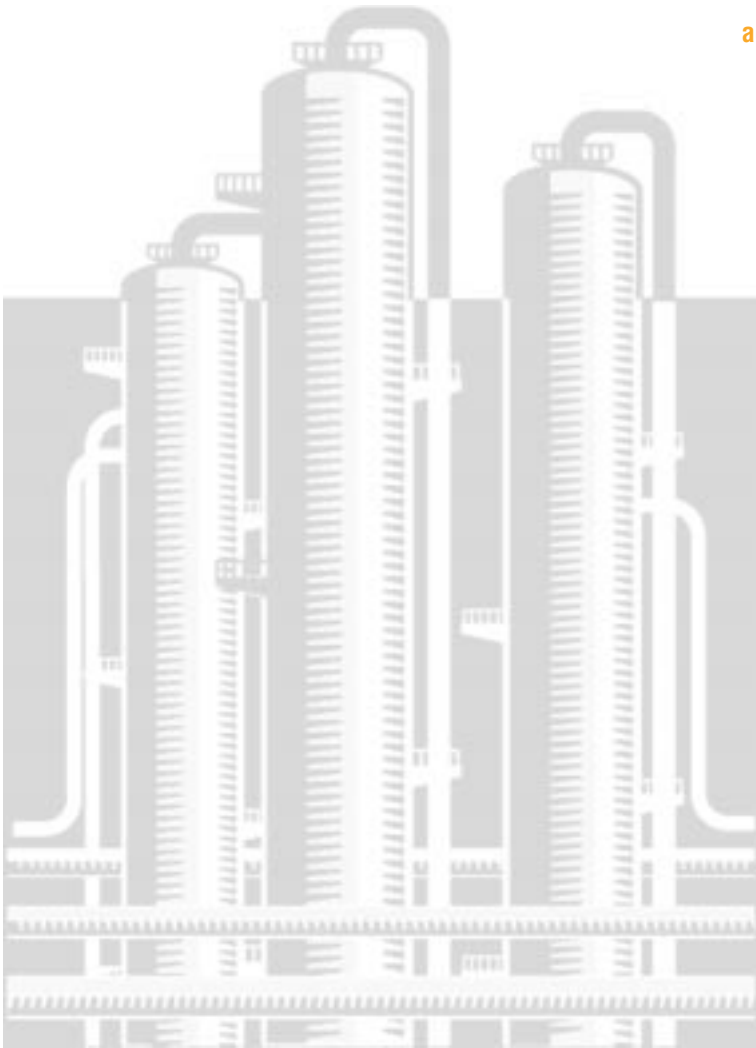


# petroleum

Petroleum — Industry of the Future



The petroleum industry is fueling a secure future through advanced technology research and development.



Office of Industrial Technologies



Office of Energy Efficiency and Renewable Energy  
U.S. Department of Energy



# partnership

## A platform for technology research, development, and deployment

### Cooperative advantages

The Industries of the Future strategy enhances the petroleum industry's efforts to

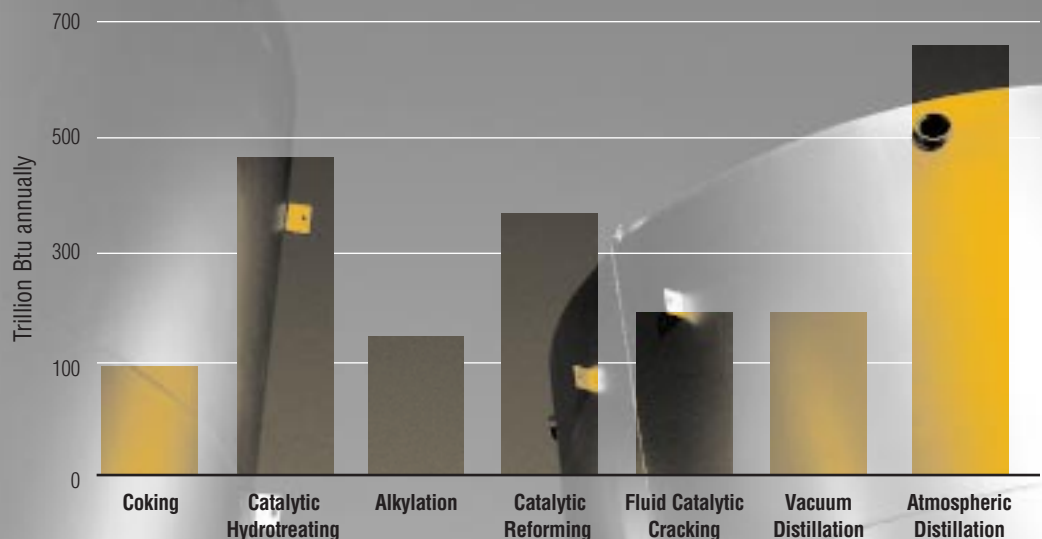
- Ensure that technology priorities are identified and advanced.
- Strategically invest in R&D and new technologies that will drive higher levels of performance.
- Leverage scarce funds for research.
- Increase cooperation among the business, government, and research communities.

