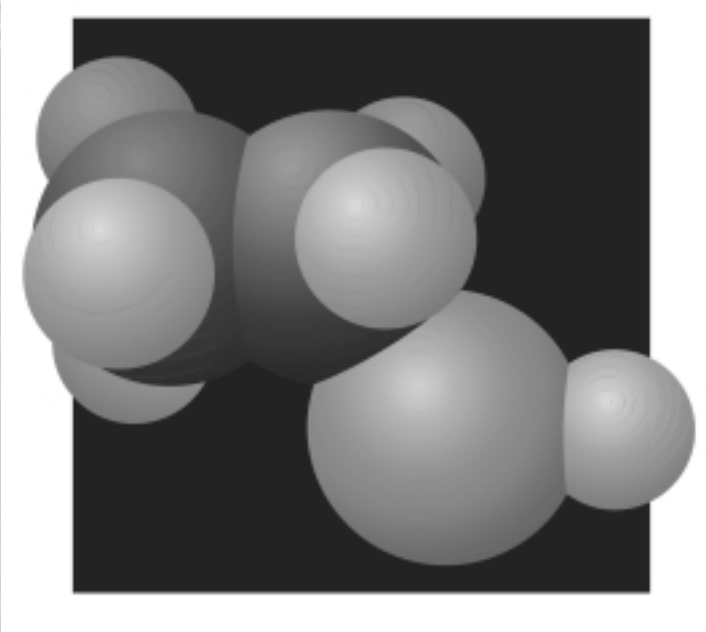
CHEMICALS

INDUSTRY OF THE FUTURE



Building

Partnerships

for the

Chemical Enterprise

U.S. DEPARTMENT OF ENERGY
OFFICE OF INDUSTRIAL TECHNOLOGIES • ENERGY EFFICIENCY AND RENEWABLE ENERGY

THE VISION

Industry vision provides framework for cooperative R&D

The chemical industry is a keystone of U.S. manufacturing. Chemicals provide the building blocks for products that meet society's needs, from the most basic to the most high-tech. The U.S. chemical industry accounts for 25% of the worlds chemical production.

A rapidly changing business environment in the U.S. chemical industry reflects its need for continued global competitiveness. Companies that once produced only primary or commodity chemicals now produce a spectrum of chemical products, including consumer goods. Some companies have begun focusing on life sciences and biotechnology.

In a unique partnership, chemical industry leaders have teamed with the U.S. Department of Energy's Office of Industrial Technologies (OIT) to focus on innovative technologies to strengthen the U.S. chemical industry's competitive position and further important national goals. This industry-led partnership, the Chemical Industry of the Future, promotes technologies that optimize energy-efficiency in operations and reduce waste and energy-related emissions.

Partnerships for the Future

Industry leaders representing the American Chemical Society (ACS), the American Institute of Chemical Engineers (AIChE), the Chemical Manufacturers Association (CMA), the Council for Chemical Research (CCR), and the Synthetic Organic Chemical Manufacturers Association (SOCMA) developed a unified vision of the future U.S. chemical industry. Their vision document, *Technology Vision 2020: The Chemical Industry*, defines R&D needs, which are directly linked to growth and competitiveness over the next 20 years.

Continued global leadership requires the combined resources of the industry, universities, and government laboratories. *Vision 2020* provides a framework for the next step in the Industries of the Future Process—the development of technology roadmaps to facilitate cooperative R&D.

THE ROADMAP

Roadmaps define technology priorities and performance targets

Working in partnership with representatives from a wide variety of companies and associations, the chemical industry and OIT are developing a portfolio of energy-efficient technologies to ensure the global competitiveness of U.S. chemical companies and products. *Technology Vision 2020*, identifies the following areas as critical to improving the industry's competitiveness:

- New chemical science and engineering technologies
- Supply chain management
- Information systems
- Manufacturing and operations

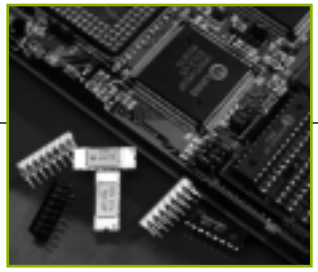
The U.S. chemical industry has developed technology roadmaps in five key areas that describe priorities and performance targets to meet the needs and challenges facing the industry. This system of roadmaps serves as a framework to guide R&D efforts in the four critical areas outlined in the vision.

