DEPARTMENT OF ENERGY
FY 2001 CONGRESSIONAL BUDGET REQUEST
ENERGY EFFICIENCY AND RENEWABLE ENERGY
ENERGY CONSERVATION
(Tabular Dollars in Thousands, Narrative in Whole Dollars)

INDUSTRY SECTOR

PROGRAM MISSION

Sector Mission, Situation, Goals and Strategic Approach:

Mission

The mission of the Office of Industrial Technologies (OIT) is to improve the energy efficiency, environmental performance, and productivity of energy-intensive industries by developing and delivering advanced science and technology options which will:

- lower raw material and depletable energy use per unit output;
- improve labor and capital productivity; and
- reduce the generation of wastes and pollutants.

OIT's R&D portfolio focuses on generic precompetitive research concentrating on cooperative projects with nine of the major process and extraction industries in the industrial sector. These industries, referred to as the Industries of the Future (IOF), include: forest products, steel, aluminum, metal casting, glass, chemicals, petroleum, mining and agriculture. In addition, the portfolio includes crosscutting research and development efforts on technology needs which have been identified in technology roadmaps across multiple industries, and which form technology bases from which more industry-specific developments can derive. The crosscutting activities also include technical information and outreach programs, demonstrations, training, and tool development which assist industry in evaluating and adopting these new energy efficient and pollution preventing technologies and techniques.

Situation

Industry consumed some 35 quads of primary energy in 1997 - about 38 percent of all energy used in the United States. The industrial sector contains extraction, and material processing and product manufacturing industries. Over 80 percent of the energy consumption in manufacturing (including feedstocks) occurs in only seven process industries: forest products, steel, aluminum, metal casting, glass, chemicals, and petroleum. Mining and agriculture are major energy users in the extraction industry. These nine industries are highly capital intensive, produce significant emissions and waste products with far larger energy and pollution abatement costs per unit sales, and typically invest far lower percentages of sales into research and development than the U.S. industry average. Overall energy intensity (energy per unit output) decreased from 1973 through 1986, but has since remained nearly level, while pollution abatement costs have continued to grow; due in significant part to energy consumption.

Efficient energy use and waste disposal are important to industry in terms of operating costs. Industry spent about $120 billion on energy in 1997 and approximately $29 billion for pollution abatement and control. This represents less than 5% of total costs of operation for all of industry; however, for materials and process industries, the percentage of costs attributable to energy and waste is higher, ranging from about 7% to over 30%. Because of their intensive energy use, these industries consider energy costs to be an important driver of investment and operating decisions.

The major process industries are, and are becoming increasingly, highly capital intensive. Markets are continuing to become increasingly globally competitive. Many, such as steel, faced dire times in the 1960s and 1970s. They restructured and re-engineered themselves such that by the 1980s, they were world leaders. By the late 1990s, world financial markets, trade issues, increasing costs of environmental abatement and other costs, not necessarily shared by foreign competitors, and generally soft markets have again placed major strains on these industries. Reducing energy costs and reducing waste and reducing or eliminating environmental emissions upstream (closely related to energy use), are increasingly being recognized as controllable costs that can lead to increased productivity and profitability, increased product quality, and increased global competitiveness.

Concerns about generation of pollution and the levels and types of industrial wastes are increasing. Industry generated 14 billion tons of waste in 1994, including over 200 million tons of hazardous and toxic wastes. The manufacturing sector alone accounts for about 65% of all industrial wastes, and almost all of the hazardous and toxic wastes. Within manufacturing, materials and process industries account for about 80% of the hazardous and toxic wastes and about 95% of non-hazardous waste. These wastes often impose expensive clean up and disposal costs, and offer the potential for recovering the "embedded" energy and materials value.

Manufacturing jobs are important to the economy. About 18 million people are employed in manufacturing in the United States. Manufacturing jobs are higher-paying and higher-skilled compared to many jobs in service industries. Manufacturing jobs are also a strong stimulus to the

economy – 4 jobs are created for every manufacturing job created. Manufacturing jobs have increased from 18.1 million jobs in 1992 to 18.7 million in 1998. This resurgence follows a decline from a level of 19.6 million jobs in 1974 and has paralleled increasing U.S. industrial competitiveness and a thriving economy.

In addition to the normal uncertainties in the R&D process, timing uncertainties are in some industries of particular importance. Many large plants and large equipment modules were installed in the rapid economic growth period after WW II through the 1960s. These will be reaching their useful life by the end of the next decade. Hence, a window exists where the new technologies, if developed in time, may be adopted rapidly during the expected new or retrofit installations; if that window is missed, adoption will be slower in the face of recently installed high capital investment facilities. In addition, several of the major process industries are operating at very low or negative profit margins due in large part to low global prices associated with the current Asian and Eastern European economic situations. The restructuring of the utility industry, climate change concerns and issues, and emission requirements also have the potential for significant impacts, but the magnitude, and even the direction, are subject to the details of actual implementation; many of the details are also associated with local, state, and even global policies.

Future Industrial Growth

Energy Information Administration forecast projects delivered industrial energy consumption to grow 0.8 percent annually from 1997 to 2020, one third higher than in 1990. Achieving significant improvements in the energy intensity of industry will require considerable scientific and technological progress. OIT's visioning and road-mapping activities with energy intensive industries is playing an important role. It helps to target government and industry cost-shared R&D efforts. OIT supports development of cross-cutting technologies, and provides financial and technical assistance to improve the competitive position of U.S. industry. Leveraging DOE resources with industry R&D and energy efficiency activities will be needed to speed energy efficiency, and environmental improvements. OIT has over a 20 year history of working closely with industry partners and resulting scientific and commercial accomplishments that are helping to strengthen American industry.

Federal Role

The energy consumption by industrial processes is intimately tied to emissions and environmental impacts as well as to productivity and economic competitiveness. In turn, this has major implications for the overall environment and the economy, affecting U.S. jobs and global competitiveness. This is particularly so in the major process and extraction industries, where global competition is not always based on completely free markets and where profitability as a function of sales is, in many cases, relatively low. In turn, this necessarily leads to relatively low private sector investments in R&D (as a function of sales) by these segments of industry as compared to industry as a whole.