The U.S. is the largest, most sophisticated producer of refined petroleum products in the world, with 16.5 million barrels per day of crude distillation capacity. Revenues from petroleum and its products represent a significant portion of the U.S. gross domestic product. More than 107,000 people work in 152 refineries located in 32 states, and nearly 1 million Americans are employed by over 125,000 service stations across the nation, most of which are independently owned and operated.

Petroleum refining has grown increasingly complex in the last 20 years, due to lower-quality crude oil, crude oil price volatility, and environmental regulations that require cleaner manufacturing processes and higher-performance products. Several key drivers are impacting the industry's competitive position, including continuing its commitment to safety and the environment, exploiting changing markets and demand, responding to competitive forces, improving processes, and increasing the efficiency of energy use and energy products. In many cases, technology research and development (R&D) are key to meeting these challenges and maintaining the health and profitability of the industry.

Petroleum refining is unique among manufacturing industries from an energy standpoint. It is the country's single largest source of energy products, supplying 40 percent of total U.S. energy demand and 99 percent of transportation fuels. At the same time, it is also the largest industrial consumer, representing about 7 percent of total U.S. energy consumption.

Relative Energy Use by Major Refinery Processes



Source: Energy and Environmental Profile of the U.S. Petroleum Industry, U.S. DOE, OIT Dec. 1998.

## Petroleum industry steers the way

In February 2000, petroleum industry leaders signed a compact with the U.S. Department of Energy's Office of Industrial Technologies (OIT) to work together through the Industries of the Future initiative. This initiative is now paving the way for strategic joint development of technologies by government, national laboratories, academia, and industry in alignment with the industry-defined vision, *Technology Vision 2020*.

A key driving force behind the Petroleum Industry of the Future is the American Petroleum Institute's Technology Committee, which, along with the National Petrochemical



and Refiners Associations, has identified the technical areas of greatest concern to the industry and developed a technology roadmap to address them. The roadmapping process is encouraging new government-industry partnerships that will further strengthen the industry, while providing benefits to the nation in terms of energy efficiency and environmental performance.

### Vision

*Technology Vision 2020: A Technology Vision for the U.S. Petroleum Industry* identifies major goals for the future and outlines broad technology needs.

### Roadmap

The goals and research priorities outlined in *Technology Roadmap for the Petroleum Industry, Draft 2000*, form the basis for making new research investments by both government and industry.

### Implementation

Industry has targeted technology development in the areas of energy and process efficiency, environmental performance, materials and inspection technology, and the refinery distribution system and retail delivery services.

### Path Forward

Changing market and technical issues will be considered periodically to ensure that research priorities remain relevant to the needs of both the petroleum industry and its customers.

## Waste-heat reduces operating costs

*A waste-heat ammonia absorption refrigeration unit provides a Rocky Mountain refiner with a reduction in regulated emissions, additional LPG and gasoline recovery, and a less than two-year payback. This advanced design unit was integrated into an existing operation. It uses highly compact heat and mass transfer equipment along with state-of-the-art materials. Waste-heat from the reformer is used to power the unit, which recovers valuable products from the refinery waste fuel header.*

*Ammonia absorption refrigeration is very useful for production of chilled fluids from waste-heat energy and operates well at 250°F (121°C) or lower. Absorption*

*refrigeration, invented in 1850, has been largely replaced by compression refrigeration, a simpler system which is less capital-intensive and easier to operate. However, the ability to utilize free waste-heat allows absorption refrigeration to gain the economic advantage over compression.*

*OIT partnered with national laboratories and private industry to demonstrate that ammonia absorption refrigeration can effectively utilize refinery waste-heat to recover valuable resources. The technical and economic results of this project show that government-industry partnerships do provide valuable benefits to the industry and the nation.*



# results

## High-priority research needs

Based on industry-defined priorities and recommendations, OIT awards cost-shared support to projects that will improve the industry's energy efficiency and global competitiveness. All awards are made on a 50 percent cost-shared basis through a competitive solicitation process. Solicitations are open to collaborative teams with members from industry, academia, national laboratories, and other sectors that have a stake in the future of the petroleum industry.

