining Association (NMA) sponsored two assessments in Macon, Georgia, which focused on pumping systems and process heating.

INDUSTRY OVERVIEW

Minerals are essential to practically every aspect of our lives and our economy; however, they are scarcely noticeable to most of us. In the United States, minerals have been so readily available for decades that most of us never give a thought as 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. Minerals are required for everything that we use in our homes, offices, transportation, communications and national defense. They are the source of all the metals in buildings, cars, airplanes, and household products and are also a major source of the raw materials for the building and chemical industries. Even in today's information age, minerals play an important role in the production of telephones, computers and televisions. In fact, 30 different minerals are needed to manufacture a television or a computer, and a telephone is produced from as many as 42 kinds of 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 carbon 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, have 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 stone, sand and gravel.

Types of Mining

Surface and underground mining are the two methods used by the mining industry. 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 2002, the total amount of coal produced was 1.09 billion short tons. Of this, 357.39 million short tons, or 33 percent, came from underground mines and the remaining 735.91 million short tons, or 67 percent, came from surface mines.[1] Of the 1.17 billion short tons of crude metal ore produced in the United States in 2002, 1.15 billion short tons, or 98 percent, came from surface mining.[2] Most of the industrial minerals in the United States are extracted by surface mining. In 2002, the total amount of crude industrial ore mined in the United States was 3.26 billion short tons. Of this, 3.14 billion (96 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 or her standard of living. Processed materials of mineral origin account for nearly 5 percent of U.S. gross domestic product.

1 U.S. Department of Energy. Energy Information Administration. *Annual Coal Report 2002*.
2 U.S. Department of the Interior, U.S. Geological Survey. *Mining and Quarrying Trends 2002*.
3 U.S. Department of the Interior, U.S. Geological Survey. *Mining and Quarrying Trends 2002*.

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. As shown in Exhibit 1, coal production in 2003 dropped 24.8 million tons, or 2 percent, from 2002. There were several issues that had an impact on coal production in 2003. Some of them were minor and had temporary effects (weather and transportation). Others were major and could affect the coal industry into the future (legal and financial). The lack of rain led to low water levels in the river transportation system, particularly on the Mississippi River in January and August. There were severe rains in the Powder River Basin in June that impacted coal production (causing some mine-pit flooding and collapsing highwalls) and transportation (delays in train deliveries). The major issues that had an effect on coal production in 2003 were primarily legal and financial, but also included operational problems. Among legal battles from the past, the issue of increasing legal weight of coal trucks used to transport coal was resolved in 2003, allowing larger loads to be transported on certain highways. Second, although the circuit court overturned the suspension in the issuing of permits by the U.S. Army Corps of Engineers Office in Huntington, WV (covering eastern Kentucky, Ohio, and southern West Virginia), the resumption in permits was slow due to backlog, delaying the opening of new mines. Additionally, the industry faced new legal challenges in 2003 – a new lawsuit was filed regarding the level of environmental review needed in the permitting system. There were also challenges to the New Source Review program requirements for power plants.[3]

Of the estimated 1.09 billion short tons of coal consumed in 2003, 92 percent was used by electric power producers. The United States is a coal exporter; however, since 1997, coal exports have decreased by almost half, while imports have increased more than three-fold. From 1997 until 2003, the number of mines has decreased by an estimated 23 percent and mine employment has decreased by 8 percent.

Exhibit 1
Coal Statistics

Category	1997	2000 r/	2001 r/	2002 r/	2003 e/
Production **(millions short tons)***	***1,090.0***	***1,073.6***	***1,127.7***	***1,094.3***	***1,069.5***
Appalachian	467.8	419.4	431.2	396.2	375.0
Interior	170.9	143.5	146.9	146.6	146.2
Western	451.3	510.7	547.9	550.4	547.3
Consumption **(millions short tons)**	***1,007.8***	***1,084.1***	***1,060.1***	***1,066.4***	***1,090.4***
Electric Utilities	900.4	859.3	806.3	767.8	786.4
Other Power Producers	21.6	126.5	158.2	209.7	214.2
Coking	30.2	28.9	26.1	23.7	24.2
Other Industrial	71.5	65.2	65.3	60.7	61.2
Residential/Commercial	6.5	4.1	4.4	4.4	4.4
Trade **(1,000 short tons)**					
Exports	83.5	58.5	48.7	39.6	43.0
Imports	7.5	12.5	19.8	16.9	25.0
Net Exports	***76.0***	***46.0***	***28.9***	***22.7***	***18.0***
Number of Mines	***1,828***	***1,453***	***1,828***	***1,427***	***1,400***
Underground	874	707	874	682	650
Surface	954	746	954	745	750
Number of Workers	***81,516***	***72,748***	***77,088***	***75,466***	***75,000***
Underground	52,487	43,172	45,085	43,000	**43,000**
Surface	29,029	29,576	32,003	32,466	32,000
Total Value ($ billions)	**19.8**	**18.0**	**19.6**	**19.7**	19.3

e/ estimated; r/ revised; * Does not include Refuse Recovery
Source: National Mining Association, Most Requested Statistics - U.S. Coal Industry, April 2004.

