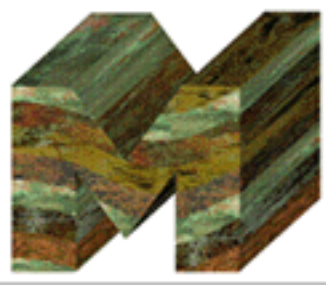


THE FUTURE BEGINS WITH MINING

*A Vision of the Mining Industry
of the Future*

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National Mining Association
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prepared by
THE NATIONAL MINING ASSOCIATION

THE FUTURE BEGINS WITH MINING

I. INTRODUCTION

Throughout history, mining products have shaped the course of civilization. Civilization passed from the stone age to the bronze age, and has entered the age of iron and coal, the industrial revolution, and now the information age. In the information age we give little thought to the role mining plays in providing the products we take for granted in our daily lives. But cars, telephones, computers and television all begin with mining. So do the roads we drive on, the buildings we work in, and over three-quarters of the electricity that makes our computers, appliances and lighting work.

The United States leads the world in developing and employing highly efficient and advanced environmental technologies to supply the world with minerals and coal. The U.S. mining industry's vision for 2020 and beyond is to continue to be the world leader by increasing the value of mining products for customers. The industry will employ processes and produce products that provide greater utility at lower costs, reduce energy consumption, and will continue to minimize the adverse environmental, health and safety effects associated with mining and mining products. Achieving this vision will provide enormous benefits to the world's growing and prospering population, their quality of life and the environment.

Development and use of advanced production and environmental technologies is a precondition to cleaner and more efficient mining processes and products that offer higher value to mining's customers. In addition, the industry will continue initiatives to educate and inform the public and to strengthen its partnership with government. Cooperative alliances with the public, workers, customers, suppliers, and investors will encourage the development of a socially, economically, and environmentally sustainable mining industry. Together they will identify a portfolio of products that enable economic growth and improved public welfare, while enhancing environmental performance.¹ The strategy for achieving this vision encompasses several critical initiatives:

- A research and development program directed to advanced management techniques and technologies that simultaneously:

- Reduces the costs of production and increases the quality of output while minimizing human health and environmental impacts and protecting its workers from hazards.

- Maximizes efficiency in the way that energy and raw materials are used and minimizes the volumes of wastes generated, and the environmental disruption associated with the mining product cycle.

- Demonstrates a portfolio of electricity production and enhanced sink technologies that will enable near zero net emissions of greenhouse gases from energy generated from coal.

- Produces recyclable mining products with low transportation costs that are competitive with other materials.

- Partnerships with federal, state, and local governments, and their constituencies to create a legal and regulatory system that supports more timely development of efficient and environmentally sound mining projects and products.

- A strong program of public information and education to enable the public to identify the value of goods derived from mining and the services that they provide and to educate communities about the importance of mining as an employer and source of income to communities.

The goals outlined in this document are ambitious. However, they represent only the beginning and not ultimate targets to be reached and held. As the industry moves forward, continuously improving in all areas, it seeks to eventually eradicate any potential negative impact from mining to employees and the environment. Concurrently, it strives to become highly profitable and attractive to investors. This document contains a snapshot of the mining industry in the year 2020 and it is this vision of the future which will be the basis for a bold research and development program to design and build the tools that will help the industry reach its goals.

II. MINING: AN INDUSTRY IN TRANSITION

A. The Value of Mining

At the most basic level, the mining industry extracts solid minerals from the earth and processes them, while simultaneously taking extraordinary measures to protect its workers and the environment affected by mining activities. Mining takes material from the earth that has little or no value and creates something of value from it. Mining products are metallic minerals, industrial minerals, and coal. Each American relies on over 46,000 pounds of new mined materials, including over 7,500 pounds of coal energy, each year.

The economic benefits of mining are far reaching. All 50 states have mining activities; mining provided direct employment for over 355,000 people in 1997. Mining operations are often the leading employers in the communities where they operate. Mining employees earn the highest wages of all U.S. industries-nearly \$44,000 per year compared with \$29,000, the average for all industries. Contrary to popular perception, the mining industry has a low rate of occupational injury, lower than retailers, hospitals, and hotels.