The petroleum industry has identified research priorities in the following areas:

### **Energy and process efficiency**

New and improved approaches are important for extracting and processing crude oil into petroleum products. The roadmap includes advances in current methods, the minimization of process energy losses, and identification of completely new approaches to extracting and processing crude oil. In particular, high-priority research topics include fouling mitigation in heat exchangers, improved real-time process measurements, and improved fuel conversion efficiency.

### **Environmental performance**

The impact of petroleum operations and products on the environment is a major area of emphasis. Key research topics aimed at continuous improvement in environmental performance include a method for risk analysis/assessment and an improved system for leak detection and repair.

### **Materials and inspection technology**

Effective materials are vital to the efficient operation of production and manufacturing operations. Inspection methods play a critical role in the performance of all phases of the petroleum industry. The highest-priority research need focusing on materials and inspection is the development of a global, on-line inspection technology.

### **Distribution system and retail delivery services**

Production and use of transportation fuels have long been associated with concerns about emissions and energy conservation. A key industry priority is to use an integrated systems approach that combines consumer requirements for fuel efficiency and performance with a need to reduce vehicle emissions.



## ***New separation technology for refining***

*Government and industry partners are researching high-performance membranes as alternatives to conventional energy-intensive distillation processes. Pervaporation and reverse-selectivity membranes are being tested for hydrocarbon separation and hydrogen recovery. Potentially, membrane separation could be 20% more energy efficient than distillation.*

## **Demonstrated success**

OIT has worked with the petroleum industry in many capacities to develop, demonstrate, and deploy energy-efficient and environmentally improved technologies. Selected emerging or commercially available technologies applicable to the petroleum industry include:

- Waste Heat Process Chiller
- Fouling Minimization
- Robotics Inspection System
- Force Internal Recirculation (FIR) Burner
- Radiation Stabilized Burner
- Low-Profile Fluid Catalytic Converter (FCC)
- Computational Fluid Dynamic Model of FCC
- Gas Imaging for Leak Detection
- Advanced Process Analysis for Refining

## **Research and Development Projects**

### **Energy and Process Efficiency**

Micro Gas Chromatograph Controller  
Gasoline BioDesulfurization Process  
Enzyme Selectivity for Desulfurization  
Catalytic Hydrogenation Retrofit Reactor  
New Nanoscale Catalysts Based Carbides  
Selective Catalytic Oxidative Dehydrogenation  
Oxidative Cracking of Hydrocarbons to Ethylene  
Alkane Functionalization Catalysts  
Low-Profile Catalytic Cracking  
Selective Surface Flow Membrane  
Catalytic Hydrogen Selective Membrane  
Advanced Process Analysis for Refining  
Multi-phase Computational Fluid Dynamics  
Gas-Phase Thermodynamics Modeling  
Membrane Reactor for Olefins  
Membrane to Recover Olefins from Gaseous Streams  
Energy-Saving Separations Technologies  
BestPractices

### **Environmental Performance**

PSA Product Recovery from Residuals  
Refinery Process Heater System  
Flame Image Analysis and Control  
Thermal Image Control for Combustion  
Rotary Burner Demonstration  
Low-NO<sub>x</sub>—Low-Swirl Burner  
Internal Recirculation Burner  
Novel Low-NO<sub>x</sub> Burners

### **Materials and Inspection Technology**

Advanced Materials for Reducing Energy  
Laser Sensor for Refinery Operations  
Laser Ultrasonic Tube Coke Monitor  
Mechanical Integrity Global Inspection  
Gas Imaging for Leak Detection  
Corrosion Monitoring System  
Metal Dusting Phenomena  
Intermetallic Alloy for Ethylene Reactors  
Alloy Selection for High Temperatures

*For more information and a complete listing of other Petroleum projects, visit [www.oit.doe.gov/petroleum](http://www.oit.doe.gov/petroleum)*

# resources

## Integrated support for today and tomorrow

OIT's Petroleum Team supplements its R&D budget by coordinating activities with other OIT programs that can help advance petroleum industry goals. For instance, the Chemical Industry of the Future Team is funding technology development that can also benefit the petroleum industry.