Partnering for a Clean and Competitive Industry of the Future

Dan W. Reicher
Assistant Secretary,
Energy Efficiency and
Renewable Energy

Our nation's strength is based in large part on our access to affordable and reliable energy. As we move into the new milennium, our mission is to develop and deploy new ways to meet our energy needs and improve our environmental quality through use of renewable energy and increased energy efficiency.

Through the Industries of the Future Program, the Office of Energy Efficiency and Renewable Energy is actively engaged with U.S. industry to capture energy and natural resources savings by developing and deploying clean and energy efficient technologies and practices. Working with the nation's most energy intensive industries, we are mapping a vision of the energy future of American Industry and developing the technology needed to implement that vision. This profile describes a few of the many ways that the DOE-Industry alliance is working towards a more competitive future for U.S. industry and our nation.



Selected high-priority research needs

Current chemical roadmaps address issues in:

Alternative Reaction Media, Conditions, and Raw Materials

Alternative reaction media, conditions, and materials are more environmentally benign and make more efficient use of raw materials than traditional chemical processing methods. Opportunities include efficient synthetic pathways for conventional processes, replacement of petrochemical-based hydrocarbons with reaction media like supercritical industrial CO_2, and new ways of activating CO_2 as a reactant or feedstock.

Catalysis

About 90% of chemical manufacturing processes and more than 20% of all industrial products in the U.S. depend on catalysis-related chemistry. Advances in catalysis can help the industry realize significant process improvements. If catalytic processes for the top 50 chemicals achieved maximum yields, energy savings could equal 85 million barrels of crude oil annually.

Computational Technologies

Computational technologies are widely used in chemical R&D, design, and manufacturing. Improved efficiencies in computational chemistry and computational fluid dynamics could have dramatic effects. For example, better modeling technology in gasoline production could save about 20 million barrels of oil per year.

Materials Technologies

New materials development has resulted in products with improved performance, energy efficiency, durability, and design and manufacturing flexibility. By 2020, the industry envisions better design and predictive capabilities and the means to manipulate materials precisely to produce low-cost, high-performance materials.

Separations

Separation processes underlie virtually all aspects of chemical production, accounting for nearly two-thirds of energy consumption. Advances in adsorbents, crystallization, distillation, extraction, membranes, and separative reactors will contribute to a 30% reduction in relative indicators for material and water usage and toxic and pollutant dispersion.

CHEMICAL INDUSTRY OF THE FUTURE

Novel public-private partnerships

The Industries of the Future process is driven by industry. Through technology roadmaps, industry participants set technology priorities, assess the progress of R&D, and ultimately lead the way in using the results. This new approach to private-public partnerships ensures the most strategic allocation possible of limited resources for the development of new technologies.

OIT's role is to help facilitate the Industries of the Future process and to support the development and deployment of technologies that will shape the future of the chemical industry. Part of this role is to encourage industry to undertake long-term, sector-wide technology planning and to selectively co-invest with OIT in collaborative R&D efforts that match OIT's Federal mission.

Through this partnership, OIT provides streamlined access to the resources and capabilities of the National Laboratories and other Federal programs that share interests with the chemical industry. Supporting this streamlined access is the Laboratory Coordinating Council (www.oit.doe.gov/lcc/lccintro.html), which produces detailed documentation of current and past research projects and laboratory capabilities that correspond to chemical technology needs.

TAKING ACTION BASED ON INDUSTRY'S VISION

Step 1: Vision

Under the leadership of ACS, AIChE, CMA, CCR, and SOCMA, the chemical industry published *Technology Vision 2020: The U.S. Chemical Industry*, which defines its 20-year vision of how to maintain and build the competitive position of the U.S. chemical industry.

Step 2: Technology Roadmap

The chemical industry developed detailed technology roadmaps outlining the requirements for achieving industry goals and a focused R&D agenda.

