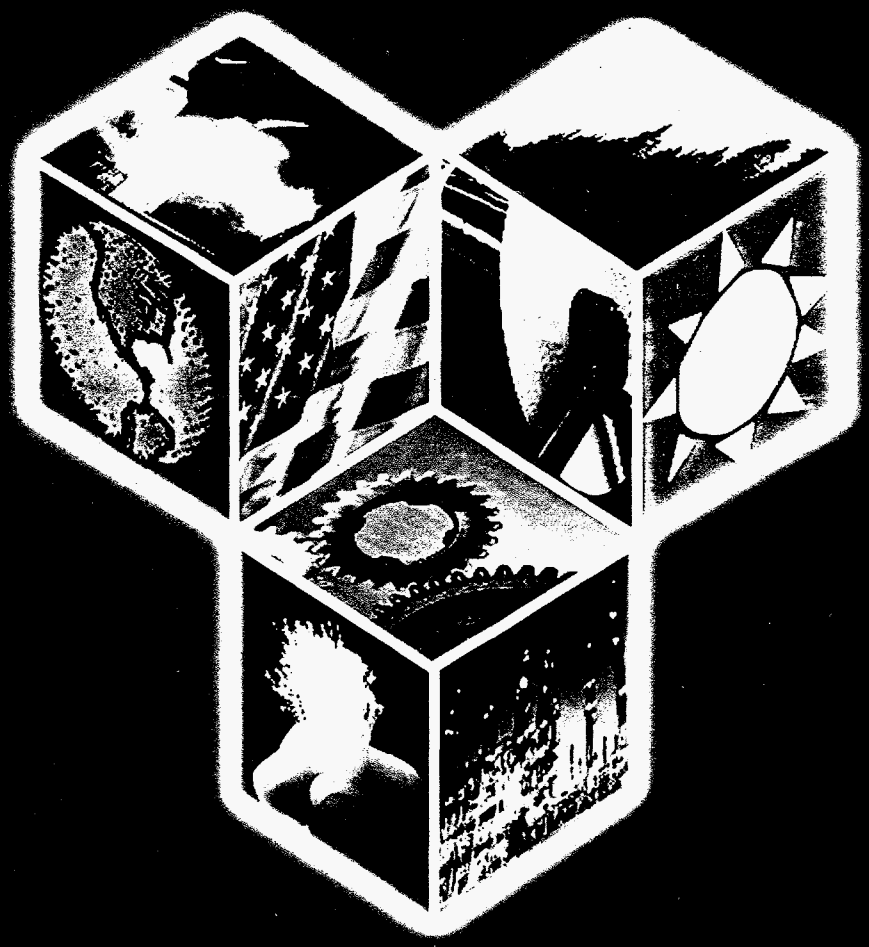
TURNING INDUSTRY VISIONS INTO REALITY



ENERGY EFFICIENCY AND RENEWABLE ENERGY
U.S. DEPARTMENT OF ENERGY

"OIT's Industries of the Future strategy is paying off for industry participants and for the nation ... through enhanced industry productivity, energy efficiency, pollution prevention, and preservation of jobs."

Denise Swink
Deputy Assistant Secretary
Office of Industrial Technologies

For many leading companies, "lean and clean" technologies and "resource productivity" are becoming key strategies. More and more companies recognize in these concepts opportunities for reducing costs, cutting pollution, improving products, and boosting customer satisfaction.

OIT is helping ... through new partnering strategies, through focused R&D, and through wide-ranging, innovative programs that leverage technology resources to benefit industry and the nation.

THE INDUSTRIES OF THE FUTURE STRATEGY

VISIONS INTO REALITY

The activities of the Office of Industrial Technologies (OIT) in the Department of Energy encompass many roles, all aimed at encouraging and accelerating industry's adoption of energy-efficient, pollution-reducing technologies. The roles range from conducting R&D on advanced technologies, to innovative financing, technical assistance, information dissemination, education, and serving as a catalyst in bringing together various combinations of industry groups, universities, National Laboratories, states, and environmentalists.

OIT's core initiative, the Industries of the Future, is based upon facilitation of partnerships within seven materials and process industries. These seven are the most energy- and waste-intensive in the U.S. manufacturing sector; they are the aluminum, chemicals, forest products, glass, metalcasting, petroleum refining, and steel industries. OIT supports each industry in defining its vision of the future and in identifying technology priorities. OIT then draws upon those industry-defined needs to shape R&D programs. These fall into two general categories: process technologies for important production areas in a specific industry, and crosscutting or enabling technologies, which are eventually applied across multiple industries.

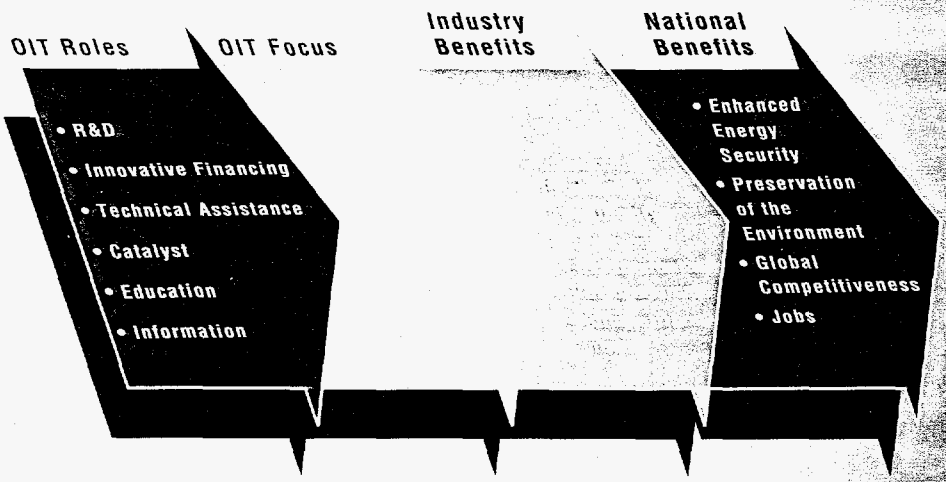
The Industries of the Future initiative exemplifies positive roles that government can play. Government is uniquely positioned to think and act on behalf of the whole nation with a long-term perspective. Government can make some of the investments needed to ensure that industry can achieve goals that are beyond the scope of private industry ... national goals of energy efficiency, the preservation of the environment, global competitiveness, and the jobs of our citizens.