3 *Mining Engineering.* Annual Review 2003, May 2004, p. 38-39

Metals

In reviewing Exhibit 2, metals production has decreased 21 percent since 1997, with a large decrease in 2001. However, 2003 production increased an estimated 7 percent from 2001. Consumption of metals in the United States has also fallen since 1997 by 28 percent, with a 12 percent drop from 2001 to 2002 and an estimated 5 percent drop from 2002 to 2003. The United States is an importer of metals, and although imports were decreasing until 2001, an increase of 21 percent has resulted since. Exports have remained constant since 1997; however, there was a 20 percent increase in 2002. The number of mines has been fairly constant since 2001; however, employment in the metals sector has dropped 46 percent since 1997. All values are reported by the U.S. Geological Survey (USGS). The state of measurement used by USGS is termed as "mine output." This term refers to minerals or ores in the form in which they are first extracted from the ground and customarily may include the output from auxiliary processing at or near the mines.

Exhibit 2
Metal Statistics

Category	1997	2000	2001	2002 r/	2003 e/
Production (millions short tons)	**72.9**	**72.6**	**53.8**	**59.4**	**57.6**
Consumption (millions short tons)	93.9	91.0	80.1	70.8	67.3
Trade (millions short tons)					
Exports	7.8	7.5	7.3	8.76	8.23
Imports	20.7	17.6	12.1	14.12	14.64
Net Exports	***-13.0***	***-10.0***	***-4.8***	***-5.37***	***-6.41***
Number of Mines/Companies	**179**	**151**	**142**	**147**	**145**
Number of Workers	**45,202**	**34,092**	**29,576**	**25,786**	**24,515**
Total Value ($ millions)	**9,064.4**	**7,835.2**	**6,519.5**	**6,530.5**	**6,531.7**

e/ estimated; r/ revised

Source: U.S. Geological Survey, Summary of 12 Metal Mineral Commodity Summaries (Antimony, Beryllium, Copper, Gold, Iron Ore: Usable, Lead, Magnesium Metal, Molybdenum, Platimum Group, Rare Earth Metal Concentrates, Silver, Zinc)

Industrial Minerals

In 2003, industrial mineral production increased by an estimated 9 percent from 1997, as shown in Exhibit 3 (see page 4). In 2001, consumption increased by 13 percent from 1997, but in 2003 has decreased by 4 percent. The United States is an importer of industrial minerals, with the net exports remaining consistent from year to year. The number of mines and mining companies has increased by 4 percent since 1997, and the number of workers has decreased by 3 percent.

Exhibit 3
Industrial Minerals Statistics

Category	1997	2000	2001	2002 r/	2003 e/
Production (millions short tons)	**2,831.8**	**3,200.2**	**3,220.5**	**3,128.9**	**3,095.7**
Consumption (millions short tons)	**2,885.9**	**3,226.0**	**3,253.7**	**3,159.3**	**3,137.8**
Trade (millions short tons)					
Exports	17.6	22.3	22.4	20.9	20.4
Imports	48.6	51.8	56.2	52.3	56.1
Net Exports	***-31.0***	***-29.4***	***-33.8***	***-31.4***	**-35.7**
Number of Mines/Companies	**10,651**	**11,161**	**11,096**	**10,903**	**11,025**
Number of Workers	**158,800**	**173,384**	**171,610**	**156,245**	**154,680**
Total Value ($ millions)	**21,630.4**	**23,556.4**	**23,577.8**	**24,030.7**	**24,089.3**

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

Energy Use in Mining

Energy consumption in mining operations is estimated at approximately 753 trillion Btu.[4,5] 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 (see page 5) shows that 50 percent of fuel needs are met by fuel oil, followed by natural gas at 32 percent. Coal and gasoline supply the balance. Major energy requirements include electricity for ventilation systems, water pumping, and crushing and grinding operations. In total, 748 trillion Btu electricity equivalent is used for the mining industry: 243 trillion Btu are used on-site, while 505 trillion Btu are 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.