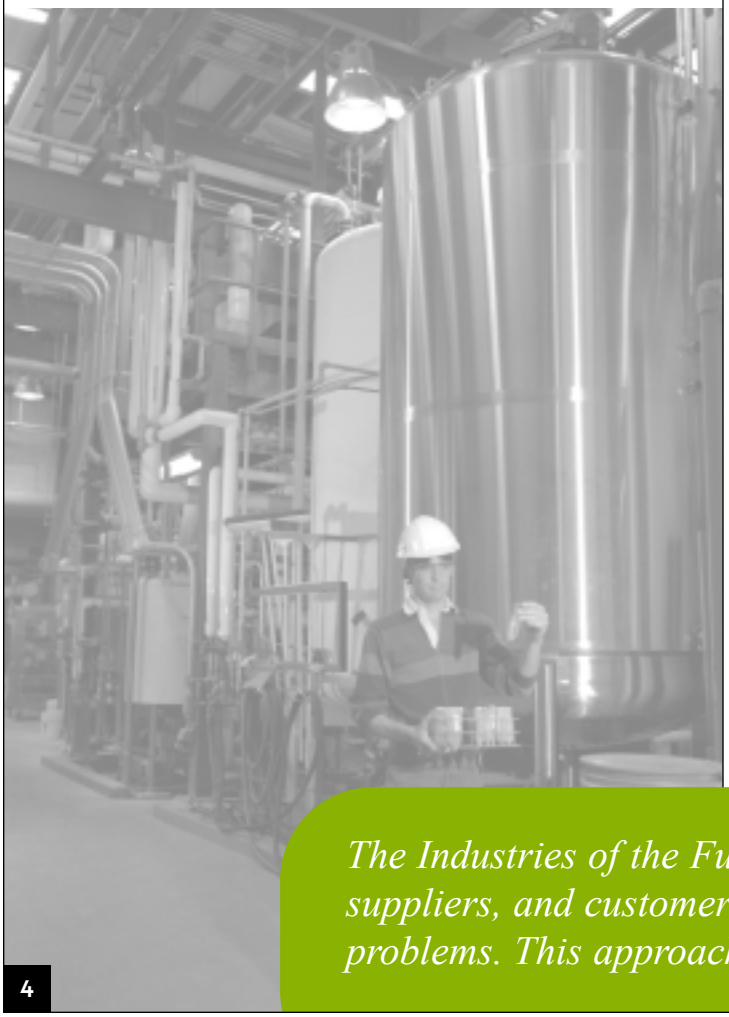
Step 3: R&D Partnerships

Research is conducted through collaborative partnerships composed of private companies, suppliers, trade associations, National Laboratories, private research institutions, and government agencies.

Enhanced Competitiveness

Industry of the Future projects advance chemical vision

Through the Industries of the Future process, chemical industry leaders can ensure the most strategic possible allocation of limited resources for technology development. The process encourages companies, the academic community, and National Laboratories to refocus their research efforts to conform with the needs of the industry. OIT selectively co-funds R&D efforts, targeting potentially high-payoff technologies where risks are too high or results too long-term to attract adequate private-sector investment.



The following describes technology areas in which Chemical Industry of the Future initiatives are underway.

Catalysis

Seven new projects address the industry's roadmap goals to accelerate the catalyst discovery process and to develop catalysts with selectivity approaching 100%. These projects focus on discovering new families of catalysts, improving chemical conversion processes to reduce waste and energy, or finding new methods for converting abundant chemical feedstocks into more valuable chemical products.

Partners

- Akzo Nobel Chemicals, Inc.
- Argonne National Laboratory
- Sandia National Laboratories
- Los Alamos National Laboratory
- Dow Chemical Company
- Reaction Engineering International
- GE Research and Development Center
- Molecular Simulations, Inc.
- OMG Americas
- Hyperion Catalysis International
- Worcester Polytechnic Institute
- Pacific Northwest National Laboratory
- Harvard University
- Utrecht University
- University of Minnisota
- Northwestern University
- California Institute of Technology

Computational Fluid Dynamics

Two new projects in computational fluid dynamics address the need for generating high-quality data, better models, and new computational techniques for gas/solid transport in the chemical industry. These projects focus on developing effective models in multiphase flows. Advances in these areas could improve many chemical processes by streamlining costly and lengthy experimentation.

Partners

- Los Alamos National Laboratory
- Sandia National Laboratories
- Pacific Northwest National Laboratory
- Chevron Research and Technology
- Silicon Graphics, Inc.
- Dow Chemical Company
- Dow Corning Corporation
- DuPont
- Exxon Research and Engineering
- Siemens Westinghouse Power Corporation
- Particle Systems
- Lawrence Berkeley National Laboratory
- Oak Ridge National Laboratory
- Fluent Technologies
- Federal Energy Technology Center

The Industries of the Future process enables competitors, suppliers, and customers to work together to solve precompetitive problems. This approach reduces the cost and risk of R&D.