Government also has broad capabilities for collecting and spreading information, for forming liaisons and linkages, and for creating synergies among diverse stakeholders. These government roles are central to OIT's Industries of the Future initiative.

OIT has created a diverse portfolio of other programs to leverage maximum impact from limited resources. Some examples of the groups targeted and the techniques used:

- Manufacturers using electric motors—information and technology guidance
- Small and medium-size manufacturers—plant assessments and productivity recommendations for energy and waste savings
- Firms wanting to demonstrate technology—grants, and involvement of State energy offices through their sponsorship
- Industrial companies—voluntary commitments to reduce greenhouse gas emissions, and support and recognition for their actions
- Inventors of promising technologies for energy supply, energy savings, and pollution reduction—commercialization guidance
- All industry—alerting companies to potential opportunities from technologies applied in other industries

In order to ensure that the right information, technologies, and services are delivered effectively to our customers, OIT has also developed a focused point-of-contact approach that provides coordination and ease of access to the OIT programs.



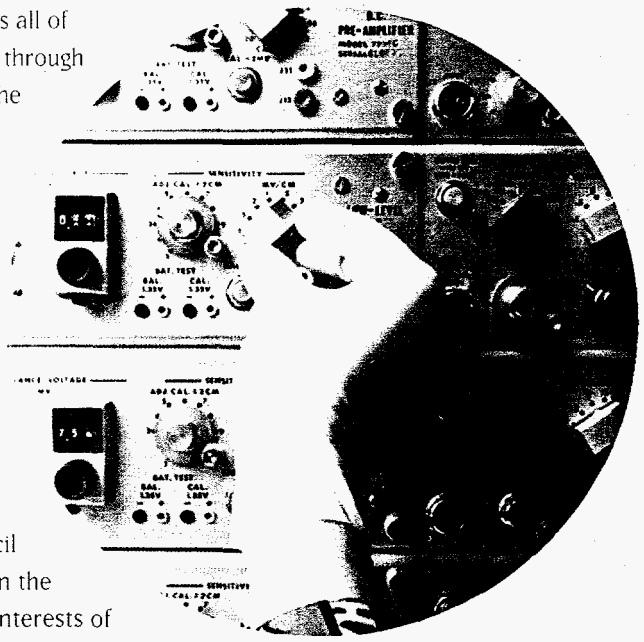
OIT constantly seeks to multiply results from resources to gain maximum benefit for the U.S. manufacturing sector and the public.

THE INDUSTRY VISIONS

FOR ACTION

The Industries of the Future process begins with industry participants creating a vision for their industry's future. The vision reflects the dynamic impact of market, business, social, and regulatory drivers and identifies those technologies required to turn the vision into reality. OIT encourages each industry to develop its vision and provides support for this process as requested by the industry. Guided by priorities that industry identifies and by DOE's strategic mission, OIT then shapes a research and development portfolio with near-, medium-, and long-term activities for funding.

Though OIT plays the lead role in facilitating the Industries of the Future process, the Secretary of Energy commits all of DOE to support this broadly collaborative initiative through compacts signed with the individual industries. In the process, teams comprising representatives from industry, government, universities, and the National Laboratories are formed and work closely together to design and carry out research and development programs.



The National Laboratory Coordination Council

The National Laboratories have recently formed the National Laboratory Coordination Council to facilitate industry access to the extremely broad array of technical expertise in the Labs. The Council has developed a capability matrix designed to align the Labs' specialized capabilities with the technology interests of each of the seven industries. This matrix will be a valuable reference as the industries structure roadmaps for their technology development efforts.

The seven industries currently involved are the following materials and process industries:

ALUMINUM

CHEMICALS

FOREST PRODUCTS

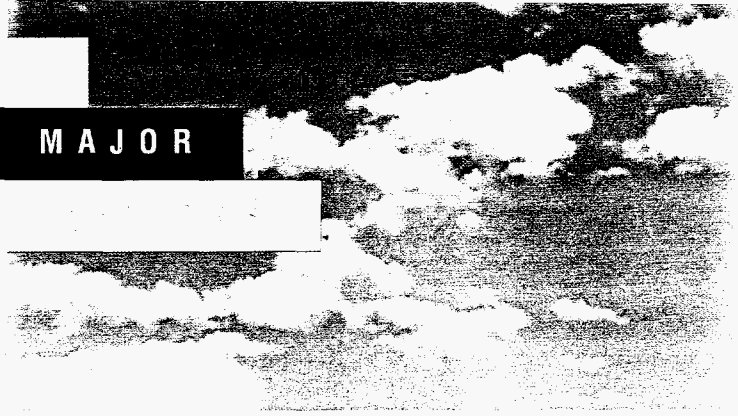
GLASS

METALCASTING

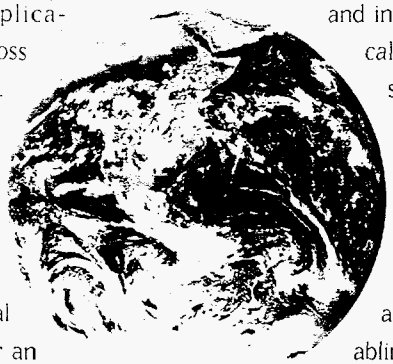
PETROLEUM REFINING

STEEL

LEADS TO MAJOR



Many technologies of interest to the materials and processing sectors have potential applications that cut across multiple industries. Yet, because the investment returns from these technologies may be too small or too long-term for an individual company or even for an entire industry, government support is often required to gain the very large pay-offs that can be realized. OIT supports R&D in a variety of these cross-cutting technologies, such as R&D on alternatives to inefficient and energy-intensive separations processes and on bioprocessing, which has potential applications in processing fossil fuels and in synthesizing organic chemicals from alternative feedstocks.



Other areas of research with broad applicability are industrial sensors and controls, combustion, alternative feedstocks, enabling materials, ceramic composites, and industrial cogeneration. (The Advanced Turbine Systems program, conducted in partnership with DOE's Office of Fossil Energy, targets the development of highly efficient low-emissions gas turbines.)