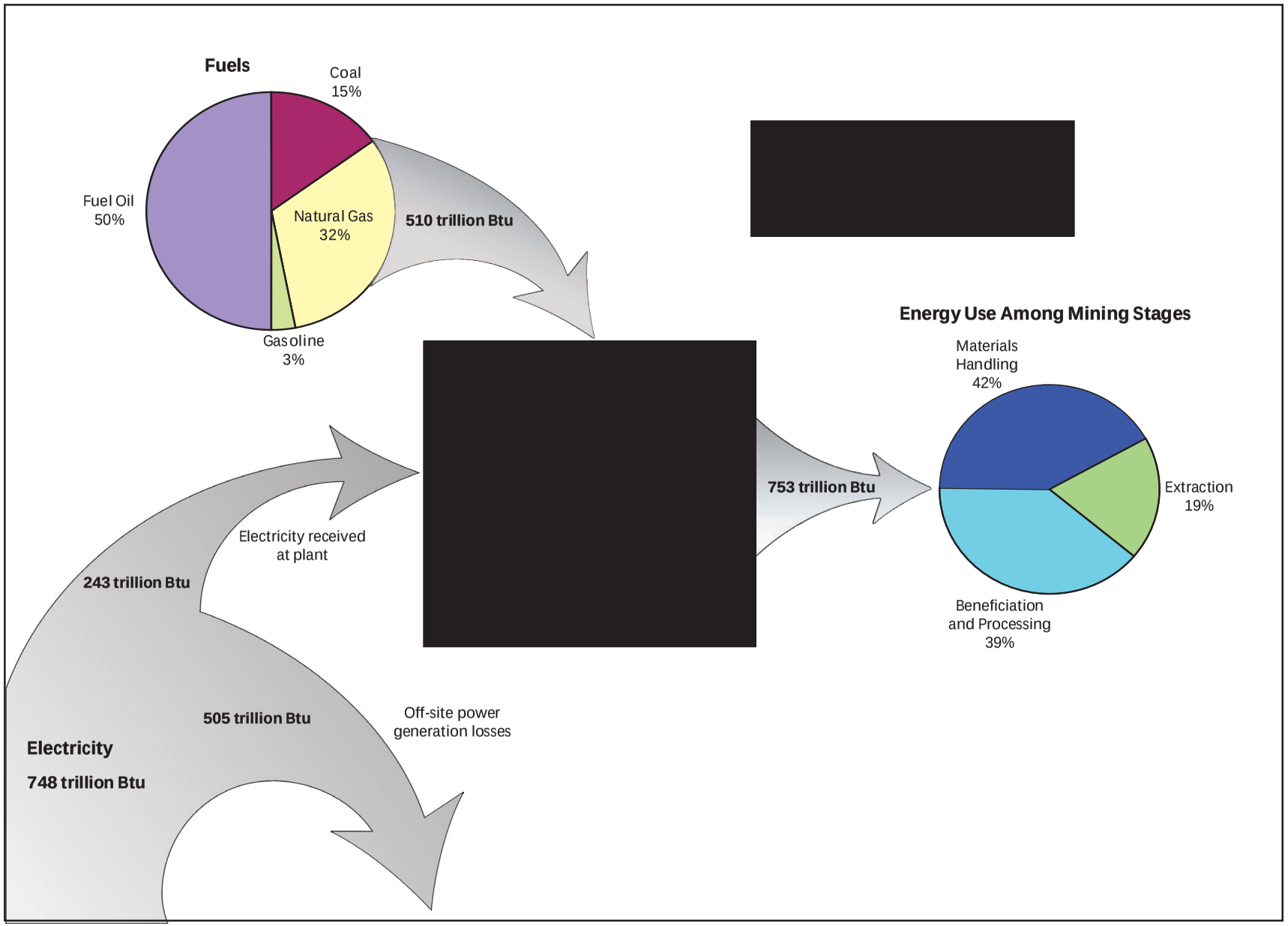
The mining industry is a capital-intensive industry. Total supply costs for minerals received, machinery, fuels, and electricity were approximately $19.0 billion in 1997. While the purchase of minerals and machinery accounted for 81 percent of this figure, purchased fuels (over $1.5 billion dollars) and purchased electricity (over $2 billion) accounted 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 consumed the highest amount of energy 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 consumed the most energy in extraction, accounting for 41 percent. Although materials handling, and beneficiation and processing consume the largest amount of energy, improvements in extraction could reduce downstream materials handling and processing, reducing energy needs.

4 U.S. Department of Energy, *Energy and Environment Profile of the U.S. Mining Industry*, 2002.
5 U.S. Department of Energy, *Mining Footprint Analysis*, 2003.
6 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.