The levels of risk involved in the adoption of major new technologies in these industries is also relatively high. Most process plants operate continuously at very high throughputs; down-times and retrofits or repairs associated with some new technology could be financially devastating. These processes are also very highly capital intensive and involve plants with generally very long, even half-century, lifetimes. Competition for capital and the nature of the downside risks further hinder adoption of many new technologies. Less capital intensive advances

such as process parameter changes or advanced sensing and controls and simulation capability suffer from relatively limited capability to maintain intellectual property.

Collectively these factors lead to individual companies being unable, or rationally unwilling, to invest in many areas of advanced R&D. Hence, there is a need for a Federal role in helping to support, primarily, generic, pre-competitive R&D which can benefit the industry as a whole, from which individual companies can then further develop in a competitive environment, and which would be unlikely to occur without such Federal involvement. Further, it leads to the need for testing, verification, demonstration, and information dissemination to provide the levels of information needed for critical investment decisions for the rapid adoption of advanced technologies.

OIT's energy intensive industries produce a wide range of basic commodities for the American economy. Many of these industries face intense competition. Traditionally they invest much less than industry averages in R&D and have had relatively slows rates of capital investment and capital equipment turnover. This context has set the stage for the OIT strategic approach.

Goals and Strategic Approach

- Improve industrial energy intensity by 25 percent by 2010 from the 1990 level.
- Save 170 trillion BTUs of energy in 2001, increasing to 400 trillion BTUs in 2010, through the introduction of new OIT-sponsored technologies.
- Save 90 trillion BTUs in 2001, increasing to 210 trillion BTUs per year in 2010 through Best Practices and Industrial Assessment Centers (IAC) programs.

An ambitious goal for U.S. industry for the year 2010 is a 25% reduction in energy consumption per unit of output. Projects supported by OIT will work not only towards these goals, but will assist industry in other efforts to meet energy, environmental and productivity goals. Advanced technologies can improve industrial productivity, not only through reducing energy cost expenditures, but also through productivity enhancements and innovative solutions for meeting environmental requirements. In fact, the value of the non-energy productivity improvements often exceeds the energy cost savings. For example, the use of super-hard Nickel Aluminide (a DOE-developed technology) in rolls in a re-heating furnace of a steel mill has resulted in both energy and productivity improvements. The rolls last at least 3, and sometimes as long as 10, times longer than conventional rolls, requiring replacement on a much less frequent basis. This in turn conserves energy by avoiding disruptions to the furnace cycle (shut downs and cold starts), and has improved productivity by keeping the furnace operational for a much longer period of time. The sum of these savings can also be expected to preserve and increase industrial jobs by helping the international competitiveness of U.S. industry.

PROGRAM MISSION - INDUSTRY SECTOR (Cont'd)

The Industries of the Future (IOF) process includes:

- *Facilitate industry visions and technology roadmaps*. Industry leaders outline a future vision of their industry that is defined by explicit market, business, and technology goals. A *technology roadmap* is developed to articulate specific technology strategies and create a comprehensive R&D agenda. OIT assists industry during this process and acts as a neutral party that can bring together competitors, suppliers, customers, and other key stakeholders.

- *Cooperatively fund strategic projects*. Once industry has developed its technology roadmap, OIT selectively cost-shares technology projects contained within the roadmap that are consistent with the Department's strategic goals and the government role.

Essentially all research projects and research performers are selected through a competitive solicitation, with direct industry involvement in the process with universities, DOE laboratories, and private sector companies performing the research. A significant number of efforts involve a mix of performers including industry-laboratory-university teams or combinations thereof. These mixes vary from industry to industry and the process is flexible to be responsive to the diverse nature of the different industries.

The strategy also includes providing an integrated set of activities ranging from the applied research phase through technology development and/or adoption of energy efficient technologies such as demonstrations of advanced technologies and best practices tools and training on both industry-wide and plant floor levels. Research is conducted principally at the industry-wide, pre-competitive stage with results available to all industry participants, rather than individual members of the IOF industries. Typically, the industry partnership is spearheaded by one (or occasionally more) industry trade association and/or professional society. Participation by the majority of the industry members is involved and individual companies provide staff for technical roadmapping teams, peer and program reviews, and other support. Projects and programs are cost shared, generally with IOF industry collaboratives to average at least 50 percent over the program's life.

- The Industries of the Future (Specific) program develops promising new process-related technologies with industry and other organizations to address needs identified in industry-wide developed visions and roadmaps. These technologies are chosen for their pre-competitive nature; ultimate impact on energy and waste reduction; high priority and high risk; and wide-spread applicability. Project costs are almost always shared with industry on roughly a 50/50 basis.

- The Industries of the Future (Crosscutting) develops technologies which are useful to multiple industries simultaneously. The program delivers information and tools to help plant managers make informed decisions on technology choices today that result in energy, waste and dollar savings. The program supports research to develop power generation equipment, combustion equipment, and sensors and

controls. OIT also develops advanced materials which address a multitude of wear and corrosion problems. In addition, OIT supports new ideas from inventors, and funds grants for demonstration of technologies that will be viable in the near term.

These two programs provide an integrated set of options responsive to the near, mid and long term goals and objectives of industry as set forth in their visions and roadmaps. They are also responsive to the national goals of improved energy efficiency, expanded adoption of pollution prevention, increased productivity, and more globally competitive industries.

The OIT program initially focused on seven major process industries, temporarily decreased to six when one industry was unable to reach a consensus. That industry has since reached a level of consensus and in addition, mining and agriculture (in particular the bioproducts area of agriculture) have been added to the IOF portfolio. This represents a balancing of available resources and the major energy consuming industries; further expansion is not anticipated at current resource levels in order to maintain that balance. In addition, the development of IOF programs at the State level is being initiated providing closer relationships between State and Federal programs and promising more efficient development and adoption of technologies by local industries.