OIT also supports advanced process technologies, such as inert anodes for aluminum smelting, advanced electrodialysis for chemicals separations, impulse drying for forest products, advanced combustion space models for glass, an advanced lost foam process in metalcasting, an advanced fluid catalytic cracker in petroleum refining, and advanced process controls for steel production. These industrial applications are developed and demonstrated in specific industries, generally through shared public-private funding. Such process technologies promise to be more energy-efficient, productive, and environmentally friendly than conventional technologies.

ADVANCED TECHNOLOGIES INCREASE ENERGY EFFICIENCY, REDUCE POLLUTION, CUT COSTS, AND BOOST INDUSTRY COMPETITIVENESS

THE ADOPTION OF ADVANCED TECHNOLOGIES

To support and complement the Industries of the Future initiative, OIT uses diverse communications channels, education, and other methods of technology dissemination to speed up industry adoption of advanced technology. Key groups in the manufacturing sector are served:

- **Small and medium-size plants,** which commonly lack the specialized knowledge required for tackling energy waste opportunities, are helped with no-cost assessments and recommendations from 30 university-based centers across the country. Professors lead and train student assessment teams. Over 50% of the teams' recommendations are carried out by the firms. (Industrial Assessment Centers—IACs)

- **Equipment makers and state energy offices** join forces to seek grants for up to 45% of demonstration costs for innovative energy-saving, pollution-reducing technologies. (National Industrial Competitiveness through Energy Environment/Economics—NICE[3])

- **Manufacturers with motor-driven applications** account for over 70% of the electric energy used in all manufacturing. OIT has been a catalyst for development, acceptance, and distribution of industry-wide best practices and technical education, which improve performance and yield cost reductions in motor systems—electric motors, drives, pumps, fans, etc. (Motor Challenge)

- **All manufacturers** can receive recognition and information assistance for voluntarily pledging and implementing cost-effective measures to reduce green house gas emissions, thereby helping to meet the commitments the nation made at the Rio Conference on Global Warming. (Climate Wise—jointly managed by OIT and the Environmental Protection Agency)

- **Inventors of promising technologies for achieving improved energy supply, energy efficiency, and pollution reduction** receive guidance and seed funding to advance a technology beyond the concept stage to a point where it can be evaluated for private sector support. (Inventions & Innovation)

- **Potential users of technologies from other industries** are alerted by OIT to proven, yet not well-known, equipment and techniques that might be effectively applied. (Technology Transfer)

EXAMPLES OF OIT-SUPPORTED R&D TECHNOLOGIES CURRENTLY BEING COMMERCIALIZED BY INDUSTRY

Oxygen-Enriched Combustion/Oxy-Fuel Firing for the Glass Industry

Oxygen-enriched combustion has significantly reduced the energy requirements and has enhanced the environmental performance of glass melting furnaces. It saves from 15% to 45% of energy used in furnace operation and reduces emissions of nitrogen oxide by up to 90%, of carbon monoxide by up to 96%, and of particulates up to 30%. The technology has quickly gained industry acceptance (15% of all U.S. glass melting capacity uses it), and has ended the concern that NO_x emissions standards will force curtailments of glass production.

Advanced Process Control Sensor for the Steel Industry

An optical sensor that provides more accurate measurements of the bath temperature of the steel melt in a Basic Oxygen Furnace (BOF) performed successfully in a series of field trials completed July 1996. Contained within an existing BOF oxygen lance, the sensor uses two-color imaging pyrometry for the measurements. The sensor is now commercially available to the steel companies participating in the American Iron and Steel Institute/DOE Advanced Process Control Program, and will be made available to all of industry in 1997.

Exo-Melt Process Used in the Metalcasting and Steel Industries

The Exo-Melt process, first developed to encourage the use of new alloys, now enables the production of very high-quality alloys while cutting both energy consumption and production time in half. In producing a nickel-aluminide alloy, for example, as the component materials are heated, melt heat is released (exothermic reaction) which in turn contributes to that needed to produce the alloy. Nickel and iron aluminide alloys of uniform, superior quality result, which allows their use in parts applications not previously possible, including transfer rolls for steel mill heat-treating furnaces, rails for walking beam furnaces, belts and conveyors for all furnaces, and high-quality dies. The nickel-aluminide parts are both higher in quality and longer lasting.

LEVERAGING PUBLIC AND PRIVATE R&D RESOURCES

Through its partnerships with the private sector, OIT has demonstrated that the federal government has valuable roles to play in fostering increased resource productivity in U.S. industry. Sharing the costs and risks of developing new technologies is one of these roles.

In particular, government investments are valuable when technical and commercial risks to a private investor are too high, yet the innovation would yield substantial benefits to the nation.

Many energy efficiency and pollution prevention technologies fall into the "longer term, higher risk" category, particularly when innovative, first-of-a-kind concepts are involved. By selectively investing public funds in research, development, and demonstration of enabling technologies that are identified as priorities by industry, OIT stimulates [illegible] to invest in innovations that otherwise they would not fund.

Almost all OIT projects involve industry cost sharing, both to ensure industry's commitment to the technologies selected and to enhance the probability of subsequent commercialization.

ENERGY EFFICIENCY AND POLLUTION PREVENTION

A SOLID BUSINESS CASE

For industry, improving energy efficiency and preventing pollution make solid business sense. Companies realize a host of benefits, including direct cost savings in energy and materials; reduction of waste-handling, storage, and disposal costs, and avoidance of fines and future liabilities.

But the most significant paybacks are less obvious and often unanticipated. Streamlining and upgrading production processes, redesigning or reformulating products, and improving the workplace environment often yield improvements in capital and labor productivity and product quality that far exceed the direct savings.

By accounting for the full range of benefits, the "lean and clean" approach breaks the longstanding assumption that controlling pollution is innately a drain on businesses. In fact, several studies show that investments in energy efficiency and pollution prevention have higher rates of return than most other investments companies are making.

The following pages describe the seven individual Industries of the Future, profiling each and providing information on the current status and R&D priorities in industry/OIT collaborative initiatives.