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. Advanced mining technologies and processes are 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."[7]

Research Categories of the Mining Portfolio

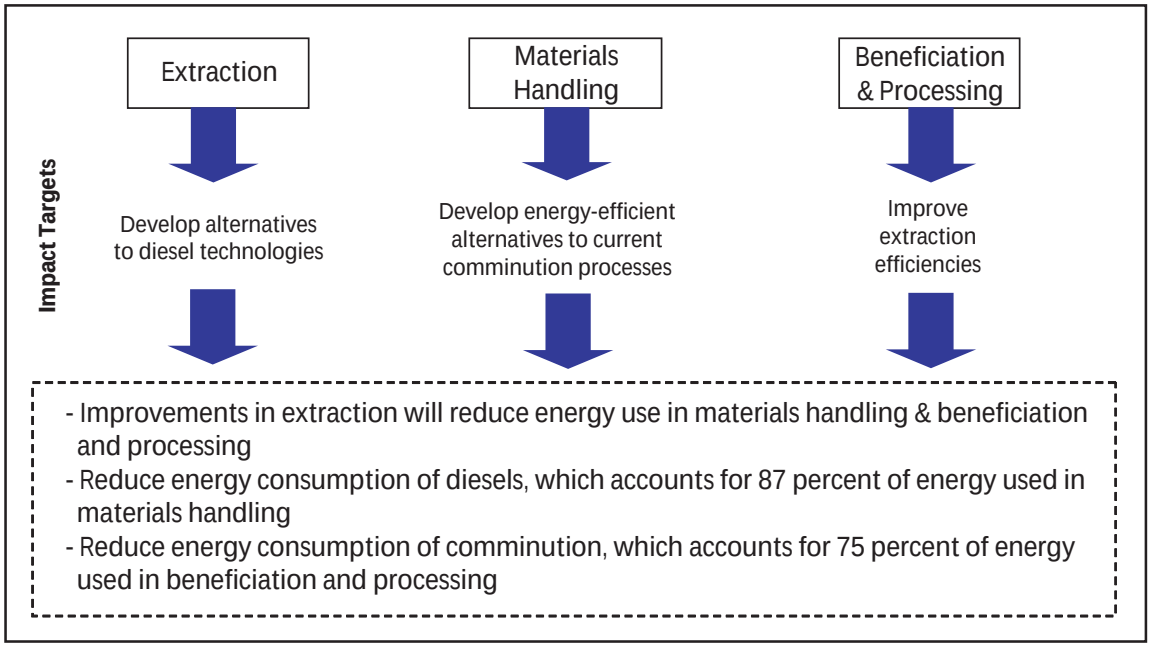
The success of the ITP's Mining portfolio is the result of a strong partnership between the mining industry and EERE. In the future, this partnership will direct its efforts to address high-impact research to make revolutionary improvements in energy efficiency in mining. Research is grouped into three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

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

Energy-Intensive Industry

The mining industry consumed an estimated 1,258 trillion Btu in 2001, including the off-site losses in electricity generation. Energy-intensive processes in mining include materials handling, beneficiation and processing, and extraction. The Mining portfolio is funding research to improve energy efficiency in these processes, illustrated in Exhibit 5. This research is improving production, environmental impacts, and health and safety. A 2004 analysis of current mining research projects estimates that the current R&D portfolio will save 5.86 trillion Btu annually in 2010. This is estimated to increase to 73.24 trillion Btu in 2020.

Exhibit 5
Process and Technology Improvements Target Energy Efficiency



7 Department of Energy, Assistant Secretary for Energy Efficiency and Renewable Energy, Organization Mission and Functions, 2002, pg.1

Important Role in State and Local Economies

The mining industry plays an important role in all 50 states. Minerals are formed based on varying geologic conditions, thus the same minerals are found in limited areas. As a supplier of coal, metals and industrial minerals (including sandstone and gravel) to businesses, manufacturers, utilities and others, the mining industry is vital to the well-being of communities across the country.

Mining operations are often the leading employers in the communities where they are located. Nearly 270,000 people work directly in mining throughout the United States. Employment in industries that support mining—including manufacturing, engineering, environmental and geological consultants—account for nearly three million jobs. The average miner makes $49,000 per year in salary, not including overtime, bonuses and benefits.[8]

Meeting the Challenge

The ITP Peer Review conducted by the National Academy of Science addressed industry-perceived gaps with the Mining portfolio. These include: (1) gaps in mineral processing research, (2) a need to investigate new technologies and compare them to mature technologies and (3) more projects seem to implement non-mining technologies, such as wireless communications. To address the first issue, the Mining portfolio has developed three technology roadmaps. Two of these roadmaps, the *Crosscutting Technologies Roadmap* and the *Mineral Processing Roadmap,* specifically address mineral processing. In 2004 alone, 10 out of 22 active projects were directed at mineral processing. Regarding the second issue, the Mining portfolio issued an "Innovative Concepts" solicitation in 2003 that awarded grants to develop white papers on revolutionary concepts for mining. Through the Grand Challenge solicitation, new and mature technologies will be investigated and compared. Finally, the last issue recognizes that although some projects have smaller energy savings relative to other projects, they will increase the productivity and efficiency of the mining industry.