The need for advanced sensors and controls and advanced combustion technologies have been identified as a high priority need in many industry roadmaps. Hence, a focus on new applied research efforts in those areas has been initiated to help provide the technology base from which industry-specific sensors and controls and combustion components can be developed. In addition, the prior research portfolios for each industry have, by FY 1998, been revamped to match industry developed technology roadmaps. Most recently, the Chemical program has been reoriented and a catalysis program developed to support it. All FY 1998 catalysis research projects are new, replacing other prior efforts which were completed or terminated.

Increasing integration of the products and services provided by the industrial RD&D programs has been fully implemented in FY 1999. In this integration, industrial customers were made aware and encouraged to adopt technologies developed in other programs. For example, while the Aluminum program was developing advanced aluminum processing technologies, with the aluminum industry, additional efficient technologies, tools, or techniques arising from other OIT programs, such as in electric motor systems, steam, and compressed air, were being

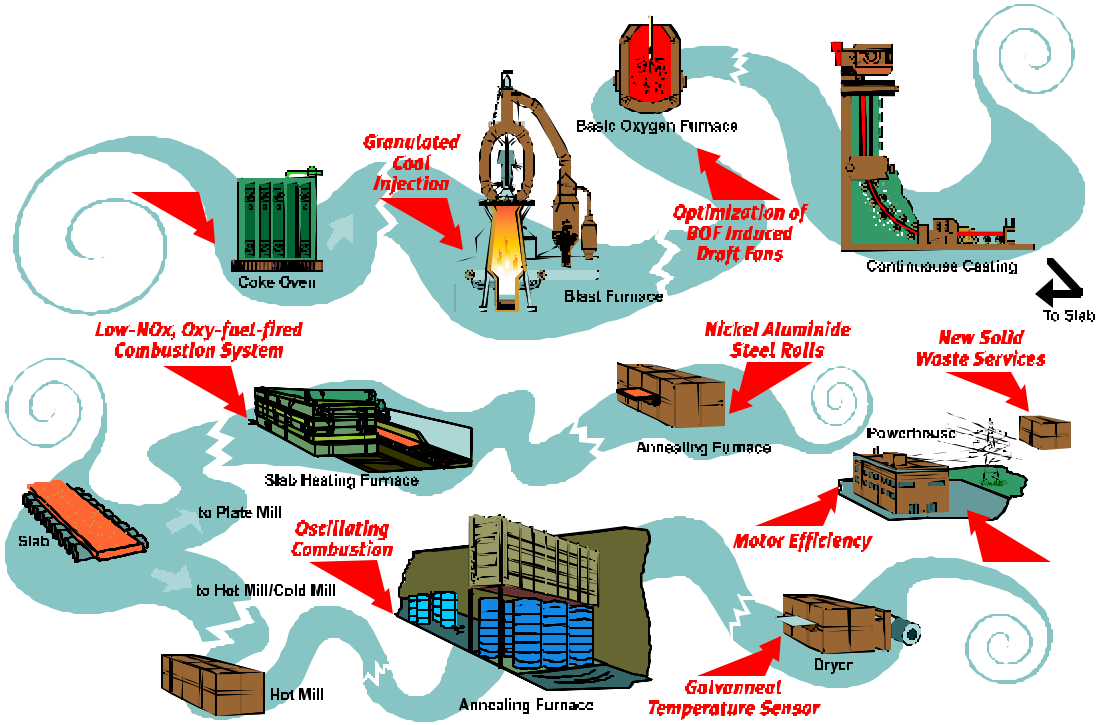
Industries of the Future Successes

OIT has funded 16 technologies which have become *R&D 100 Award* winners over the last 7 years. Ten of these were achieved in the last four years under the Industries of the Future.

114 OIT technologies have been successfully commercialized since 1976, one-fourth since the inception of the Industries of the Future four years ago. In addition, more than 100 additional technologies developed under the Industries of the Future have been identified as having potential for commercialization in the near future.

Integrated Delivery

OIT's newest endeavor to improve the delivery of the full range of programs to its customers is Integrated Delivery. A premier example of Integrated Delivery was implemented at Burns Harbor, Indiana, at the flagship steel mill of Bethlehem Steel. DOE technologies and information assistance for several OIT programs were demonstrated in an operating plant environment, as shown in the following schematic, to hundreds of people in the industry.



presented to these aluminum industrial customers for a more system view of energy use. Increasing collaborations with State energy technology institutes, and State energy and economic development and similar agencies, were also envisioned as an approach to assist the adoption of new technologies at the State and local level as well as to further the identification of State and local level needs into the national roadmapping process.

The Office of Industrial Technologies portfolio responds to the vision goals and roadmap targets through Industries of the Future (Specific) and Industries of the Future (Crosscutting) programs.

Integrated Delivery

OIT is increasingly delivering programs at the corporate, management, technical, and plant levels of U.S. industry. OIT calls this mechanism Integrated Delivery. Involvement of the States in the Industries of the Future is part of this effort.

- An example of Integrated Delivery is the hosting of a plant-level showcase of multiple technologies and information assistance programs by an

industrial firm. Demonstrations to other companies show how successful the technologies and systems approaches are and increase awareness of and confidence in advanced technologies.

- The State-level Industries of the Future (IOF) provides grants to States through the State Energy Program, managed by the Office of Building Technology, State and Community Programs. These grants enable State to work on IOF-related activities. The goal is to increase the awareness of the IOF process at the State government level and increase the involvement of more companies in each of the IOF industries in their vision and technology roadmap efforts.