The Industry Creates Its Vision

The U.S. aluminum industry is poised to lead the world in 21st century aluminum technology by pursuing manufacturing process improvements which also serve national goals for energy, the economy, and the environment. The Aluminum Association constructed the industry's vision of its future and identified specific needs in precompetitive research areas in a document published in March 1996, *Aluminum Industry: Industry-Government Partnerships for the Future*. The vision document points to six areas crucial to the industry's success:

- **Energy Efficiency.** By continuing to optimize processes for refining and smelting, the industry will make efficiency gains beyond the 20 percent energy reduction level it already has achieved.
- **Manufacturing Processes and Technologies.** Much of the quality of semifabricated products is initially determined during thermomechanical processes and solidification. Success in these arenas will require advances in surface science and tribology, sensors, measurement, and maximum application of computer-aided manufacturing technologies.
- **Ecological Sustainability.** A material's ecological sustainability can be determined through its life-cycle energy requirements. Studies show that vehicle "lightweighting" through the use of aluminum substantially reduces vehicle life-cycle energy consumption and emissions of gasoline-powered vehicles in comparison to heavier steel vehicles. Also, aluminum recycling reduces the energy needed to make new primary ingot and sheet by 95 percent while reducing harmful air emissions.
- **Enabling Technologies.** Laser joining, friction stir welding, enhanced coating technologies, process monitors, and high-speed non-contact sensors for in-line measurement of temperature and performance properties are enabling technologies that offer the highest payoffs for future research and development in the aluminum industry.
- **Information Technologies.** The industry must take full advantage of information technology, including online communications and data resources, to seamlessly integrate its technical community with counterparts in the product manufacturing sector. The industry also needs to interact electronically with academia and government laboratories worldwide.
- **Computational Materials Science.** The success of the aluminum industry will hinge on its ability to use its understanding of computational materials science to control the process-microstructure-performance continuum of aluminum and to develop new aluminum-matrix composite systems.

Profile – U.S. Aluminum Industry

- U.S.: world's largest producer and consumer of aluminum
- Industry shipments, 1993: 8.2M metric tons valued at $21B
- 134,000 workers; wages 41% above average of domestic industries
- Segments:
  - Raw materials
  - Aumina refining
  - Primary metal smelting
  - Secondary (recycled) smelting
  - Semifabricated products
  - Finished products
- Annual energy use:
  - One quad (highly energy-intensive manufacturing)
  - $2B spent on energy, 8.6% of value of total shipments (1991)
  - Production of recycled aluminum slashes energy use by 95%
- States of concentration: Oregon, Montana, West Virginia, Illinois, Indiana, Kentucky, Michigan, Missouri, Ohio, Pennsylvania, Connecticut, Massachusetts, New Jersey, Alabama, Arkansas, Georgia, North Carolina, South Carolina, Tennessee, Texas

Aluminum Industry of the Future Participants

Aluminum Association; The Minerals, Metals, and Materials Society (TMS) Aluminum Committee; aluminum companies; National Laboratories; universities; aluminum industry suppliers and customers

Mapping the Industry's Future

The industry has signed a compact with DOE to engage in collaborative R&D that will serve both industry-identified needs and broader national goals of energy efficiency and pollution prevention. In order to link the broadly defined goals of the industry's vision document and the actual pursuit of research activities, the industry is creating a technology roadmap that will plot a course for meeting the technology milestones critical to achieving the industry goals. To leverage the unique strengths and capabilities of all participants, representatives from the aluminum industry, the Aluminum Association, professional associations, universities, Federal agencies, and National Laboratories will guide the projects identified by the completed technology roadmap.

Opportunities for a More Competitive Industry

To remain globally competitive in the future, the aluminum industry must find ways to lower costs, improve product quality, and enhance environmental performance in the three sectors that dominate the industry: raw materials, semifabricated products, and finished products.

The **raw materials** business can be strengthened by further improvements in energy, operating, and environmental efficiencies. Increased recycling — key to future growth of the industry — will depend on advanced scrap separation and remelting processes and on integrating product and process design to maximize the value and usability of scrap and post-consumer metal products.

Growth in the **semifabricated** area will depend on the development of advanced manufacturing processes. Further research on the continuous casting process will enable the operation of flexible, highly versatile mini- and micro-mills that can produce small quantities of products tailored to meet individual customer needs. The development of net-shape production processes will reduce both energy inputs and process waste.

Opportunities in the **finished product** sector will likely hinge on increased integration of aluminum with other materials, and on advanced design technologies that can create products to meet the needs of tomorrow's manufacturers and consumers. The key to success will be the development of engineered materials that combine the unique advantages of aluminum with other materials in customer-tailored products. Enabling technologies such as enhanced joining and forming processes will increase the cost-effective applications of aluminum alloys and composite structures.

R&D Priorities to Maximize the Industry's Vision

Specific technology needs and priorities will be identified and explored in depth through the technology roadmap process, and the aluminum industry and DOE will work together to develop and implement a portfolio of near-, mid-, and long-term RD&D activities. At this time, specific R&D needs fall into three major categories: Raw Materials and Semifabrication Production Technology, Manufacturing and Enabling Technology, and Application Technology.

ALUMINUM

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The Chemical Industry's Vision Document Nearing Completion

Technology Vision 2020: Report of the U.S. Chemical Industry was approved in Spring 1996 by the Chemical Manufacturers Association (CMA), the American Chemical Society (ACS), the American Institute of Chemical Engineers (AIChE), the Council for Chemical Research (CCR), and the Synthetic Organic Chemicals Manufacturers Association (SOCMA). As the report moves forward, the cosponsoring organizations are in the process of developing roadmaps and implementation plans.