In 1997, the total direct value of non-fuel mining production in the United States was \$39.5 billion. Industrial minerals, the mining products used in construction, agriculture and manufacturing, had the highest value totaling \$27.1 billion. Industrial mineral production includes kaolin (a specialty clay used in the production of paint and glossy paper), phosphate (critical to agriculture), and salts, each having production values that exceed \$1 billion.

The total production value of metallic minerals was \$12.4 billion including copper, gold, zinc and iron ore, which each had production values in excess of \$1 billion. Other domestically produced metallic minerals with annual values approximating one-half billion dollars per year include lead, magnesium, and molybdenum.

Coal had a total production value in excess of \$19.9 billion in 1997. Low cost coal and uranium generate over three-quarters of the nation's electricity supply, helping to keep U.S. electricity

Minerals in Our World

One way to understand the value of mining is to try to visualize a world without minerals, the products of mining. A world without minerals, for example, would be a world without motorized vehicles-cars, trucks, trains, ships, and airplanes-the basic structures of which, as well as the engines, are metal. Buildings would be based on wood, other biomass, and limited volumes of surface available clay and stones. The large structures that characterize the twentieth century-skyscrapers, hospitals, bridges, factories-would not exist because they require the products of mining-concrete, cement, stone, glass, and metal. Inside buildings, a world without mining would mean no electrical appliances or office equipment. Stereos, televisions, computers and photocopiers all rely on multiple mining products. Indeed, silicon-the material that to some defines the information age-is derived from silica, a mineral.

Minerals also play less obvious roles. The world could not sustain the volumes of food production needed to feed the population without equipment that is based on mining products, nor without the fertilizers and soil conditioners produced from minerals. Similarly, without the products of mining, there would be limited equipment to produce other critical materials in the world-plastics, ceramics, wood, and paper, to name a few. Obviously, coal and uranium based nuclear electricity, accounting for over 77 percent of the electricity supply in the United States, would not be available. In addition, the production and transmission of most other forms of energy-oil, gas, solar, hydro, and wind-would

costs among the lowest in the world and thereby enhancing the competitiveness of U.S. industry. Clean coal technologies have played a large role in ensuring coal's continued dominance as a fuel for electricity production. Since 1970, U.S. electric utilities have increased coal use by 173 percent and at the same time reduced sulfur dioxide emissions by over 23 percent.

The value of mining multiplies in the economy. The products of mining provide incomes for an additional 5 million Americans employed in other industries and in government. The combined direct and indirect impact of the mining industry was \$524 billion, about 7 percent of GDP. That sum included combined direct and indirect contributions of \$143.7 billion in personal income, \$57.0 billion in federal government revenues, and \$27.2 billion in state and local revenues. The total economic benefit was nearly nine times the value of solid minerals mined in the U.S. that year. The total employment benefit was more than 15 times the number of workers directly involved in mining. In addition, the United States exported over \$3.5 billion of coal, over \$3 billion in raw minerals and \$34 billion processed materials of mineral origin in 1997; among the export mineral products are copper, iron ore, gold, molybdenum, coal, phosphate rock, boron and kaolin.

B. Preparing for the Twenty-first Century

As we approach the twenty-first century, two factors affect the political, economic and environmental scene: population growth and the elimination of poverty. Clearly the world is poised for burgeoning economic opportunities. The United States leads the world in adopting policies to promote long term economic growth through competition and financial reforms. The European Union and several Latin American nations are adopting similar macroeconomic policies and in several Asian countries, recent economic turmoil is encouraging similar reforms. Throughout the world, the benefits of information technology are only beginning to be realized.

These trends portend well for the mining industry. As the mining industry grows and demand for energy and the products of mining increase, the economy grows and the cycle continues. Economic growth is the result of an expanding mining industry. It is widely accepted that economic growth is driven by energy consumption, which in many countries of the world means increased coal use. Increased production of fertilizers based on phosphorous and potash will help feed an increasing world population as we strive to improve the quality and quantity of the food supply. Rising and stable production of steel (including the numerous mining products contained in steel), copper and cement will build the infrastructure needed to support the world's growing and prospering population. As global standards of living improve, an increasing fraction of the world population will demand more consumer goods, i.e., cars, telephones, televisions, computers, household appliances. Expanding industries and businesses will also increase their demand for sophisticated electronic equipment, computers and telecommunications devices.