Separations

Research in separations includes five projects that could improve efficiency in chemical processes and waste stream recovery. Advances in these areas will have applications in a wide range of industries, from aluminum production to petroleum refining. Potential benefits from these projects include energy and cost savings, waste reduction, and better use of chemical components.

Partners

- Center for Waste Reduction Technologies (AIChe)
- Monsanto Company
- SRI International
- Eastman Chemical Company
- Center for Engineering and Environmental Technology
- Mott Corporation
- Prototech Company
- Argonne National Laboratory
- Praxair, Inc.
- Air Products and Chemicals, Inc.
- Coors Technical Ceramics Company
- Oak Ridge National Laboratory
- Union Carbide Corporation
- Penn State University
- Innovative Membrane Systems, Inc.
- Chemical Industry Environmental Technology Projects
- Battelle Memorial Institute
- Membrane Technology and Research, Inc.
- Amoco Corporation
- Phillips Petroleum Company
- Georgia Tech Research Foundation
- Hoechst Celanese Corporation
- Hercules, Inc.
- Sloan Foundation

Biotechnology and Bioprocessing

Seven projects underway focus on improving performance of biocatalysts and biochemical processing. Biotechnology contributes to the production of commercial products from food ingredients to diagnostics. In industrial processes, biotechnology helps make organic chemicals, recover minerals, reduce waste streams, or produce energy. Compared to traditional processes, biotechnology promises near-ambient operating conditions and enables a more efficient industrial pathway for chemical manufacture.

Partners

- Arkenol Holdings, L.L.C.
- Rensselear Polytechnic Institute
- University of California, Berkeley
- Massachusetts Institute of Technology
- Oak Ridge National Laboratory
- Applied CarboChemicals
- Enzymol International
- Kraft Foods
- Altus Biologics, Inc.
- Enzy Med, Inc.
- Applied Power Concepts, Inc.
- National Corn Growers Association
- National Renewable Energy Laboratory
- Michigan State University
- Eastman Chemical Company
- Genencor International
- Hercules, Inc.
- Dow Chemical Company

Case Studies

Promising solder process requires no CFC cleaning

An electronic soldering method for printed wire boards (PWBs) eliminates the use of environmentally dangerous chlorofluorocarbon (CFC) solvents. Conventionally, rosin mildly activated (RMA) flux is applied to the PWB prior to soldering to remove oxides that form. After soldering, residual RMA flux must be removed with CFC solvents to avoid corroding electronic components and causing electrical shorts. However, the use of CFC solvents results in noxious gas emissions.

The new method substitutes adipic acid for RMA, thus cleaning with CFCs is unnecessary. Adipic acid burns off completely, leaving no residue during printing and generating harmless carbon dioxide and water as by-products. Approximately 90% of commercial PWB soldering processes now use the no-clean technology.

Benefits

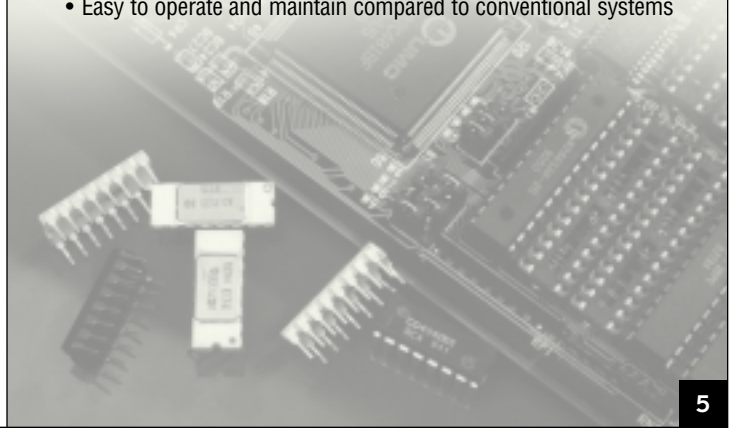
- Eliminates the generation of ozone-depleting CFC emissions from in-line cleaning of electronic assemblies
- Saves electricity used during the cleaning stage
- Saves petroleum feedstock otherwise needed to produce cleaning solvents

Membrane separation offers an economical and environmentally friendly way to recover industrial solutions

VaporSep is a new membrane separation system for recovering volatile organic compounds (VOCs) and chlorofluorocarbons (CFCs) from producer and user streams. Forty-seven units are installed and working, 38 of them in the United States. This technology works by first compressing the contaminated air stream and then condensing it. The gas mixture flows through a highly selective membrane that separates an organic-enriched permeate stream for recycling to the compressor. Meanwhile, a harmless organic-depleted stream is vented to the environment.