These roadmaps and implementation plans respond to key challenges and broad goals identified in the vision. These are to:

- Improve operations, with a focus on better management of the supply chain
- Improve efficiency in the use of raw materials, the reuse of recycled materials, and the generation and use of energy
- Continue to play a leadership role in balancing environmental and economic considerations
- Aggressively commit to longer term investment in R&D
- Balance investments in technology by leveraging the capabilities of government, academia, and the chemical industry as a whole, through targeted collaborative efforts in R&D

Chemical Industry Vision — Targeted Areas

NEW CHEMICAL SCIENCE AND ENGINEERING TECHNOLOGY

- Synthesis and catalysis
- Materials technology
- Chemical measurement
- Bioprocesses and biotechnology
- Computational technologies
- Process science and engineering technology

SUPPLY-CHAIN MANAGEMENT

- Market globalization
- Regulatory restrictions
- Environmental, health, and safety
- Growth of free trade
- Transportation
- Information processing

INFORMATION SYSTEMS

- Manufacturing and operations
- Infrastructure and open systems management
- Production process design and development
- Business/enterprise
- Computers in plan engineering and construction

MANUFACTURING OPERATIONS

- Customer focus
- Information and process control
- Supplier relationships
- Production capability
- Building new plants
- Global operations

Profile – U.S. Chemical Industry

- Annual shipments: $341.3B (1994)
- Employment: over 1 million
- 10.3% of U.S. manufacturing (value added), and 1.8 % of U.S. GDP
- Nation's largest exporter ($51.5B in 1994) with a positive export balance for over 50 years
- More than 70,000 products:
  - Raw and basic materials for other industries
  - Intermediate materials for other industries
  - Finished products for industry, agriculture, business, and individual customers
- Nation's top R&D spender:
  - $18.4B (1994)
  - 90,000 R&D chemists, engineers, and technicians
- States of concentration: Texas, New Jersey, Louisiana, Illinois, Ohio, California, North Carolina, Pennsylvania, New York, Indiana, Tennessee, Michigan, South Carolina, Virginia, Missouri

Chemicals — The Keystone Industry in the United States

Industry innovations are critical to U.S. competitiveness and to sustainable development. In addition to producing a vast array of products, the chemical industry is the second largest energy-consuming industry in the United States (5.1 quads in 1991) and the nation's largest generator of hazardous wastes. The chemical industry spends more than any other for pollution abatement and control, fully $6.3 billion in 1994. Against this background, the chemical industry is wisely seeking opportunities for collaborative long-range R&D. It is embracing the Industries of the Future initiative to improve efficiency in the use of energy and materials and remain more competitive in world markets.

Chemicals R&D Profoundly Impacts the Nation and the World

The chemical industry has appropriately been called a keystone industry because of its economic importance to the United States and the world and because of the range of its products. Few goods and services are produced in modern industrial societies without some input from the chemical industry — not only consumer goods, but building-block products essential to agriculture, manufacturing, construction, and service industries. It is a huge, highly technical, and dynamic industry, one with a long tradition of commitment to R&D. In 1992, the industry spent more than $18 billion on R&D, or about 5% of industry sales, 2% higher than the average for the manufacturing sector. About one of every eight U.S. patents is awarded to a member of the chemical industry. Yet, even though the industry continues to increase total expenditure on R&D, intense global competition has forced it to focus more and more on short-term product or process R&D at the expense of long-term R&D. The industry recognizes the problem and is concerned about how and where the breakthrough, leapfrog technologies for the future can be developed.

OIT Supports the Industry's Efforts

As the sponsoring organizations near completion of *Technology Vision 2020*, industry leaders have joined to begin work on technology "roadmaps," a process for implementing the R&D areas identified in the chemical industry's vision. These roadmaps will serve as a framework to guide industry, academia, and government R&D efforts in developing energy-efficient and pollution-preventing technologies for the chemical industry into the 21st century.

CHEMICALS

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A Leadership Role by the Forest Products Industry

The forest products industry has led the way in working with DOE to establish the approach and set the pace of OIT's Industries of the Future (IOF) strategy. When the Secretary of Energy and the Chairman of the American Forest and Paper Association (AF&PA) signed a compact in November 1994 to jointly implement the research agenda of the industry, forest products became the first of the seven IOF industries to launch this new way of doing business between industry and government. This collaborative approach is industry led, and based upon the industry's vision document, *Agenda 2020—A Technology Vision and Research Agenda for America's Forest, Wood, and Paper Industry.*

Over recent months, the industry and OIT have made significant progress in developing an implementation plan for cooperative research, development, and technology demonstration. Several accomplishments are notable:

- In the past year, universities and National Laboratories have documented their capabilities related to the forest products industry's research and technology needs. To facilitate industry's access to their research capabilities, the universities formed the Pulp and Paper Education and Research Alliance and the National Laboratories formed the Laboratory Coordination Council. Both organizations have played key roles in the vision implementation process.
- At the First OIT Expo, the Forest Products Vision Implementation Session represented another important step in the vision implementation process. Six key speakers from major stakeholders presented their views and laid the groundwork for structuring the process.
- Industry-led task groups have produced research plans in four of the six key strategic research areas identified in *Agenda 2020*. Using these research plans as a guide and working with all involved stakeholders, the task groups have identified a set of research projects of vital importance to the industry. Over the next year, research plans and priorities will be set in the two remaining areas. These projects will form the basis of the forest products IOF research program.

As vision implementation teams proceed in this dynamic process, they will regularly revisit, evaluate, and update research plans and priorities.

The forest products IOF program exemplifies the results that can be achieved in an accelerated time frame by industry and government working in partnership.

Profile – U.S. Forest Products Industry

- Annual shipments: $210B+
- Employment: 1.3 million
- Energy consumption: 3 quads
- 57% energy self-sufficient (up from 36% in 1972)
- Total wastes: 2.5B tons
- Among the top 10 manufacturing employers in 46 out of 50 states
- States of concentration: California, Oregon, Pennsylvania, Wisconsin, North Carolina, Texas, Washington, Ohio, Alabama, Illinois, Georgia, Michigan, Florida

Challenges and Opportunities

The *Agenda 2020* document establishes ambitious intentions for the industry, which is building upon an excellent track record. For example, the industry produces safe, functional products that are essential contributors to modern life. The industry is a leader in environmental and energy fields. It uses and produces clean, renewable energy sources; it contributes to the preservation of soils and animal welfare through well-maintained forest habitats; and it plays a crucially important role in absorbing greenhouse-gas emissions through forest maintenance and replanting.

The industry intends to be the global leader in products and productivity and to remain a financially healthy and attractive industry. Its members intend to achieve these business objectives through responsible stewardship in growing and harvesting trees; intensive recycling; and, particularly, encouraging cooperative, precompetitive efforts between the industry, universities, and government in the area of R&D.