OIT executes research, development and demonstration primarily through competitive solicitations, guided by industry-developed technology roadmaps to ensure focusing on key needs and best performers. This approach matches DOE's economic, environmental, and science and technology goals with the needs and expectations of technology users in the private sector. It also targets Federal R&D investments to market requirements. OIT is establishing partnerships with industry and government to develop the advanced manufacturing and process technologies which can help to strengthen U.S. materials and process industries. Many of the individual firms in these industries are small or medium sized and do not have the resources to pursue the often expensive and lengthy research needed to develop advanced technologies. These advanced technological options can preserve existing industry jobs as well as create new jobs, and can result in increased exports. They can also provide strong economic and environmental benefits without the market dislocations which regulatory approaches often entail.

Best Practices Program

Feedback from OIT’s industry partners and many years of experience with the delivery of technical assistance to manufacturing plants has led OIT to develop a new concept to better integrate the delivery of best-available and emerging energy efficient technology. Instead of delivery of technical assistance through singular technology application programs, the Best Practices Program includes Motors, Combined Heat and Power, Steam, and Compressed Air industry partnerships. By working closely with customers to help them analyze the range of technology options, and by better defining their needs and opportunities, limited plant resources can be maximized. The Best Practices Program will focus on reducing energy use and improving industrial competitiveness in the IOF sectors by matching industry needs and commitments to the appropriate OIT program resources.

Climate Change

PROGRAM MISSION - INDUSTRY SECTOR (Cont'd)

The research and development OIT executes is focused on energy, environment, and improving industrial productivity. Since improvements in energy efficiency have a direct relationship to carbon dioxide reductions, OIT's research constitutes a key element of the Administration's goal of reducing climate change gases in the industrial sector.

Linkage to CNES Goals and Objectives

The Industries of the Future directly supports Goal I, Objective 2 of the Comprehensive National Energy Strategy, which is to significantly increase energy efficiency in the transportation, industrial and buildings sectors by 2010. The program also directly supports the DOE Strategic Plan, in particular Energy Resources Objective 3, which is to increase the efficiency and productivity of energy use, while limiting environmental impacts.

Program Benefits

Office of Industrial Technologies (Non-cumulative)			
	2005	**2010**	**2020**
Total Primary Energy Displaced (Quads)	0.57	1.37	4.83
Total Energy Cost Savings (Billion $)	2.15	5.51	19.27
Total Carbon Reduction (Million Metric Tons)	10.26	26.80	99.80

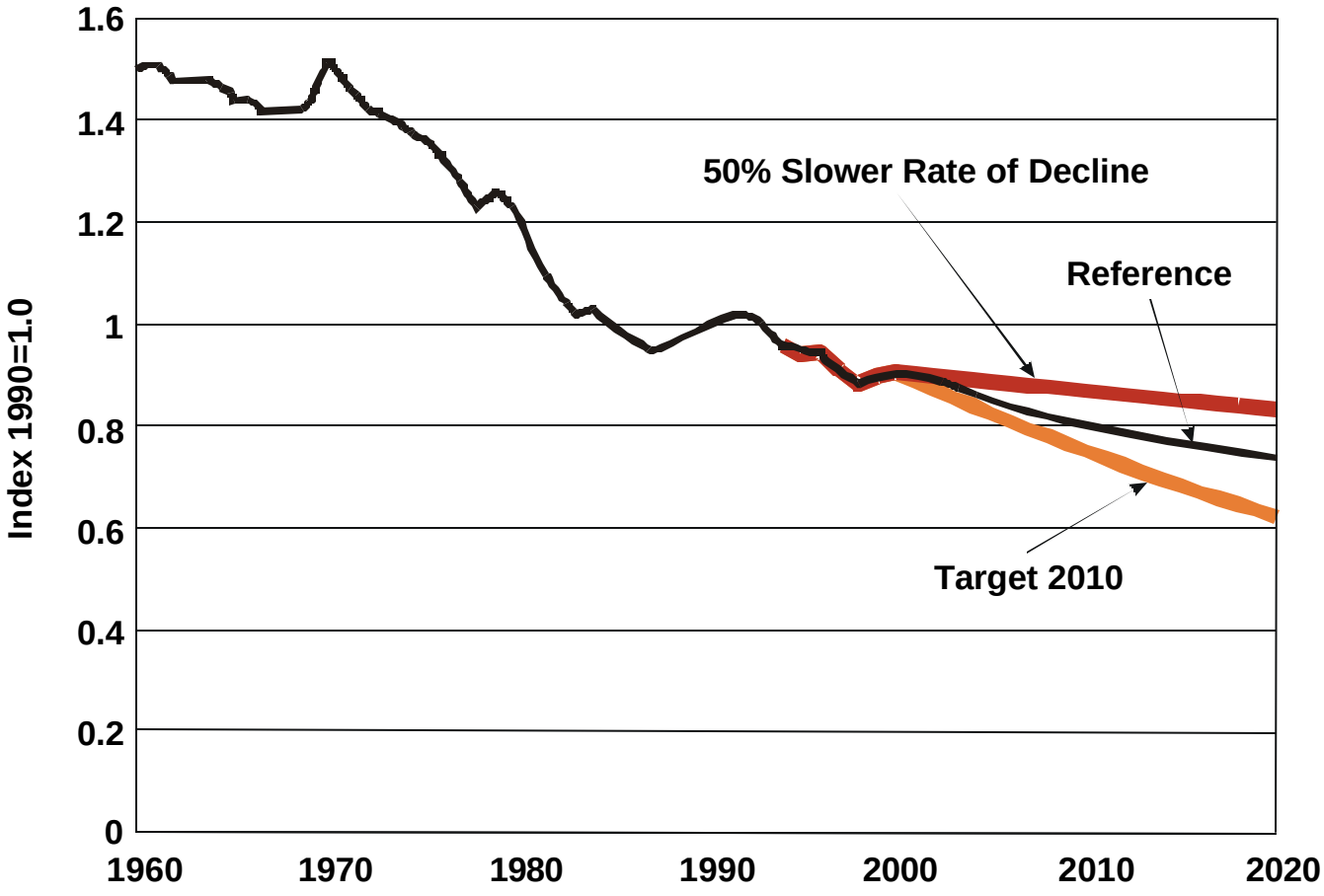
Performance Measures

Measure: Industrial Delivered Energy Intensity, 1960-2020

Improving industrial energy intensity per unit output by 25% from 1990 by 2010 is an important challenge. OIT has a team management structure to achieve its energy intensity goal. The approach focuses on the integrated delivery of R&D, crosscutting technology, financial and technical assistance to both small and medium and large industry partners in energy intensive industries. U.S. industry has demonstrated

impressive energy intensity gains in response to increasing competition and past energy price increases. To remain competitive and to respond to environmental and other industry challenges, OIT seeks to leverage its activities through replication and the rapid dissemination of best practices. Figure 1.; Industrial Energy Intensity in Alternative Scenarios, 1960-2020, developed by the Energy Information Administration shows energy intensity in several possible scenarios to the year 2020.