8 National Mining Association, *Fast Facts About Minerals*, http://www.nma.org/statistics/pub_fast_facts_2.asp

FY 2004 HIGHLIGHTS & ACCOMPLISHMENTS

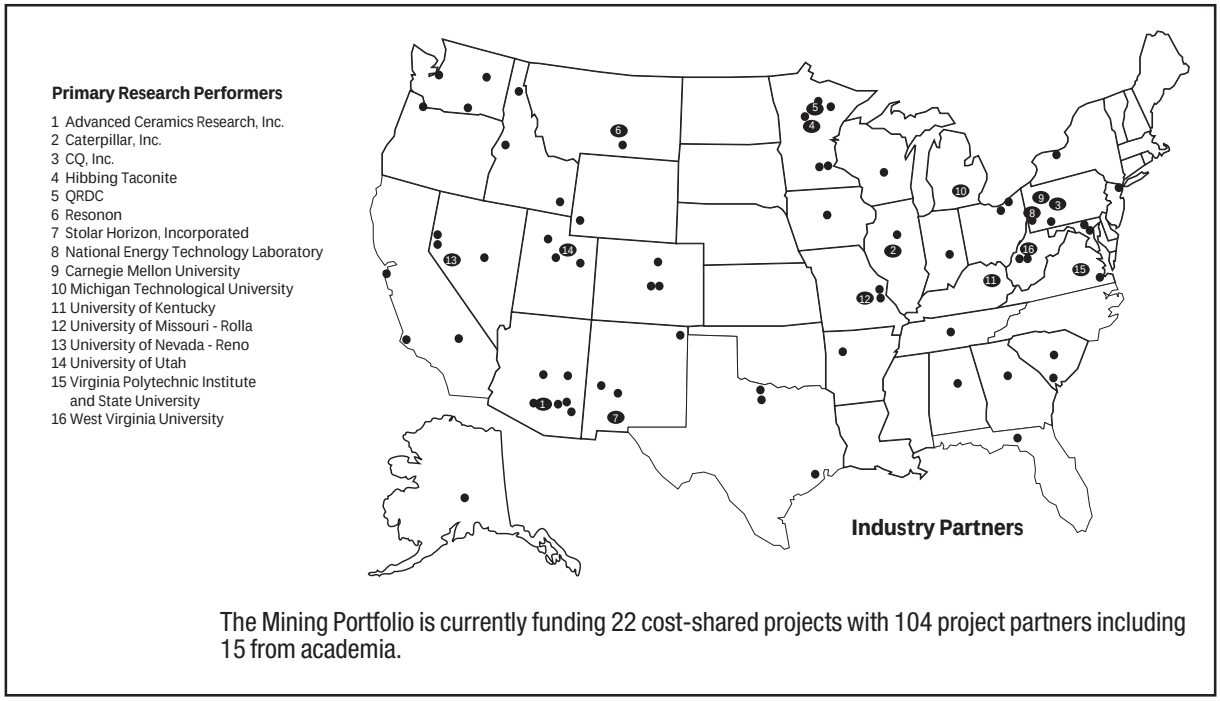
ITP supports a diverse mining portfolio of cost-shared, pre-competitive research. Research projects address high-risk/high-impact needs that have broad application throughout the mining industry. All the mining research projects are selected through a competitive review. Mining research must address both the priorities outlined in the related technology roadmap, as well as the DOE's national energy efficiency goals. Solicitations are announced in the *Commerce Business Daily* and on *FedBizOpps*, the DOE's *E-Center* and ITP's Mining portfolio Web sites.

Maintaining a strong and well-balanced portfolio requires careful attention throughout the competitive solicitation, evaluation and selection process. The 2004 Mining research portfolio consisted of 22 active projects, addressing the diverse research needs of the energy analysis study (derived from the *Energy and Environmental Profile for the U.S. Mining Industry* and *Footprint Analysis*), as well as the *Exploration and Mining Technologies Roadmap*, *Crosscutting Technologies Roadmap* and *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 Partnership

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 104 industry, university, national laboratory and government agency partners in 34 states across the United States. The geographic reach of ITP's Mining portfolio partnership is illustrated in Exhibit 6.

Exhibit 6
Broad Industry Partnership – Mining Research Performers and Project Partners



The Mining Portfolio is currently funding 22 cost-shared projects with 104 project partners including 15 from academia.

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 others. The Mining portfolio also enables the industry to have direct access to technical expertise available at universities and national laboratories.

A Diverse Research Portfolio

Exhibit 7 illustrates active mining R&D funding by focus areas. As shown, the portfolio addresses each of the focus areas discussed in the mining energy analysis study. The last mining solicitation issued in February 2003 was based on the Exploration and Mining Technologies Roadmap that focused on extraction. This is why most of the active projects are extraction projects. Funding distribution for each focus area is more evenly distributed when examining the entire life of the Mining portfolio. Improvements in extraction technology can potentially reduce energy needs for downstream processes, i.e. more efficient ore-sizing during extraction could decrease the amount of ore to be processed and result in energy savings. Exhibit 8 displays a list of current mining projects organized by portfolio category.