Coping with the needs of population growth and eliminating poverty will be the U.S. mining industry's challenge for the next 20 years and beyond. Several factors will affect our ability to face those goals. Factors affecting achievement of that future take many forms, but those that are most apparent today include:

Technology

Widespread use of emerging and yet to be developed technologies presents great opportunity. Concurrently, the industry will be required to generate sufficient returns to make these investments and attract a highly skilled interdisciplinary workforce that can apply and advance the use of technologies that are not traditionally associated with mining.

Historically, technology has been a critical factor in the mining industry's ability to reduce environmental impacts and occupational hazards while continuing to increase productivity and cut costs. Technology will enable the mining industry to maintain its international competitiveness and locate, measure, and extract products from lower grade ores than those utilized in the 20th century.

As the mining industry moves towards the twenty-first century, the opportunity to apply emerging technologies to enhance production and resource performance and provide new products are critical to the industry's ability to serve the nation and achieve profitability. Once these technologies are developed and in place, they will allow the industry to use its energy, land, capital and labor resources even more efficiently during all stages of the mining cycle which will in turn, create a safer,

less environmentally disruptive industry with higher quality output at lower cost. Satellite communications systems and information processing technologies are already reducing costs and minimizing environmental disruption associated with reserve characterization and production. Automated machines reduce worker exposure to hazards while in situ processes contain the disruption associated with extraction and processing. Advanced processing technologies, based on biological processes and solvent extraction-electrowinning, are improving recovery rates and reducing the costs of mitigating environmental impacts.

A basic technology change that enables a 1 percent increase in metal recovery will equate to an additional \$5 million in annual revenues for a mine with \$500 million annual sales. It simultaneously reduces the amount of material extracted, processed, and disposed, which all have positive economic and environmental effects.

For coal, higher productivity and lower costs are the result of advances in longwalls, shearers and plows, blasting techniques, and haulage equipment. Coal technologies can remove up to 98 percent of the SO₂ and up to 99 percent of the particulate matter. Coal conversion processes enable 10 times as much energy to be recovered as was possible 40 years ago.

Changing Markets

Markets are demanding low cost products that have high levels of performance and minimal environmental impacts. For the products of mining, shifts in markets have a range of effects. One that is common to all is the drive for more efficient use of natural resources. Optimization of resources, whether it be through higher energy efficiency, increased recycling, or less intense use of materials, has become a driving force in mature economies. It is also evident in emerging economies as they adopt more advanced processes and products.

In a market based economy, competition from innovative substitutes drives progress. Coal and uranium are the fuels of choice for over 77 percent of U.S. electricity generators and contribute to the relatively low electricity prices in the United States. To maintain and increase that share, these industries must continue to make their products attractive and increasingly affordable to the customer despite other alternative fuel sources. In materials markets, producers of plastics and other polymers, glass, advanced composites and wood are continuing to upgrade their products to compete for markets now held by metals and industrial minerals. The emergence of new technologies and their products-zero emission cars, advanced electronics and communications systems-will intensify the competition. The success of the U.S. mining industry will be determined by its ability to compete in this evolving marketplace.

Advances in technology also create new markets for metals and industrial minerals. The consumption of zinc is now increasing, after years of decline, because its use as an anti-corrosive coating for metals has grown. Copper, with its high degree of conductivity and relatively low cost,

has an opportunity to expand its markets. High efficiency motors, for example, contain larger volumes of copper and copper is also becoming the metal of choice for high performance integrated circuits. Gold's corrosion resistance and high conductivity make it an essential component in the growing market for sensitive electronics and other advanced products (i.e., airbags, satellites, scientific instruments). The spread of economic prosperity in developing countries and the world's growing population will further expand markets.

Environmental and Energy Efficiency Policies

Increasingly stringent environmental policies in the United States will put upward pressures on production, processing and product costs at the same time that international competition and alternatives to mining products will require that costs remain competitive. Environmental costs can be significant. For example, the cost of environmental compliance in the United States for metal mining, processing and fabrication was about 10 percent of total costs in 1990. Despite these costs, progress has been significant. Coal mining operators, for example, have reclaimed in excess of 2 million acres over the past 20 years, an area equal to that of Rhode Island.

Domestically, we can expect continued improvement in land use and management, environmental, and health and safety programs that have made the U.S. mining industry the leader in environmental, health and safety performance throughout the world. The public's and therefore the political perception of the industry, as well as the scientific and technical information that affects our understanding of environmental and occupational risk, will drive the change. New approaches, such as voluntary strengthening of safety standards and other mechanisms for self regulation and stakeholder compacts, have the potential to play a larger role in the mining industry of the future.