Figure 1. Industrial Energy Intensity in Alternative Scenarios, 1960-2020



Reference Case is from the EIA Annual Energy Outlook 1999.

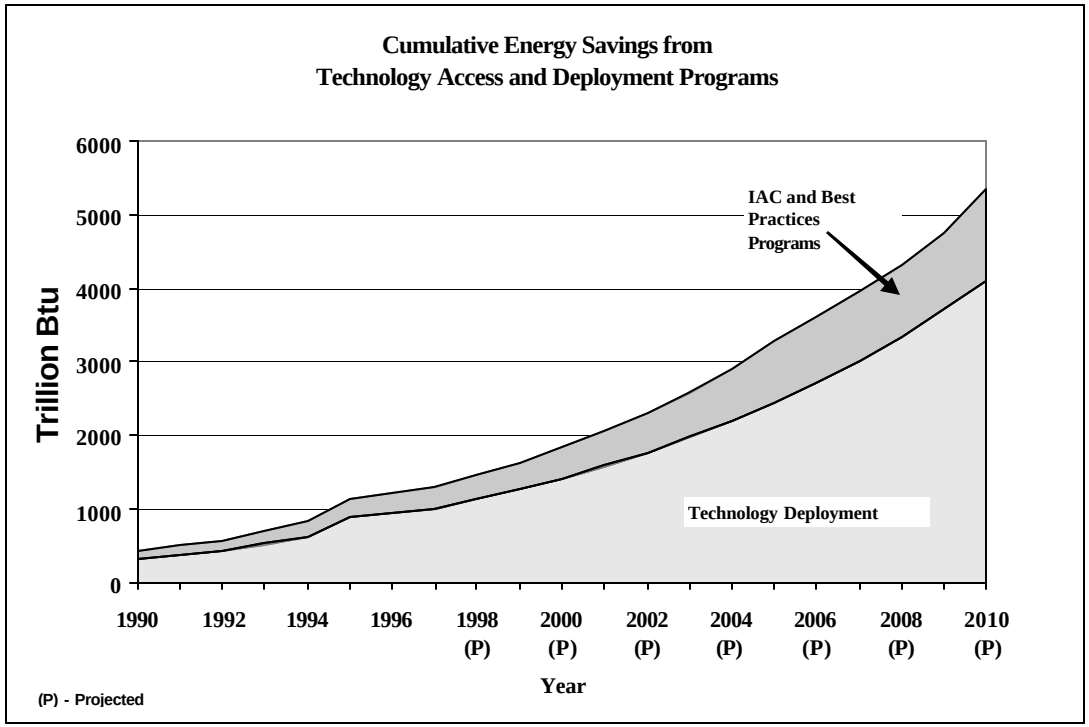
PROGRAM MISSION - INDUSTRY SECTOR (Cont'd)

<u>Measure</u>: BTUs of energy saved through deployment of OIT-sponsored technologies and programs

The industrial sector consumes approximately one-third of US primary energy (over 35 quads in 1997), for which it spends over $110 billion annually. The Office of Industrial Technologies works closely with industry to develop and commercialize technologies that lower energy consumption and thus save costs. OIT also provides access to technology information and assistance that helps industry save energy. Measure of success of such efforts include the amount of BTUs saved as a result of deployment of OIT-sponsored technologies (including those from the Industries of the Future (Specific) and the IOF (Crosscutting) programs such as Combustion Materials, Inventions and Innovations, NICE[3] and the Industrial Assessment Centers (IACs) and Best Practices (technology challenge) Programs.

<u>Goals</u>:

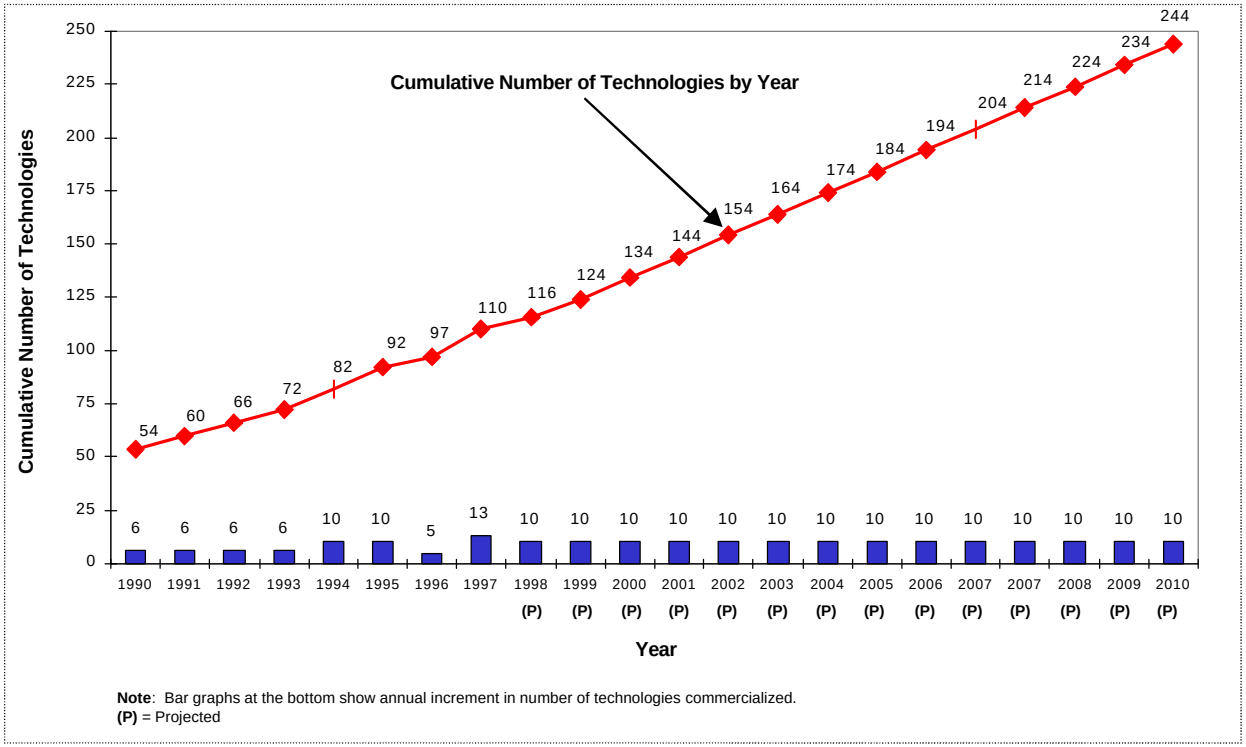
- *Save 170 trillion BTUs of energy in 2001, and 400 trillion BTU in 2010, through introduction of new OIT-sponsored technologies.*
- *Save an additional 90 trillion BTUs per year in 2001, and 210 trillion BTU in 2010, through Best Practices and IAC programs.*



In 1997, industry saved approximately 115.4 trillion Btu (approximately $430 million) through the use of OIT-sponsored technologies in industrial facilities. This represents an over 40% increase over the 1992 annual energy savings. In addition, industry saved over 61 trillion Btus (approximately $230 million) of energy as a result of OIT's IAC and Best Practices efforts involving information exchange and technical assistance. The targets for future years show a 10% per year increase in the annual energy savings, with a total increase over the four-year period (1998-2001) of 46%. Note the curve above shows cumulative energy savings over time (the sum of all past annual savings).

PROGRAM MISSION - INDUSTRY SECTOR (Cont'd)

Commercialized six technologies in 1998, eight technologies in 1999, and will commercialize ten technologies per year in the period 2000 through 2010.



The Office of Industrial Technologies works closely with industry to address technology needs aimed at increasing productivity, decreasing energy consumption and reducing pollution loads and costs. One measure of success of such a technology-development thrust is the number of technologies developed through OIT-sponsorship that have been successfully commercialized.

Commercial success depends first on technical success of the technology-development project and then on cost competitiveness and other market factors bearing on the ability of a new technology to penetrate the market. The target value for 1998 is based on average historical commercial success rates (on average over the last 10 years, approximately six new technologies have been introduced each year). The target for the 1999 period shows an annual increase to eight new technologies, and in 2000-2010 to a value of 10 commercial successes per year to reflect OIT's optimism about the potential of its "Industries of the Future" programs.

PROGRAM MISSION - INDUSTRY SECTOR (Cont'd)

OIT (Industries Overview) Office of Energy Efficiency and Renewable Energy Energy Efficiency Accomplishments through the Year 1999		
Metric	**1999 Benefits**	**Cumulative benefits through 1999**
Primary Energy Displaced (quads)	0.176 (projected for 1999) 0.148 (1997, estimated)	1.64 (projected for 1999) 1.30 (1997, estimated)
Energy Savings ($billions)	$0.87 billion (projected for 1999) $0.73 billion (1997, estimated)	4.39 (projected for 1999) 3.66 (1997, estimated)
Carbon Reduction (million metric tons)	3.2 MMTCE (projected for 1999) 2.7 MMTCE (1997, estimated)	29.5 (projected for 1999) 23.5 (1997, estimated)
Note: Not all benefits are captured. Productivity benefits to industry and benefits relating to waste minimization and the environment are considerably larger than the direct energy benefits. For the Industrial Assessment Centers (IAC) program alone, annual non-energy cost benefits are projected to be $228 million in 1999 (with a cumulative total of $1.7 billion through 1999).		

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ENERGY CONSERVATION
(Dollars in Thousands)

INDUSTRY SECTOR

PROGRAM FUNDING PROFILE

Activity	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Base	FY 2001 Request	Program Change Request vs. Base	
					Dollar	Percent
Industries of the Future (Specific) Operating Expenses	$56,447	$66,000	$66,000	$83,900	$17,900	27.1%
Industries of the Future (Crosscutting) Operating Expenses	$98,141	$94,400	$94,400	$90,826	$-3,574	-3.8%
Cooperative Programs with States Operating Expenses	$0	$2,000	$2,000	$0	$-2,000	-100.0%
Energy Efficiency Science Initiative Operating Expenses	$0	$3,900	$3,900	$0	$-3,900	-100.0%
Management and Planning Operating Expenses	$8,187	$8,900	$8,900	$9,300	$400	4.5%
TOTAL	$162,775	$175,200	$175,200	$184,026	$8,826	5.0%
Summary						
Operating Expenses	$162,775	$175,200	$175,200	$184,026	$8,826	5.0%
Total Program	$162,775[a]	$175,200	$175,200	$184,026	$8,826	5.0%
Staffing (FTE's)						
HQ FTEs	56	63	63	63		
Field FTEs	10	10	10	10		
Total FTEs	66	73	73	73		

[a]/ Reflects adjustment for approved reprogrammings 99-R-4 of $-2,607.0 thousand for the Small Business Innovative Research (SBIR) program and $-157.0 thousand for the Small Business Technology Transfer Pilot Program (STTR) activities, and $-320.0 thousand associated with the Administration and Travel rescission, P.L. 105-61.