Exhibit 7
Active Research Funding by Focus Area

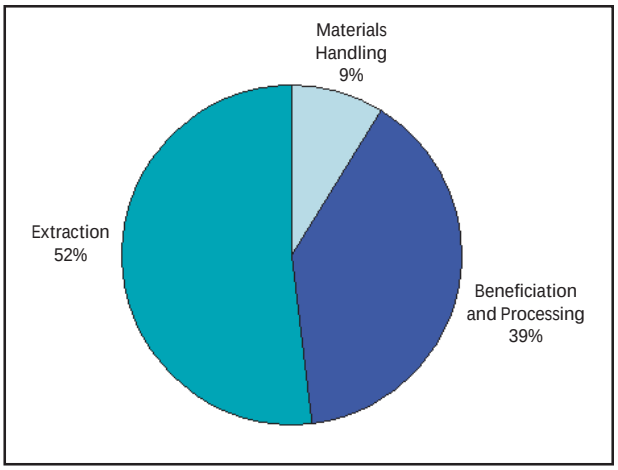


Exhibit 8
Active Mining Portfolio Funded in 2004 by Focus Area

(Fact sheets are available at http://www.eere.energy.gov/industry/mining/portfolio.html)

Extraction
- Wireless Mini-Wide Telecommunications Technology
- Computerized Roof Bolt Design System
- Reducing Energy Consumption for Water Pumping at Limestone Quarries
- Development of New Geophysical Techniques Mineral Exploration and Mineral Discrimination
- Demonstration of Crosswell Imaging Technology and Advanced Drill String Radar Navigation for Horizontal Directional Drilling
- Investigation of GPS/IMU Positioning System for Mining Equipment
- Robot-Human Control Interactions in Mining Operations
- On-line SAG Mill Grinding Pulse Measurement and Optimization
- Upgrading Low-Grade Ore by In-Pit Crushing and Cobbing
- Mine-to-Mill Optimization of Aggregate Production

Materials Handling
- Fibrous Monolithic Composites as Wear-Resistant Components for Mining
- Effective Conveyor Belt Inspection for Improving Mining Productivity

Beneficiation & Processing
- Metal-Matrix Composites and Thermal Spray Coatings for Mining Machines
- Real-Time Coal/Ore Grade Sensor
- Smart Screening System for Mining
- Comminution Circuit Optimization
- Improving Energy Efficiency via Optimized Charge Motion and Slurry Flow in Plant-Scale SAG Mills
- Total Ore Process Integration & Management
- Advanced Surface Enhancement Technology for Decreasing Wear and Corrosion for Mineral Processing
- Use of Granuflow™ process in Coal Preparation Plants
- Novel Binders and Methods for Agglomeration of Ore for Heap Leaching
- In-Plant Testing of High-Efficiency Hydraulic Separators

Integrated Technical Assistance for the Mining Industry

The ITP's Mining portfolio has funded $25.3 million in research to 43 cost-shared projects, with an additional $37.4 million provided by industry cost-share from its inception to the present. A number of other EERE portfolios have performed research related to mining. These include Inventions and Innovation, and ITP's Aluminum, Metal Casting, Steel and Chemicals portfolios. Combined, they have provided approximately $22.3 million in funding on current research and technical assistance relevant to mining and leveraged an additional $13.8 million in cost-share.

In addition to programs listed in Exhibit 9, EERE provides research on leading-edge enabling technologies, including Sensors & Controls, Industrial Materials, Combustion and others. The crosscutting activities listed in Exhibit 10 enable risk-sharing on industry-specific, pre-competitive, long-term high-impact research available through other ITP portfolios such as Aluminum, Metal Casting, Chemicals and Steel. Small Business Innovative Research grants also provide financial assistance for small businesses.

Furthermore, the Mining portfolio 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 ITP 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 9
Examples of EERE Technical and Financial Assistance

- 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 (IACs) enable eligible small- and medium-sized manufacturers to have comprehensive industrial assessments performed at no cost to the manufacturer.

Exhibit 10
Examples of ITP Research Related to Mining

Financial Assistance
- 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)
- Furnaces that Burn Biomass, Coal, and Other Solid Fuels (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 Refractory Materials (Steel)
- On-line, Non-Destructive Measurement of Mechanical Properties (Steel)
- Recycling Waste Oxides into Primary Process (Steel)
- Advanced Anodes and Cathodes Utilized in Energy Efficient Aluminum Production Cells.
- 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)
- Wettable Ceramic-Based Drained Technology for Aluminum Electrolysis (Aluminum)
- Membranes for Corrosive Oxidation (Chemicals)
- Recovery of Select Thermoplastics via Froth Flotation (Chemicals)
- Selective Catalytic Oxidative Dehydrogenation of Alkanes to Olefins: Effective Catalysts (Chemicals)
- Performance Data to Increase Reuse of Foundry Byproducts (Metal Casting)

Technical Assistance
- Two Best Practices Assessment workshops were held in Macon, GA sponsored by the National Mining Association. These workshops involved a pumping system assessment and a process heating assessment.