OIT programs of value to the petroleum industry include R&D for **Enabling Technologies**, **BestPractices** initiatives, and **Financial Assistance**. In addition, **State-Level Industries of the Future** programs have begun in a number of states to bring the energy, environmental, and economic benefits of industrial partnerships to the local level.



### Enabling Technologies

OIT's **Industrial Materials** program works with industry, the national laboratories, academia, and others to develop and commercialize new and improved materials that offer superior strength and corrosion resistance in high-temperature industrial environments. One project with direct application across the petroleum industry is the development of new oxide membranes for more efficient liquid and gas separations. The **Combustion** program is co-funding R&D on three high-efficiency industrial burners that promise to reduce the cost of pollution control through very low emissions of nitrogen oxide, carbon monoxide, and unburned hydrocarbons. Research in **Sensors and Controls** addresses such challenges as improving sensor reach and accuracy in harsh environments and providing integrated, on-line measurement systems for operator-independent control of refining processes.



### Motor system upgrades pay off in energy savings

Annual electricity savings of more than 12 million kWh and over \$700,000 were achieved by a large West Coast refiner using OIT's Motor Challenge. This industry-government partnership assists the refining industry by identifying near-term gains in energy efficiency that can be achieved by adopting existing technologies. This program uses a "systems approach" to motors, drives, and motor-driven equipment that results in reduced energy consumption. The West Coast refiner used this program to identify and justify upgrades on motors, motor drives, and power recovery turbines.



## BestPractices

Through BestPractices, OIT helps the petroleum industry apply existing technologies and methods to save energy and reduce costs, wastes, and emissions. Upgrading or fine-tuning motors, pumps, steam systems, and compressed air systems can result in significant improvements in efficiency and equipment durability. BestPractices offers funding, tools, training, and expert advice and information.

BestPractices also provides **plant-wide assessments** to help petroleum refineries develop an integrated strategy to increase efficiency, reduce emissions, and improve productivity. Up to \$100,000 in matching funds is awarded for each assessment through a competitive solicitation process. Participants agree to a case study follow-up that helps publicize the results. Alternatively, small to mid-size manufacturers can take advantage of the **Industrial Assessment Centers**, which provide no-charge assessments through a network of engineering universities.

## Financial Assistance

OIT offers targeted Financial Assistance to accelerate technology development and deployment. **NICE<sup>3</sup>** (National Industrial Competitiveness through Energy, Environment, and Economics) provides cost-shared grants of up to \$500,000 to industry-state partnerships for demonstrations of clean and energy-efficient technologies. Several emerging petroleum technologies—including an advanced process analysis system, a low-profile fluid catalytic cracking plant, and a robotics inspection system for storage tanks—have been successfully demonstrated with help from NICE<sup>3</sup>.

A second program, **Inventions and Innovation**, awards grants of up to \$200,000 to inventors of energy-efficient technologies. Grants are used to establish technical performance, conduct early development efforts, and plan commercialization strategies.

**For more information on these and other resources, please contact the OIT Clearinghouse at (800) 862-2086.**

## How to get involved

*Through Industries of the Future partnerships, U.S. petroleum industry companies reap the competitive advantages of more efficient and productive technologies and, in turn, contribute to our nation's energy efficiency and environmental quality.*

*To participate:*

- *Monitor the OIT Petroleum Industry Team's Web site for news and announcements of R&D solicitations, meetings and conferences, and research projects.*
- *Team with other organizations and respond to solicitations for cost-shared research.*
- *Begin saving energy, reducing costs, and cutting pollution today by participating in any of the BestPractices programs.*
- *Take advantage of OIT's extensive information resources, including fact sheets and case studies, training, software decision tools, searchable CDs, newsletters, and publications catalog.*
- *Attend the biennial Industrial Energy Efficiency Symposium and Expo.*

**[www.oit.doe.gov/petroleum](http://www.oit.doe.gov/petroleum)**



For more information on the Petroleum Industry of the Future,  
contact the OIT Clearinghouse at (800) 862-2086  
or visit [www.oit.doe.gov/petroleum](http://www.oit.doe.gov/petroleum)

Please send any comments, questions, or suggestions to [webmaster.oit@ee.doe.gov](mailto:webmaster.oit@ee.doe.gov)



Office of Industrial Technologies  
Office of Energy Efficiency and Renewable Energy  
U.S. Department of Energy



Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 20% postconsumer waste.

February 2001  
DOE/GO-102001-1158