PROGRAM FUNDING PROFILE - INDUSTRY SECTOR (Cont'd)

Authorizations:
P.L. 102-486, "Energy Policy Act of 1992"
P.L. 94-163, "Energy Policy and Conservation Act" (EPCA) (1975)
P.L. 94-385, "Energy Conservation and Production Act" (ECPA) (1976)
P.L. 95-91, "Department of Energy Organization Act" (1977)
P.L. 95-618, "Energy Tax Act of 1978"
P.L. 95-619, "National Energy Conservation Policy Act" (NECPA) (1978)
P.L. 95-620, "Powerplants and Industrial Fuel Use Act of 1978"
P.L. 96-294, "Energy Security Act" (1980)
P.L. 100-12, "National Appliance Energy Conservation Act of 1987"
P.L. 100-615, "Federal Energy Management Improvement Act of 1988"
P.L. 101-218, "Renewable Energy and Energy Efficiency Technology Competitiveness Act of 1989"
P.L. 101-549, "Clean Air Act Amendments of 1990"
P.L. 101-575, "Solar, Wind, Waste, and Geothermal Power Production Incentives Act of 1990"
P.L. 93-577, "Federal Non-nuclear Energy Research and Development Act of 1974"

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FUNDING DETAILS

Activity	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Base	FY 2001 Request	Program Change Request vs. Base	
					Dollar	Percent
Industries of the Future (Specific)						
Forest and Paper Products Vision	$11,753	$12,076	$12,076	$17,100	$5,024	41.6%
Steel Vision	$10,308	$10,627	$10,627	$10,900	$273	2.6%
Aluminum Vision	$7,925	$11,178	$11,178	$11,000	$-178	-1.6%
Metal Casting Vision	$5,675	$5,797	$5,797	$5,800	$3	0.1%
Glass Vision	$4,701	$4,830	$4,830	$4,800	$-30	-0.6%
Chemicals Vision	$12,123	$12,492	$12,492	$12,500	$8	0.1%
Petroleum Refining Vision	$0	$2,000	$2,000	$3,000	$1,000	50.0%
Mining Vision	$1,981	$3,000	$3,000	$4,000	$1,000	33.3%
Agriculture Vision	$1,981	$4,000	$4,000	$13,000	$9,000	225.0%
Supporting Industries	$0	$0	$0	$1,800	$1,800	>999%
Total, Industries of the Future (Specific)	$56,447	$66,000	$66,000	$83,900	$17,900	27.1%

INDUSTRY SECTOR - FUNDING DETAILS (Cont'd)

Activity	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Base	FY 2001 Request	Program Change Request vs. Base	
					Dollar	Percent
Industries of the Future (Crosscutting)						
Enabling Technologies	$18,881	$36,000	$36,000	$35,726	$-274	-0.8%
Distributed Generation	$50,103	$27,300	$27,300	$17,300	$-10,000	-36.6%
Financial Assistance	$10,512	$11,350	$11,350	$12,000	$650	5.7%
Technical Assistance	$18,645	$19,750	$19,750	$25,800	$6,050	30.6%
Total, Industries of the Future (Crosscutting)	$98,141	$94,400	$94,400	$90,826	$-3,574	-3.8%
Cooperative Programs with States	$0	$2,000	$2,000	$0	$-2,000	-100.0%
Energy Efficiency Science Initiative	$0	$3,900	$3,900	$0	$-3,900	-100.0%
Management and Planning						
Evaluation and Planning	$628	$1,090	$1,090	$700	$-390	-35.8%
Program Direction	$7,559	$7,810	$7,810	$8,600	$790	10.1%
	$8,187	$8,900	$8,900	$9,300	$400	4.5%
TOTAL	$162,775[a]	$175,200	$175,200	$184,026	$8,826	5.0%

[a]/ Reflects adjustment for approved reprogrammings 99-R-4 of $-2,607.0 thousand for the Small Business Innovative Research (SBIR) program and $-157.0 thousand for the Small Business Technology Transfer Pilot Program (STTR) activities, and $-320.0 thousand associated with the Administration and Travel rescission, P.L. 105-61.

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INDUSTRY SECTOR

SUMMARY OF CHANGES

	FY 2001 Request
FY 2000 Enacted	$ 175,200
S Non-Discretionary	0
FY 2001 Base	$ 175,200
Industries of the Future (Specific)	
S Forest and Paper Products Vision - The increase will support the relevant portions of the EERE Bioenergy/Bioproducts Initiative (energy performance and sustainable forestry).	5,024
S Steel Vision - The increase will maintain support for the steel technology roadmap process and novel concept efforts.	273
S Aluminum Vision - The reduction will mildly impact projects in support of the primary sector of the aluminum technology roadmap.	-178
S Metal Casting Vision - The increase will support enhanced efforts in the manufacturing technologies area..	3
S Glass Vision - The decrease will slightly impact support for the technology roadmap assessments.	-30
S Chemicals Vision - The increase will continue FY 2000 efforts.	8
S Petroleum Industry Vision - The increase will fund high priority Petroleum Vision and roadmap activities.	1,000
S Mining Vision - The increase will allow initiation of activities in the mining technology roadmap.	1,000

SUMMARY OF CHANGES - INDUSTRY SECTOR (Cont'd)