The Mining portfolio achieved a number of important accomplishments in 2004 in energy efficiency improvements to be transferred to and applied by the mining industry. Accomplishments were made in several key areas:

- Applying R&D Results
- Building R&D Partnerships
- Disseminating Research Results
- Energy Analysis

Applying R&D Results

Mining portfolio 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

A Real-Time Coal Content/Ore Grade Sensor – This project aims to install a machine vision system into a working mine. Using modern reflectance spectroscopy and digital image processing techniques, the spectral signatures of target minerals will be used to generate and easily interpret a false color map indicating mineral content in coal or ore. This will allow for greater selectivity as well as decrease environmental impacts and energy requirements in exploration, mining and processing activities. Resonon, Inc. has been selected for a

Small Business Innovation Research (SBIR) Phase I Award from the National Science Foundation (NSF) and SBIR Phase II Award from DOE. The DOE-awarded project in particular is closely related to this effort and will advance hyperspectral imaging for mining applications.

Radio Imaging Method Technology Winner of* R&D 100 *Award – Stolar Research Corporation of Raton, New Mexico received a prestigious *R&D 100* Award recognizing Radio Imaging Method System 4 (RIM-IV) technology as one of the most innovative ideas of the year. It was developed in cooperation with the National Energy Technology Laboratory and Sandia National Laboratory with funding from ITP's Mining portfolio. RIM-IV is a radio frequency device that generates high-resolution tomographic images of features below the surface of the ground. Locating geologic anomalies and hazards ahead of mining operations improves mine planning, lowers operating costs and reduces the risk of intersecting abandoned, potentially flooded mines. It also reduces energy consumption by decreasing the amount of unwanted material handling and processing. Mining companies, construction firms and the military have already used the technology worldwide as a safe and effective means of subsurface exploration and extraction. Recognized by industry, government and academia, an *R&D 100* Award provides an important boost to new products just entering the marketplace.

Crosswell Imaging Technology & Advanced DSR Navigation for Horizontal Directional Drilling – The project team at Stolar Research Corporation, with the assistance of their partners, are developing and demonstrating real-time measurement while drilling (MWD) for guidance and navigation of drill strings during horizontal drilling operations for both short and long holes. The goal is to provide more positive results pertaining to the location of and definition of mine voids, and valuable material. The advanced development of this technology will improve the recovery efficiency of both coal bed and coal mine methane. MSHA has approved to insert RIM probes into a gas environment with possible ignition risks. RIM-IV & Drillstring Radar (DSR) electronics tubes, and RIM-IV display and DSR controller enclosures have been approved by MSHA as explosion-proof. As part of DSR field-testing, Sufco Mine test-holes have been drilled and lined.

Innovative Concept Papers – Twelve papers were to be submitted at the end of FY 2004, at which time the awardees have the option to move to Phase II and III for future solicitations. These innovative concepts may provide future focus areas for the Mining portfolio.

Commercial Success

QRDC, Inc. Wins* R&D 100 *Award – QRDC, Inc. received a prestigious *R&D 100* Award recognizing *SmartScreensSystems™* technology as one of the most innovative ideas of the year. Since FY 2002, the Mining portfolio has been funding research in Smart Screening Technologies for the mining industry. To date, 11 Smart Screening Systems have been sold to mining plants in Minnesota. Six more systems will be installed in taconite plants in 2004. The Minntac plant will save an estimated $7 million when they convert to the Smart Screening System. Thirty-two magnet-based systems have been sold to mining plants in Minnesota. Also, Smart Screening Systems have crosscutting applications. Eriez Manufacturing, Inc., one of the leaders in vibrating machines for food and chemical plants, is negotiating a license to manufacture and sell Smart Screening Systems. The Smart Screening Systems are expected to reduce the energy requirements for screening by 75 percent and significantly reduce noise/vibration levels for workers.

Emerging Technologies

Emerging Technologies are projects that are no longer receiving ITP funding but are anticipated to be commercialized within the next three years.

In-Plant Testing of High-Efficiency Hydraulic Separators – Technological advances are needed to reduce inefficiencies associated with the conventional hydraulic separators. The project team lead by Virginia Polytechnic and State University is developing a new generation of high-efficiency teeter-bed separators. A full-scale prototype of the Crossflow technology has been sold to the Ohio Valley Coal Company and Cargill agreed to retrofit a unit in coarse circuit with HydroFloat technology. Eriez Manufacturing, Inc. is pushing commercialization of the new technologies.