Forest Products R&D Priorities

Agenda 2020 clearly defines the industry's R&D priorities in the following categories:

- Sustainable forest management
- Environmental performance
- Energy performance
- Improved capital effectiveness
- Recycling
- Sensors and control

The Industry Is Seizing the Initiative

Industry leaders have recognized that individual companies will be unable to address all the issues they face. Demands on available resources to meet intense global competition are escalating and R&D dollars for longer term technology are shrinking. They also recognize that the Industries of the Future process represents an opportunity to be proactive in shaping the industry's future. The partnership approach can ensure that diverse capabilities from the industry, academia, and the National Laboratory system are optimized to realize benefits for the industry and the nation.

FOREST PRODUCTS

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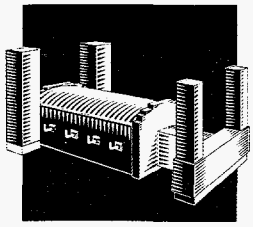


Industry Leaders Sign Compact with DOE for R&D Partnerships

On April 29, 1996, glass industry leaders agreed to voluntary collaborative efforts with DOE, based upon the industry's published document, *Glass: A Clear Vision for a Bright Future*. The purpose of the compact is to provide the framework for determining and pursuing areas of joint research, development, and technology demonstrations. The resulting partnership projects will target appropriate opportunities to demonstrate, evaluate, and accelerate new technologies and scientific insights. These new technologies will be critical to the industry's continued success and survival in the face of intense competition from other materials and particularly from international competitors. Four general areas of need have been identified in the industry vision document:

- Processing advances in melting and refining, and fabricating and forming
- Technology development of new glassmaking techniques, processing controls, and computer simulations to model new processes
- Systems improvements in emission controls, recycling methods, and solid-waste management
- Product development of innovative new uses for glass

The industry has embraced the idea of collaborative alliances with federal agencies and research institutions, academia, and other industrial firms. They recognize that the competitive business environment reduces the industry's ability to finance as much long-term research as in the past and that such alliances are becoming increasingly vital to the timely development of technologies.

To meet industry needs and minimize red tape, the Office of Industrial Technologies will work closely with the industry to simplify policy and procedures. Areas to be tackled include:

- Program priorities and their distribution among different segments of the industry
- Criteria for projects that meet OIT's mission and goals
- Participation of other funding sources
- Intellectual property and licensing issues
- Technology commercialization and transfer to industry
- Periodic review and update of the industry's goals and technical needs
- Periodic update of the technology roadmap and implementation plans

Profile – U.S. Glass Industry

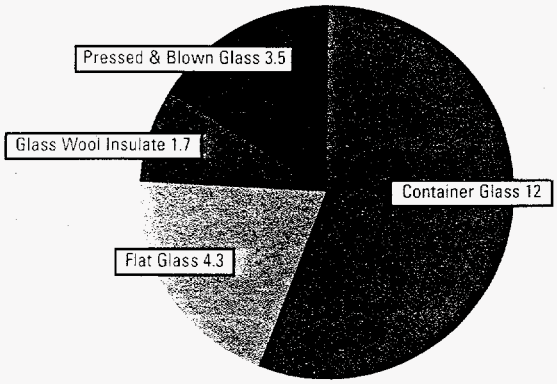
- Oldest American industry
- 2M metric tons of consumer products annually, valued at $22B
- 250,000 employed
- Sectors:
  - *Container*. For bottles, jars, etc.
  - *Flat*. For windows, windshields, mirrors, etc.
  - *Fiberglass*. For building insulation and textile fibers
  - *Specialty*. Including cookware, flat panel displays, light bulbs, fiber optics, and medical equipment
- 100% recyclable material
- Energy intensive: 12% of sales (1994), 0.4 quad
- States of concentration: California, Illinois, New York, Ohio, Pennsylvania, West Virginia

Technology Roadmap

The glass industry is developing a technology roadmap to help it achieve the goals articulated in its vision document. The roadmap is addressing all four of the principal industry segments: flat, container, fiberglass, and specialty. An industry-led subcommittee structure has been formed to focus on the principal technology challenges identified in the vision. Each subcommittee is led by an industry chairperson and includes representatives from all major segments of the industry. These subcommittees will be preparing an initial draft of the roadmap during the early months of 1997.

Glass Shipments by Industry Segment, 1994

Million Tons



Total = 21.5 Million Tons

Joint Industry-DOE R&D Is Already Paying Off

The glass industry, OIT, and academia are currently conducting research projects that will provide substantial reductions in pollution emissions and energy consumption. These include development of technology that will permit oxygen, instead of air, to fire large glass-melting furnaces; increase the use of waste glass (cullet) in manufacturing; produce new coatings and new structural components for enhanced manufacturing; and design temperature sensors for improving the energy efficiency of furnaces.

GLASS

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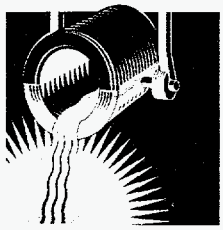

Metalcasting Industry Vision for the Future

The metalcasting industry and the U.S. Department of Energy, Office of Industrial Technologies (OIT), are working together to build a stronger, more competitive metalcasting industry. The goal is to develop a partnering process between the federal government and industry through a common vision for improving productivity, energy efficiency, and competitiveness. Industry and government have recently forged three documents:

- The metalcasting industry vision
- An industry-government partnership agreement
- The metalcasting industry technology roadmap

Industry Vision

In September 1995, chief executive officers and presidents from the foundry, die-casting, and foundry supply industries published *Beyond 2000: A Vision for the American Metalcasting Industry*. Development of the vision illustrates the commitment of industry members to join forces for increasing the global competitiveness of the U.S. metalcasting industry. It lays out a framework for addressing industry needs in six important areas:

- Production efficiency
- Recycling
- Pollution prevention
- Application development
- Process control
- New technology development

The vision identifies one of the metalcasting industry's ultimate goals—to be the preferred supplier of near-net-shape metal components beyond the year 2000—and lists other specific industry goals for the future as well:

- **To increase market development activities.** These activities should help improve market share in current markets by 10%, recapture 25-50% of lost markets, and increase the rate of new market development.
- **To develop materials technologies.** These will improve the variety, integrity, and performance of cast metal products.
- **To develop advanced manufacturing technologies**. These technologies should increase productivity by 15%, reduce average lead times by 50%, and reduce energy consumption by 3-5%.
- **To develop environmental technologies.** The industry has set environmental goals of achieving 100% pre- and postconsumer recycling, 75% beneficial reuse of foundry by-products, and the complete elimination of waste streams.