Recent adoption of international treaties affecting the handling and disposal of hazardous wastes and products containing metals, long range transport of air pollutants and agreements addressing other environmental concerns presage an increasing global approach to environmental concerns and issues. Although CO₂ is not a pollutant, international political agreements to reduce CO₂ emissions could be a major factor in energy markets, especially markets that use coal. Climate change strategies that may affect the mining industry are likely to emphasize energy efficiency, methane emission control, reduction of carbon use and carbon dioxide sequestration. They will increase the need for energy efficiency in mining operations and in the processing and use of mining products. They would almost certainly raise the cost of mining products.

Mining and Fiscal Policies

Public policies and regulations affect the ability of the U.S. mining industry to compete for international mining investments and jobs. A 1992 United Nations survey found that the most important non-geological criteria for exploration investments were all related to the fiscal policies and mining codes of particular countries.

Many foreign countries are adopting mining favorable policies. They are privatizing their state-owned companies and are encouraging foreign investment. To maximize profitability, they are relaxing exploration regulations, reducing corporate tax rates, decreasing trade barriers, streamlining permitting processes, and reducing taxes and fees on the industry. South American governments

(particularly Chile, Argentina and Peru) began their reforms in the late 1980's and Asian countries (including the Philippines, Indonesia, Vietnam, India, and China) are now following their lead. With reform, many countries have driven the lead time needed to permit new mining sites to one-half to one-third of the time required in the United States.

Exploration investments reflect this difference. In 1991, Canada, Australia, the United States and Africa were the leading regions for metals exploration investments, totaling about 78 percent of the world's total. By 1997, the share for those four regions had fallen to 53 percent. The regions that gained share have created favorable mining fiscal and mining code policies. In 1996 Latin America was the leader, with 29 percent of the exploration budgets, and the Pacific had the highest rate of growth, with 11 percent of the total.

Capital Attractiveness

Despite the significant economic contributions of the U.S. mining industry, returns on investment have not kept pace with competing industries. Capital inflows are the lifeblood of the mining industry and the industry must become more attractive to investors by using technologies to increase returns by lowering costs, increasing the quality of the output and developing new markets and products while simultaneously reducing workplace hazards and minimizing negative environmental impacts.

The global competition driving the mining industry is unlikely to abate. Over the past 35 years, the mining industry production of coal, industrial minerals, and many metallic minerals has increased while cutting costs and prices. Mine mouth coal prices, for example, peaked in 1975, and have since fallen over 68 percent in real terms. Over the same period, the volume of coal production has increased more than two-thirds. Similarly, copper production has increased by 50 percent while the inflation adjusted price has fallen 43 percent during the same period.

Labor Market Attractiveness

Securing a skilled labor force-both hourly and salary-is a continuing challenge. Public opinion is one factor that will determine whether men and women become mining professionals rather than engage in opportunities in other industries. Another factor is the pool of academics available to teach mining related subjects. Critical shortages of university faculty that can teach mining and the use of new technologies in mining applications are emerging at a time when the need for workers with ever advancing skills is increasing. The emerging mining industry needs employees with a broader range of skills-computers, chemical engineering, environmental sciences and multiple languages, as well as mechanical, electronic and electrical skills.

Public Awareness and Education

Enabling the public to better understand and support the industry will continue to be a major challenge. The paradox of mining is that at least half of the general public does not recognize the role mining plays in our everyday lives despite the fact that everything begins with mining. In addition,

about 15 percent of the people involved in a recent survey had a negative impression of mining, believing that environment, unhealthy working conditions, and low wages are major problems. In other words, the successes of today's mining industry and reasons to support it are not readily apparent to most Americans.

III. OUR VISION OF THE U.S. MINING INDUSTRY IN THE YEAR 2020

The factors affecting the U.S. mining industry in 1998 are identified and discussed in the preceding text. In this next section, we fast-forward to the year 2020 and detail our vision of the U.S. mining industry of the future.