Benefits

- Maintains solvent atmosphere concentrations below worker exposure thresholds
- Eliminates atmospheric release of VOCs and CFCs
- Reduces energy costs and recovers solvents for less than their purchase price
- Easy to operate and maintain compared to conventional systems



Case Studies

Motor Challenge program helps 3M improve motor system performance and save energy costs

Working with OIT's Motor Challenge program, the 3M Corporation found ways to optimize electric motor systems throughout its 7.5 million square foot corporate campus facility in Maplewood, MN. An in-depth performance study and upgrades at one representative building reduced electricity use by 41% and resulted in annual cost savings of $77,554. Later, 3M applied motor, fan, and other systems improvements to all 29 lab facilities on the campus; the company achieved a company-wide electricity reduction of 6% and an annual energy cost savings of $823,000.

Potential Benefits

- Electricity reduction of 41% in one building, 6% company-wide
- Energy cost savings of $823,000 company-wide
- Payback of 1.9 years

Steam trap inspection and maintenance program cuts energy costs and carbon emissions

Rohm and Hass Kentucky makes products from methyl methacrylate and uses 540/lbs per hour of steam in the process. The company surveyed one of its plant's 1,500 steam traps and found that 12%, or 180 traps, were failing and wasting steam.

Plant management addressed the problem by replacing all failed steam traps over a one-year period. Management also began a formal steam trap inspection and maintenence program to regularly survey and replace any failed traps. This new program of personnel training, inspection, and trap maintenance has saved nearly $500,000 per year with an average payback of 22 days per steam trap replaced. Additionally, the company has reduced carbon emissions by 2,000 tons per year.

Potential Benefits

- Energy cost savings of $500,000 annually
- Carbon emissions reduced by 2,000 tons per year
- Average payback of 22 days per trap replaced

RESEARCH, SERVICES, AND RESOURCES

DOE programs support Chemical Industry of the Future

OIT's Industries of the Future strategy accelerates R&D of novel technologies of interest to eight energy-intensive industries: aluminum, chemicals, forest products, glass, metalcasting, mining, renewable bioproducts, and steel. The strategy is sponsored and facilitated by OIT, a unit of DOE's Office of Energy Efficiency and Renewable Energy. Focus is on developing high-risk, high-payoff pre-competitive technologies within a 20-year planning time frame.

As an integral component of the Chemical Industry of the Future strategy, OIT offers a range of programs that can help the chemical industry begin saving energy, reducing costs, and cutting pollution right away. Using an "integrated delivery" approach, OIT focuses on making an individual company aware of all the potentially applicable technologies, tools, and expertise in the organization's extensive portfolio of products and services and then providing the right services to meet the customer's needs.

Enabling Technologies

AIM (Advanced Industrial Materials) develops and commercializes new and improved materials to increase energy efficiency, improve productivity, and enhance material longevity and product quality.

The **Combustion** program increases productivity, improves energy efficiency, reduces emissions, and enhances fuel flexibility by developing cost-effective and energy-efficient technologies that are necessary for global competitiveness.

Continuous Fiber Ceramic Composite Materials pursues ceramic composite technologies that improve productivity by utilizing higher process temperatures, extending component and system lifetimes, and reducing downtime.

Sensors & Controls develops and deploys integrated measurement systems for operator-independent control of the manufacturing process. Priority goals are improving technology both in sensors embedded in high temperatures and harsh environmental applications, and in information processing to detect and remedy malfunctions.

Distributed Generation Technologies

Cogeneration improves the efficiency of fuel use and reduces overall emissions. This program supports extensive research, development, and demonstration to meet the technical and market challenges associated with enhancing industrial cogeneration and moderate-size independent power production opportunities.

Financial Assistance

The **Inventions & Innovation** program provides financial assistance for establishing technical performance and conducting early development of innovative ideas and inventions. Ideas with potential for significant energy savings and commercial use are chosen for financial support through a competitive solicitation process. Technical guidance and commercialization support are offered to successful applicants.

NICE^3 (National Industrial Competitiveness Through Energy, Environment, Economics) is an innovative cost-sharing program that promotes energy efficiency, clean production, and economic competitiveness in industry by providing funding to State and industry partnerships for technology demonstration projects.

Technical Assistance

Combined Heat & Power Challenge is focused on overcoming major barriers that currently exist in implementing combined heat and power systems, including complex and costly environmental permitting, unclear environmental regulations, excessive utility fees and rates, and long and varied Federal tax depreciation schedules.