Profile – U.S. Metalcasting Industry

- Annual shipments: $23B+, 13M tons
- Employment: more than 210,000
- Over 3,100 companies, 80% with fewer than 100 employees
- Companies in all 50 states
- Energy consumption: 250 trillion Btu
- States of concentration: California, Pennsylvania, Ohio, Michigan, Illinois, Indiana, Wisconsin, Texas, New York

- **To renew emphasis on human resources, education, and training.** The industry seeks to attract talented individuals as well as improve training of current employees in the latest technologies and techniques.
- **To increase industry reinvestment research, education, and marketing programs.** The goal is to increase reinvestment in these programs by 10%.
- **To encourage partnerships and collaborations that combine the experience, resources, and knowledge available.** The vision also identifies specific areas of research that can assist the industry in meeting the challenges it faces. The industry recognizes that a collaborative effort by research institutions, societies, industry, and government agencies is the best way to achieve these goals.

Industry-Government Partnership

Representatives from three major metalcasting industry societies—the American Foundrymen's Society (AFS), the Steel Founders' Society of America (SFSA), and the North American Die Casting Association (NADCA)—addressed the issue of collaboration. In October 1995, these representatives signed a voluntary cooperative agreement with U.S. Secretary of Energy Hazel O'Leary, which sets forth a framework for identifying appropriate areas of joint research, development, and technology demonstrations between the U.S. government and the industry.

The projects this partnership identifies will be carried out in a joint federal-industry program designed to develop technologies for industry customers. The program will be guided by various combinations of collaborations among industry, metalcasting associations, agencies of the federal government, universities, National Laboratories, and other major research institutions with expertise in the diverse metalcasting industry.

Metalcasting Technology Roadmap

Representatives from the AFS, SFSA, and NADCA formed the Cast Metals Coalition (CMC) to work toward developing a technology roadmap. The roadmap will set out a strategy for pursuing and achieving the goals articulated in the vision. CMC is working with industry and research institutions, including universities and National Laboratories, to develop this roadmap, and OIT is facilitating the effort.

Metalcasting research, development, and demonstration projects will be selected based on the metalcasting technology roadmap. The CMC will operate with input and guidance from industry, academia, OIT, and other government agencies to develop candidate research, development, and demonstration projects. Through the CMC process, the CMC will identify key research, development, and demonstration activities and will solicit, review, and select proposals from organizations that demonstrate technical expertise and partnership or collaboration between industry and government.

OIT will select projects for joint funding based on the guidance of the CMC Technical Committee and the DOE Metalcasting Industry Board. Once a project begins, the CMC process will manage and evaluate the project and its progress.

METALCASTING

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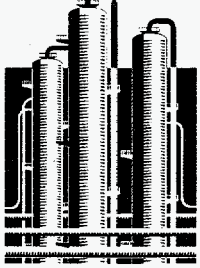

INDUSTRIES OF THE FUTURE

PETROLEUM REFINING

Background

The petroleum refining industry must find ways to effectively and efficiently convert oil and gas into products while complying with regulations at acceptable costs. The industry will not be able to meet these goals without developing advanced new technologies. Consequently, the Department of Energy is exploring new avenues toward supporting partnerships for the development of new process technologies. These critical technologies will improve the whole industry's competitiveness and, at the same time, contribute significantly to the national goals of energy efficiency and pollution prevention. This strategy is based on the industry's vision of the future and will be used to create the framework for future research and development efforts. These cost-shared collaborative efforts should result in:

- Development of technologies responsive to industry needs and broadly applicable across the industry
- Research and development that is longer term and high risk, which would not be undertaken by industry on its own
- Leveraging of available resources and reduction of the inefficiencies of uncoordinated technological development

The Program

OIT's activities are being developed to respond to the industry's needs, as defined by multiple industry inputs, including a 1994 workshop report and a 1995 National Petroleum Council (NPC) report on research, development, and demonstration needs of the oil and gas industry. The NPC report listed the following research priorities:

- Catalysts with improved selectivities
- Plant and process reliability
- Energy efficiency of operations
- New approaches for refining heavy feedstocks
- Relating chemical composition to performance of process and products
- Performance (including environmental) characteristics of new hydrocarbon fuels, such as future reformulated gasolines
- Separations

OIT's research and development agenda for petroleum refining is being formed in response to these priorities.

Profile – U.S. Petroleum Refining Industry

- Annual shipments: $136B
- 97% of the nation's transportation fuels
- Annual energy consumption: 6 quads
- 180M tons of wastes per year
- 174 refineries in 35 states, 80 in Louisiana and Texas
- Employment: 77,000
- States of concentration: Louisiana, Texas, California, Illinois, New Jersey, Oklahoma, Kansas, Ohio, Pennsylvania

Virtual Laboratory

In seeking to become more customer oriented, DOE is identifying and developing improved approaches that will leverage limited industry and DOE resources for research and development of advanced process technologies and provide improved interaction with government agencies. DOE is making an ongoing effort to improve the coordination of activities across the Department as they relate to the refining industry. Among other measures, a Virtual Petroleum Refining National Laboratory, consisting of 12 National Laboratories, was formally organized in response to the refining industry's request to DOE-OIT for better ways to facilitate access to the Laboratory system. This Virtual Laboratory was organized under the auspices of the Laboratory Coordinating Council (representing 16 member organizations), which was established to coordinate and expand collaboration between the National Laboratories and the seven industries that are the focus of DOE's Industries of the Future programs.

Industry Response

Private-sector oil and gas company executives produced the NPC study, which represents the oil and gas industry's views of its technology needs and the role the government should play in partnering with industry. The theme of the recommendations is the need for the Secretary of Energy to establish a process that embodies the "new paradigm" in oil and gas RD&D user-driven technology development.

Mr. John R. Hall, Chairman and Chief Executive Officer, Ashland Inc., in his remarks to the 94th annual Meeting of the National Petroleum Refiners Association, San Antonio, Texas, March 18, 1996, looked back over the past 40 years for lessons learned and ways these might be applied to the future. "Lesson 1: Global and domestic politics can have an enormous, immediate, and lasting impact on our business, and we had better be ready to adapt to change at a moment's notice. Lesson 2: Change is our constant companion on all fronts, not just in the political arena. Lesson 3: The race goes to the swift, the innovative, and the efficient...innovation and technology will drive our industry into the future."