As the mining industry has moved into the twenty-first century, it is producing higher value products (products with lower costs and superior qualities) that enable continued economic growth and the widespread use of conventional and advanced products and energy resources to support the world's growing population and emerging markets in developing and industrialized countries. The U.S. mining industry in 2020 remains the world's leader in producing and processing competitively priced minerals and mineral products and some of the world's lowest cost coal while minimizing land disturbance, environmental disruptions and hazards to workers. U.S. companies continue to dominate the international mining industry and to practice responsible stewardship of national resources by developing and applying advanced mining and environmental management technologies in the United States and throughout the world.

The U.S. mining industry has doubled its global presence since the turn of the century by continuing to be the supplier of choice for high value mining products that serve the global market. Mining products are the building blocks of our society. They are still the primary materials in our buildings, roads, and machines. Mining products are the basis of many products that have become increasingly critical to everyday life in the twenty-first century-advanced materials, zero emission vehicles, information technology, and advanced pollution prevention and environmental control technologies-to name a few. Mining is not taken for granted in 2020-the general public has become aware of the nation's dependence on mining to maintain and improve our quality of life. Developing countries have embraced the concept that the mining industry and their products provide the standards for measurement of nation development. Communities welcome mining operations, recognizing their contribution to employment and economic growth.

The industry is achieving this vision by encompassing all elements of mining (exploration, development, production, processing, utilization, recycling, disposal and the associated transportation systems). This strategy emphasizes:

Strengthening the industry's performance in terms of cost, productivity, worker and public health and safety, and the environment through improved management and application of technology.

Building partnerships with local, state and federal governments and their constituencies to develop fair and cost-effective legislation and regulations.

Providing information to students, grassroots community groups, and consumers to educate them on the value of mining and its role in their lives and in their communities.

A. Advanced Processes and Products

Advanced management techniques and technologies are increasing productivity and permits exploration, extraction and processing to occur with minimal environmental impact. The mining product cycle is optimized across all stages-exploration and resource identification, extraction, processing (including smelting, refining, and coal preparation), recycling, waste disposal, conversion to a salable product, and transport.

Mining in the twenty-first century:

- Is highly productive, with low production costs and significantly fewer work related accidents and health effects.
- Optimizes the consumption of energy and raw materials and minimizes the volume of wastes generated and environmental disruption associated with the mining product cycle.
- Demonstrates a portfolio of electricity production and enhanced sink technologies that will enable near zero net emissions of greenhouse gases from energy generated from coal.
- Produces recyclable products with low transportation costs.

A jointly sponsored government-industry research and development program, organized around centers of excellence, located in university, national and private laboratories, has been critical to the development of the optimum mining cycle. The joint research and development program has emphasized strategic alliances with customers, investors, employees, and suppliers to produce products and processes that optimize the benefits and minimize costs across all stakeholders. The result has been a stronger domestic mining industry with positive GDP impacts.

Low cost and safe production

The U.S. mining industry continues to be the leader in a world of ever greater competition. American companies are maintaining their leadership through continued increases in productivity and through reductions in the costs of production, while protecting their workers and the environment. Downstream, low cost electricity from coal supports the competitiveness of American industry in world markets. The industry has dramatically improved total process efficiencies and has achieved significant reductions in workplace injuries bringing the injury rate far below all other basic industries.²

Exploration and Resource Characterization

The mining industry has developed and employs sophisticated techniques to explore and

characterize mineral and energy resources minimizing the need for extensive capital and advanced work. This reduces the costs of, and the environmental disruption that can be associated with, finding economic resources. The industry has continued to incorporate and advance social and environmental goals into exploration and characterization methodologies. These innovations combined with a cooperative partnership with government have cut the resource development cycle by two-thirds.

Large, low cost, high grade resources are being developed with minimal disruption to the environment and close to markets and ports wherever possible. Ground disturbance associated with exploration and development is minimized and the accuracy of the measurement of resource volumes and quality has been improved. Reserve maps are more accurate and mine plans are designed make mining more productive. Improved efficiency in mineral extraction reduces out-of-seam dilution and therefore reduces mineral processing costs and minimizes wastes.

Extraction and Processing

Sustainable mining in the twenty-first century requires advanced technologies-technologies that reduce the disturbance to the earth associated with mining and enable the extraction of all materials with market value from the ores and energy resources. Sophisticated modeling and information technologies are widely applied. Robotics and other artificial intelligence techniques allow human operators to increase production while reducing their own exposures to potential hazards. Advanced modeling techniques improve resource evaluation and mine planning. Overall, the improvements in energy efficiency for production and processing are among the largest of all industries.