Compressed Air Challenge is dedicated to improving the efficiency and performance of industrial compressed air systems with the goal of reducing energy use and costs.

IACs (Industrial Assessment Centers) help small and medium-size manufacturers identify opportunities to improve productivity, reduce waste, and save energy through comprehensive industrial assessments. Teams of engineering professors and students from 30 universities across the country conduct the assessments and provide recommendations to manufacturers at no cost.

Motor Challenge helps increase the productivity and reliability of electric-motor-driven systems, reduce energy costs, and improve the bottom line by providing reliable, unbiased information, tools, and technical assistance to improve motor system efficiency.

Steam Challenge provides information tools and technical assistance that can help industry enhance productivity, lower production costs, and reduce emissions of its industrial steam systems.

Additional information resources include:

IPLocator (www.oit.doe.gov/locator) provides access to information on federally sponsored R&D projects that are ongoing or recently completed, optimizing the complementary research and development strengths of industry, universities, National Laboratories, and government.

OIT's Information Resources Catalog, available by calling 202-586-2090, describes over 400 publications and other information products of interest to our customers. Also available online at www.oit.doe.gov.

HOW TO GET INVOLVED

Turning vision into reality

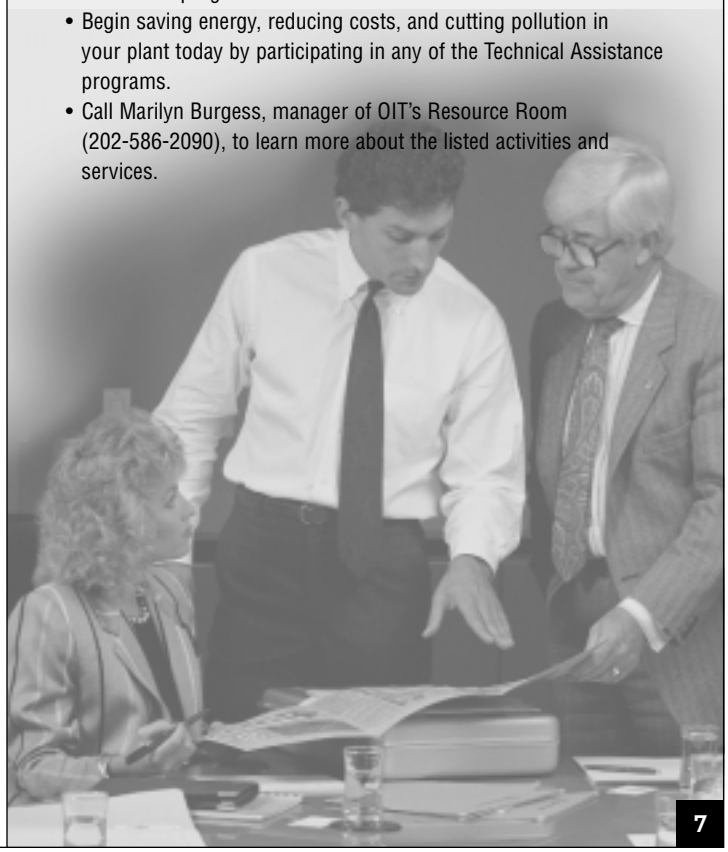
For U.S. chemical companies, Industry of the Future partnerships can bring clear competitive advantages. Participating chemical companies benefit from the reduced cost and risk of collaborative R&D and streamlined access to Federal scientific resources. Positioned at the forefront of technology development, these companies reap the benefits of more efficient and productive technologies and, in turn, contribute to our Nation's energy efficiency, industrial competitiveness, and environmental quality.

Ways to participate

By aligning R&D resources within industry and government to meet industry priorities, the Chemical Industry of the Future will be poised to compete more effectively than ever in the global market.

There are many ways to participate:

- Monitor our Web pages for news and announcements of R&D solicitations (www.oit.doe.gov/chemicals).
- Team with other organizations and respond to solicitations for cost-shared research issued by OIT's Chemical Industry of the Future team, our Enabling Technologies programs, and our Financial Assistance programs.
- Begin saving energy, reducing costs, and cutting pollution in your plant today by participating in any of the Technical Assistance programs.
- Call Marilyn Burgess, manager of OIT's Resource Room (202-586-2090), to learn more about the listed activities and services.



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