PETROLEUM REFINING

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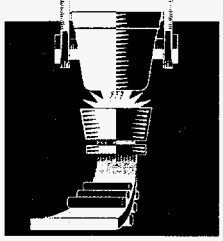

Compact Signed between DOE, American Iron and Steel Institute (AISI), and the Steel Manufacturers Association (SMA)

On May 2, 1995, a compact was signed that establishes the basis for continuing collaboration on precompetitive R&D efforts. The two steel industry groups, which represent nearly all North American steel manufacturers, have identified four areas as critical to achieving continuous improvement and retaining steel's position as material of choice for the 21st century. Three of these areas are the subject of the compact:

- **Production efficiency.** The groups will seek improvement in energy efficiency to control production costs, limit exposure to fluctuating energy costs, and produce higher quality products.
- **Recycling.** The goal is to increase the role of steel recycling and recovery of iron units from plant solid wastes. Production of steel from scrap will approach 70%.
- **Environmental engineering.** The participants hope to achieve further reductions in air and water emissions and generation of hazardous wastes and to develop new processes to avoid pollution rather than control and treat it. The industry will move toward total enclosure and zero emissions and waste.

The industry vision of the future (2010-2020), entitled *Steel ... A National Resource for the Future,* was published in May 1995 in conjunction with the compact signing.

The Office of Industrial Technologies (OIT) is now working with both AISI and SMA to develop technology roadmaps. These industry-written plans identify the industry's technology needs for the future and provide guidance to DOE to plan its future R&D. The outcome from the partnership will be the demonstration, evaluation, and acceleration of new technologies and scientific insights that address several specific and crosscutting needs.

Profile of the Steel Industry in the U.S.

- Steel consumption in the United States, 1992: 95M tons
- $50B+ sales (1994)
- 255,000 employees
- 10 top steel-producing states: Alabama, Arkansas, Illinois, Indiana, Maryland, Michigan, Ohio, Pennsylvania, Texas, West Virginia
- Steel prices at the mill less per pound than potatoes
- 94% productivity increase since 1980
- Three supplier groups:
  - Integrated steelmakers
  - Mini-mills
  - Imports
- Level demand for 25 years: worldwide capacity 20-25% above consumption
- 1.8 quads of energy consumed annually, 15% of production costs

DOE's Industries of the Future Approach Benefits the Steel Industry

The Steel Industry of the Future strategy helps to focus research, development, and deployment as well as streamline interactions with government. It provides:

- A mechanism for bringing needed new technologies on line
- Funding support for industry-identified technology programs
- A more timely, responsive, and effective government procurement system
- One point of contact, through OIT's Steel Team, to coordinate interactions between the steel industry and government

Past DOE Support Leads to Major Commercialization

Technologies under development by DOE and now reaching commercialization include dezincing of steel (which will provide an additional 4 million tons of steel scrap per year), nickel aluminide rolls (reduced furnace downtime), and advanced process control technologies. One advanced process control project will develop and test selected sensors, control devices, and software to support improvements in energy efficiency and productivity in steelmaking and casting, rolling, and coating operations. One example of the technologies under development is a computerized microstructure model for process control. It relates on-line hot-rolling parameters with material properties, helping optimize manufacturing and rolling schedules as well as new alloy development.

A postcombustion technology developed through the direct steelmaking project is being commercialized by Praxair. Postcombustion recovers much of the energy contained in electric arc furnace off-gases, saving 50 kilowatt hours per ton of steel while increasing productivity 6-7%. By the end of calendar year 1995, 3.6 million tons of steel per year were manufactured using this technology. Nationwide application could save 1.6 billion Btu per year.

The Advanced Process Control project achieved its first commercial success when a user-friendly computer model of the hot-strip mill was delivered to the industry through workshop training. This model permits steelmakers to predict the microstructure and properties of carbon steel before it is hot-rolled and to develop rolling practices for new alloys. Current research is extending this model for application with more sophisticated steels. When fully implemented, this technology will improve yield about 0.5%, saving 2.2 trillion Btu and $27.5 million annually.

STEEL

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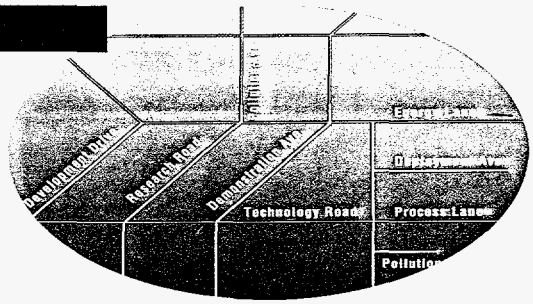
THE INDUSTRIES OF THE FUTURE PROCESS

VISION . . .

Created by industry

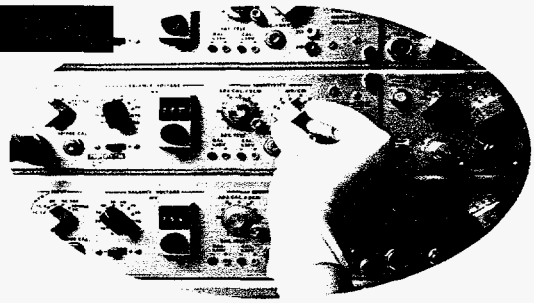
ROADMAPS . . .

Strategies to achieve the vision



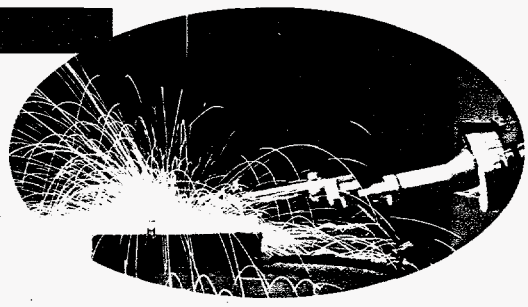
RESEARCH . . .

To improve energy efficiency, environmental performance, and productivity



DEPLOYMENT . . .

Turning the visions into reality



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