Improved process sensor controls, online analysis, advanced communication technologies, and instrumentation robotics are among the elements of information technology that improve the energy and production efficiencies of extraction and processing and that reduce worker exposures to hazards. When these technologies are applied in transport for example, mining equipment utilization and worker safety both increase and costs decline. Remote control of the complete hauling cycle is common. Advances in global positioning, out-of-sight sensing, human machine interface, and obstacle avoidance techniques have enabled the use of autonomous mobile transportation equipment.

The efficiency of separation or liberation of mineral material at the mine face has been increased, helping to reduce the volume of waste and energy consumed in transport. Improved techniques for characterizing ore for mill response have reduced processing costs and energy consumption. Advances in selective mining technology have reduced out-of-seam dilution and also the volume of associated wastes that must be transported and processed.

For processing, technologies optimize mine-mill synergies, aid in the identification and separation of fine particles, improve wear materials efficiency, and enable lower cost and less environmentally disruptive leaching. New materials, compression methods and materials handling systems have dramatically reduced the energy consumption and pollution associated with comminution. Mobile comminution machines that enable the device to move to the raw material reduce the costs of and energy required for transport.

Emission and Waste Control

Active mining is a temporary use of the earth; new production, processing and environmental technologies further shorten the time and extent of disruption in both underground and surface

operations. Even during this temporary use, extraction is conducted in a way to make operations minimally visible to the surface observer and processing or use of what is extracted has minimal environmental impact. Communities value mining operations and welcome them.

The industry is pursuing several avenues to minimize temporary environmental impact. First, environmental goals are completely integrated into the overall production planning process. By incorporating environmental goals during the planning cycle rather than developing them as separate components, lower costs for environmental performance during and after production are realized. Second, operators maximize the use of processing activities at or near the mining face and in situ techniques. Such technologies not only localize environmental effects and management, but also reduce transportation requirements.

Third, the industry utilizes processes they developed that enable all materials with market value to be extracted, processed and sold. Fourth, the industry has achieved its goal of near zero impact from discharge of solid, liquid or gaseous effluent and waste. Advances in dust suppression and control have helped to make mining safer and less disruptive to the environment. Waste streams have been reduced by reducing the amount of impurities reaching the processing facility, by altering beneficiation processes to reduce the volume of waste generated and to increase the recovery of byproducts, by employing in situ and underground water treatment and sludge disposal alternatives, and by combining waste streams that may reduce or eliminate the generation of waste water.

Fifth, the successes of the Abandoned Mine Land Initiative, Abandoned Mine Land Fund, and Acid Drainage Technology Initiative as well as the Appalachian Clean Stream Initiative are evident. Public and private investment in remediation and technological innovation has helped to clean up sites where mining occurred before modern reclamation techniques were available. Similarly, combined public-private efforts have eliminated acid mine drainage from abandoned coal mines, helping to improve the lives of the people and the ecosystems located in the affected watersheds.

Advanced Products-Clean, Recyclable and Easily Transportable

The mining industry is the critical first link in the chain that produces and improves material products. Numerous processing and fabrication industries complete the chain, providing the final consumer with an abundant assortment of high quality products that allows us to define how we live. To continue to improve the quality and quantity of mining based products used in the economy, the mining industry has formed cooperative alliances with the consuming, processing, and fabrication industries that rely on minerals. They are jointly developing higher quality and environmentally benign products. Together, these partners have developed new material and energy products that sustain growth in the world economy.

In developing these cooperative alliances, the mining industry has directed its attention to better understanding the needs of its customers and the options and problems that they have in serving their markets. Longer term relationships that enable the technology development and capital investments required for advanced extraction and processing form the core business of mining. The mining industry has grown by providing increasingly competitive markets an array of new and competitive products. Customers continue to choose mineral based products and coal because they provide extraordinary value.

As it has for millennia, everything in the 21st century begins with mining. Society has advanced and so has its demand for sophisticated materials and the traditional building blocks of our

economy. Building materials, fertilizers, metal products and over 85 percent of the nation's electricity are based on the products of mining. Mining products have kept pace with this demand. They have enabled wider distribution of advanced products, such as electric cars and increasingly advanced industrial, communications and computer equipment. They are the basis of the products that make the information age possible. And they are critical to the advances in environmental protection-providing the materials to filter the air and water and stabilize soils. Metallic minerals are competitive in part because the industry has achieved the highest rate of recycling among all materials producers. The mining industry has joined with processors and fabricators to increase the use of recycled materials.