High-Temperature Superconductors in Underground Communications – Researchers at the Los Alamos National Laboratory (LANL) are developing a compact, sensitive wideband receiver for low-frequency underground communications signals, using a high-temperature SQUID (superconducting quantum interference device). The LANL Intellectual Property Office has selected Pyott-Boone as an exclusive licensee for mining applications of the underground radio. Additional companies are negotiating for use in other fields, including emergency communications.

Building R&D Partnerships

BestPractices Training Session and Assessments: EERE BestPractices and Industrial Assessment Centers are providing hands-on technical assistance that the mining industry can apply immediately. In October 2003, National Mining Association (NMA) sponsored two assessments in Macon, Georgia focusing on pumping systems and process heating.

Disseminating Research Results

The ITP's Mining portfolio 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 ITP Mining portfolio activities. Examples of 2003 outreach activities include:

Society for Mining, Metallurgy and Exploration (SME) Annual Meeting and Exhibit: SME hosted a successful meeting in Denver, Colorado from February 23-25, 2004.

ITP Mining Web site: In 2004, this Web site was visited 35,590 times. It is a valuable resource for Mining portfolio activities and provides updates on research successes. To view the Web site visit: http://www.eere.energy.gov/industry/mining.

Energy Analysis – Targeting Energy Efficiency

The energy analysis study has been completed. This study analyzed the most energy-intensive processes/equipment in the three stages of mining: extraction, materials handling, and beneficiation and processing. *The Energy and Environmental Profile of the U.S. Mining Industry* was compiled in order to benchmark the energy and environmental characteristics of the key technologies used for selected commodities in the mining industry. This document shows, along with energy analysis studies, that the most energy-intensive stages include extraction, materials handling, and beneficiation and processing. The Metals and Mining team reviewed the results of this study with U.S. mining industry experts and developed criteria for the first Grand Challenge Solicitation in these areas.

The development of mining technologies which can reduce the amount of material that must be transported, crushed and processed can achieve significant improvements in mining energy efficiency. The Mining portfolio is currently reviewing proposals from the Grand Challenge solicitation. The solicitation has received 34 proposals aimed at conducting research in the areas of extraction, beneficiation and processing, and materials handling. The Grand Challenge Solicitation allows the submission of proposals in three phases. Phase I is primarily for basic development of new revolutionary concepts/theories/tools and to describe the feasibility in a paper or in the laboratory. Phase II is for applied research and needs to show potential advantages over commercially available technologies. Phase III is for demonstration of the newly developed revolutionary technology.

TOOLS, PUBLICATIONS, AND RESOURCES AVAILABLE

The tools and publications available from the ITP's Mining portfolio 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 industry are:

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

Energy Analysis Study – This two-page presentation illustrates the results of an energy analysis study to demonstrate where the largest energy-saving opportunities are in mining.

Mining Annual Report: Fiscal Year 2003 – Our 2003 Annual Report on the Mining Industry of the Future describes the current situation facing the industry, including challenges and opportunities. The report also provides information on the mining research portfolio, highlights and accomplishments from 2003, and how industry can get involved in ITP activities.

Water Use in the Industries of the Future: Mining Industry – This report features a chapter on the uses of water in the mining industry. It provides a brief overview of the industry, its water use, associated energy costs and water reuse practices.

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* – This report presents the results of a series of in-depth discussions with leading mining industry representatives selected for their prominent position and 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.

Evolutionary and Revolutionary Technologies for Mining – This study, conducted by the National Research Council, identifies critical research and development needs related to the exploration, mining and processing of coal, minerals and metals, and examines the federal contribution to R&D in mining processes.

Mining Brochure – This eight-page brochure highlights the benefits of ITP's Mining portfolio.

Energy Tips Sheets – These two-page tip sheets provide quick advice on how to keep your systems running at their maximum efficiency. They cover topics related to 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.eere.energy.gov/industry/catalog.

Fact Sheets

The Mining portfolio 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.eere.energy.gov/industry/mining/portfolio.html.

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 http://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 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 (ITP is one of 11) 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 http://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 reduce energy expending right away. Visit our Web site at: http://www.eere.energy.gov/industry or call the EERE Information Center at 877-337-3463 to access these resources and to get 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 nationwide network of capabilities for implementing ITP's technology delivery strategy. Regional Offices are located in the Southeast, Northeast, Midwest, Central, Mid-Atlantic, and Western regions. Visit http://www.eere.energy.gov/rso.html for more information.

Where to Go to Get More Information

Visit our Web site: http://www.eere.energy.gov/industry/mining

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

EERE Information Center answers questions on EERE's products, services and 11 technology programs, refers callers to the most appropriate EERE resources, and refers qualified callers to the appropriate expert networks. You may contact the EERE Information Center by calling 1-877-EERE-INF (1-877-337-3463) or by completing the form at this site: http://www.eere.energy.gov/informationcenter. A customer service specialist or energy expert at the EERE Information Center will respond to your inquiry.

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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 businesses

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

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

Mining Industry of the Future

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

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