Coal producers and consumers are rapidly moving towards the 2035 goal of demonstrating near zero net emissions by designing and building facilities that mitigate carbon dioxide emissions in these ways: improved efficiency, decarbonization, and carbon dioxide sequestration. New cost effective power systems have been designed that increase thermal efficiencies to greater than 60 percent by 2010 and 70 percent by 2035 for power and 85 to 90 percent for power and heat. These systems are combined with advanced decarbonization technologies that produce intermediary fuels or chemicals as by-products. Such facilities also reach near zero emission levels for air pollutants, and contain all residual wastes and effluents "within the fence." Additionally, carbon dioxide emissions can be sequestered and not emitted to the atmosphere. The capability to decarbonize emissions and sequester carbon dioxide is nearing final development and will be placed on the shelf pending the requirement to use capital to follow guidelines relating global climate change. As a result, secure, low cost supplies of coal have become an increasingly important energy resources of choice-used to produce electricity and a variety of other products, such as chemical feedstocks. For all mining products, minimal dependence on transportation infrastructure is an important element of success. For example, mine site electricity generation and smelters and mills colocated with mining operations have vertically integrated exploration, production and processing. Thus transportation volumes are lower, as is the energy consumption associated with transport.

B. Partnership with Government and Communities

Achievement of the industry's goals will lead to increasingly beneficial partnerships with federal and state government agencies to promote development of mining projects in the United States. This stronger partnership with government has reduced the time for resource development cycle by two-thirds. The industry has established trust with the public through a performance record that supports self regulation and the need for minimal government oversight. This trust also results from an effective information and education program developed in conjunction with and supported by both government and industry. A grassroots program to build stronger and more harmonious relationships with elected officials and their constituencies at the federal, state and local level complements the education and information program.

The grassroots initiatives have supported improvements in legislation and cultivated a climate favorable to positive reform. In cases where the public owns the resource, reasonable rules affecting taxes, depletion, and cost-sharing enable the public owners and the industry that creates its value to equitably share that value. In appropriate cases, the industry is able to buy (rather than lease) public mineral rights. With a rational and consistent legal and regulatory system in place, the playing field for mining, relative to other industries and to competition from other countries, is level with standards that protect workers and the environment in place in all countries.

C. The Mining Industry Compact with Its Public, Employees and Investors

The U.S. mining industry is a model industry-it is dynamic, high performing, and progressive. The public, mining industry workers, and the investment community recognize the value of the mining industry that serves them, the nation and the world. The industry addresses the needs of the public, employees and shareholders through educational programs and outstanding technical, environmental, health and safety, and financial performance.

An Educated and Safe Workforce

The industry succeeds because it attracts and retains excellent employees at all levels of skills and training. It provides rewarding working conditions and growth opportunities for its employees because of its financial strength and by practicing the highest standards of professionalism. Workers are stakeholders, with their compensation linked to the performance of the company. Improvements in production processes have reduced hazards for all workers. While better technology is an important part of a safer working environment, more effective education and training for workers are also critical. The mining industry has succeeded in their campaign to make safety and health an integral part of the production planning process. An ideal combination of management, technology and education has led to simultaneous improvement in productivity and safety and health. The mining industry has provided the management structure, tools and training to protect employees from hazards and employees have in turn embraced the attitude that both improved productivity and high standards of safety and health are critical to their standard of living. As a result, recordable accidents are nearly eliminated by 2020.

The mining industry provides professional opportunities that attract the best and the brightest. University mining programs employ interdisciplinary faculty and are offering programs that enable students to learn all of the skills applicable to an advanced mining industry, including environmental sciences, chemical engineering, computers and robotics, advanced communications, and international relations and language training. Talented students are choosing mining as a career. This quality workforce applies interdisciplinary techniques to achieve the industry's technical, financial, environmental, and health and safety goals.

An Excited Investment Community

The investment community favors the U.S. mining industry, the result of returns that are above the average for American companies and the clear indication that federal government supports mining. Because of its profitability, the industry generates and attracts sufficient capital to secure its future. Improvements in the exploration and production processes have lowered costs by increasing productivity and by enabling cost-effective approaches to achieve environmental and health and safety goals. Higher quality products have added value; these products are more profitable in highly competitive materials and energy markets. Finally, the industry matches production to the naturally

cyclical markets that it serves and has reduced the inventory surges that cause prices to fall and profits to erode.

An Informed Public

The success of the mining industry of the twenty-first century begins with its relationship with the public. The industry and the public work together to ensure that environmentally sound minerals and coal and uranium resources that are required to sustain a high quality of life in the United States and throughout the world can be produced. The public understands the value of mining. This is the result of an ongoing program that enables them to recognize the value of the goods derived from mining and their integral role in society's welfare.

The industry regularly seeks to understand public opinion and responds with accurate information programs that address public concerns. In the schools, teachers and students have credible and accurate information about mining and the importance of coal and minerals to their lives. The mining industry and the education community continually provide accurate, interesting, and informative teaching materials and delivery systems that reach the majority of administrators, teachers, and students. In communities, companies and citizens find approaches to mining that minimize environmental disturbance and enable the community to share in the value realized from producing and selling minerals and coal. In the home, a universal mining symbol is affixed to goods that contain the products of mining. The cumulative effects of education, information, and pervasive labeling enable users of mining products to link the value of those products to the need for mining.

IV. GOALS

To attain this vision, the industry has outlined the goals in Table 1.

V. TECHNOLOGY CHALLENGES

In reaching for the simultaneous goal of cleaner, more energy efficient products and processes, the industry will reduce its costs of production by shifting its production cost curves downward. Achieving this goal will provide enormous benefits for the United States, and raise the quality of life for the world's growing and prospering population and the environment.

These public benefits can only be realized if extensive investments are made to shift the paradigm of how mining products are produced through the development of new technologies and the transfer of appropriate technologies developed for other applications. Transfer of these technologies and development of new technologies will enable the industry to reach its goals and provide the nation and world with a portfolio of materials critical to economic, environmental and energy sustainability. This is a vast undertaking, beyond the financial capability of an industry that has returns that are among the lowest of U.S. industries. Paradoxically, successful development and application of new technologies that incorporate advanced technologies such as computers, radio communications and robotics is the key to the mining industry's improved profitability.

VI. RESEARCH PRIORITIES

As the industry establishes research priorities and the government and industry identify projects for joint sponsorship, it is important to realize that new technologies will in all likelihood migrate beyond the U.S. borders. U.S. mining companies are the world leaders in production, environmental control, health, and safety technologies. In the interest of sound financial management, the U.S. industry deliberately uses the state-of-the-art technologies and practices required by U.S. regulations in its overseas developments. Thus, the industry transfers many of the technologies developed for U.S. markets. All jointly sponsored research projects will address critical domestic priorities; projects that are not likely to have high value within the United States will not be included in the joint research and development program.

TABLE 1 : GOALS FOR THE MINING INDUSTRY

Low Cost and Efficient Production: Use advanced technologies to improve process efficiencies from exploration to final product.

Superior Exploration and Resource Characterization: Develop ways to find and define larger high grade reserves with minimal environmental disturbance.

Safe and Efficient Extraction and Processing: Use advanced technologies and training to improve the worker environment and reduce worker exposure to hazards that reduces lost time accidents and occupational diseases to near zero.

Responsible Emission and By-product Management: Minimize the impact from mining activities on the environment and the community by fully integrating environmental goals into production plans. Support the development of technologies to reduce carbon dioxide emissions to near zero and sequester additional emissions.

Advanced Products: Maintain and create new markets for mining products by producing clean, recyclable and efficiently transportable products and form cooperative alliances with the processing and manufacturing industries to jointly develop higher quality and more environmentally friendly products.

Positive Partnership with Government: Work with government to reduce the time for resource development cycle by two-thirds. Achieve equitable treatment for mining compared to other industries that produce materials and energy relative to international competition by making legal and regulatory framework rational and consistent.

Improved Communication and Education: Attract the best and the brightest by making careers in the mining industry attractive and promising. Educate the public about the successes in the mining industry of the 21st century and remind them that everything begins with mining.

Successful completion of these goals will inspire a committed investment community which will fuel the cycle of increased capital investment vital to the success of the industry and to the future economic growth of the United States.

¹ In this document, the concept of sustainability is defined as meeting the economic and environmental needs of the present while enhancing the ability of future generations to meet their own needs.

²Process efficiencies are the sum total efficiencies of all factors of production used in mineral extraction and processing.