S Agriculture Vision - The increase will fund projects in support of industry's strategic visions such as those in biobased industrial feedstocks and the EERE Bioenergy/Bioproducts Initiative.	9,000
S Supporting Industries - Provides technology development support to industries that provide critical support to the IOF industries.	1,800
Industries of the Future (Crosscutting)	
S Enabling Technologies - The decrease will have a mild impact on Enabling Technologies to support industrial gasification activities..	-274
S Distributed Generation - The decrease is part of the planned successful completion of the ATS Program. Energy technologies for industrial power R&D will be continued.	-10,000
S Financial Assistance - The increase provides for expanded financial assistance to energy efficient technologies.	650
S Technical Assistance - The increase will be used to implement integrated delivery through plant showcases; and motor, steam, compressed air, and combined heat and power programs. These will provide technical assistance and information to 3000 of the most energy-intensive industrial facilities and will establish working partnerships with 100 Industry of the Future plant sites. International, a new program conducted in cooperation with U.S. industry, U.S. non-government and international in-country entities to implement best practice programs and facilitate joint ventures that will create economic and environmental benefits for both the U.S. and the host country	6,050
Cooperative Programs with States - No funding for this activity was requested in FY 2001.	-2,000
Energy Efficiency Science Initiative - No funding for this activity was requested in FY 2001.	-3,900
Management and Planning	
S Evaluation and Planning - The reduction will impact lower priority Evaluation and Planning activities.	-390
S Program Direction - The increase will support on-board and additional FTEs.	790
FY 2001 Congressional Budget Request.	$ 184,026

INDUSTRIAL TECHNOLOGIES
INDUSTRY SECTOR
(Dollars in Thousands)

INDUSTRIES OF THE FUTURE (SPECIFIC)

I. Mission Supporting Goals and Objectives:

I. A. Program Strategy

OIT's Industry of the Future (IOF) strategy aligns its resources with its principal customers -- the energy- and waste-intensive industries which have developed industry-wide visions and roadmaps on improving their energy and environmental performance. These industries: steel, aluminum, glass, metalcasting, forest products, chemicals, petroleum, agriculture, and mining account for roughly three-quarters of all U.S. industrial energy use and for 75% to 90% of manufacturing wastes for most waste streams.

The Industries of the Future strategy provides the catalyst for tapping into America's vast capabilities in R&D for the development and deployment of advanced energy and material efficient technologies. The program fosters synergism among different DOE organizations and other government agencies. IOF focuses R&D on technologies that are responsive to the needs of each industry and provides benefits at a national level.

The IOF process begins with the development of an industry-wide vision which projects what changes need to be instituted over the next 20 to 25 years for the industry to remain competitive through improved energy efficiency and environmental performance. Technology roadmaps are then prepared to define the technologies which must be pursued for this change to occur. OIT works with industry partners to implement the roadmaps.

Many promising fundamental improvements in the energy, waste, and capital-intensive industries are simply too expensive and too risky for individual private firms to pursue alone. OIT acts as a catalyst in drawing together many firms with national laboratories and other interested parties in order to pool risk, investment, and know-how in developing these promising technologies. The Industries of the Future strategy makes government more responsive and effective. The strategy facilitates integrated planning and implementation by all participants. It fosters cooperative planning among different DOE organizations and other government agencies. Finally, it results in R&D focused on technologies that are responsive to the unique challenges each industry faces. Industry partners have emphasized that the Federal participation has acted as a catalyst in the process especially by lending an objective influence, adding credibility, and fostering cooperation between firms in an industry.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

OIT executes the R&D defined by the roadmaps through competitive solicitations which culminate in cooperative agreements with industrial partners, CRADA's with National Laboratories, and grants with state organizations and universities.

In FY 2001, OIT will spend about $1,340,000 on specific state projects through the State Energy Program Special Project State Grants solicitation, which is a collaborative effort with the Office of Building Technology, State and Community programs. These activities are directed toward developing partnerships between states, energy-intensive industries in those states and the Federal government in order to implement Industries of the Future at the state level. In FY 1998, grants to 20 states focused on implementing Industries of the Future in specific states taking a variety of approaches appropriate to state needs, state industries and available resources. In FY 1999, a solicitation was issued for follow-on or new projects, with 27 grants awarded to states to increase the involvement of states and their industries in implementing Industries of the Future visions and roadmaps, and deploying advanced technologies.

I. B. Program Benefits

Forest Products, Steel, Aluminum, Metal Casting, Glass, Chemicals, Petroleum, Agriculture and Mining Visions.

The Industries of the Future (Specific) current portfolio is expected to directly improve energy efficiency by over 3.0 quadrillion Btu by 2020 and reduce carbon emissions by more than 50 million tons or more. This would be far more than enough to fully operate the entire U.S. iron and steel industry, which consists of about 250 steel mills and blast furnaces, for one year. They annually produce about 100 million tons of steel. In addition, productivity will be improved in the industrial sector, thereby maintaining a strong U.S. industrial base and competitiveness in the global arena.

The industries which are participants in IOF visions and roadmaps account for a value in shipments of approximately one trillion dollars, and total direct employment of 3 million. An additional 12 million jobs are supported through supplier industries. They expend over $40 billion in capital per year. The estimated benefits include those realized directly by the process industries and those from the commercialization of the developed technologies and products used in the end use sector. The estimates are:

Industries of the Future (Industry Specific)			
	2005	**2010**	**2020**
Total Primary Energy Displaced (Quads)	.35	.86	3.45
Total Energy Cost Savings (Billion $)	1.17	3.07	13.07
Total Carbon Reduction (Million Metric Tons)	5.68	15.02	65.20

* These metrics include the bio-gasification activities.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

I. C. Performance Measures

OIT (IOF Industry Specific) Office of Energy Efficiency and Renewable Energy Energy Efficiency Accomplishments through the Year 1999		
Metric	**1999 Benefits**	**Cumulative Benefits through 1999**
Primary Energy Displaced (quads)	0.022 (projected for 1999) 0.018 (1997, estimated)	0.176 (projected for 1999) 0.136 (1997, estimated)
Energy Savings ($ billions)	$0.12 billion (projected for 1999) $0.10 billion (1997, estimated)	$0.33 billion (projected for 1999) $0.29 billion (1997, estimated)
Carbon Reduction (million metric tons)	0.56 MMTCE (projected for 1999) 0.46 MMTCE (1997, estimated)	4.1 MMTCE (projected for 1999) 3.3 MMTCE (1997, estimated)
Note: Not all benefits are captured. Productivity benefits to industry and benefits relating to waste minimization and the environment are considerably larger than the direct energy benefits.		

<u>Pre-FY 1999 Accomplishments</u>

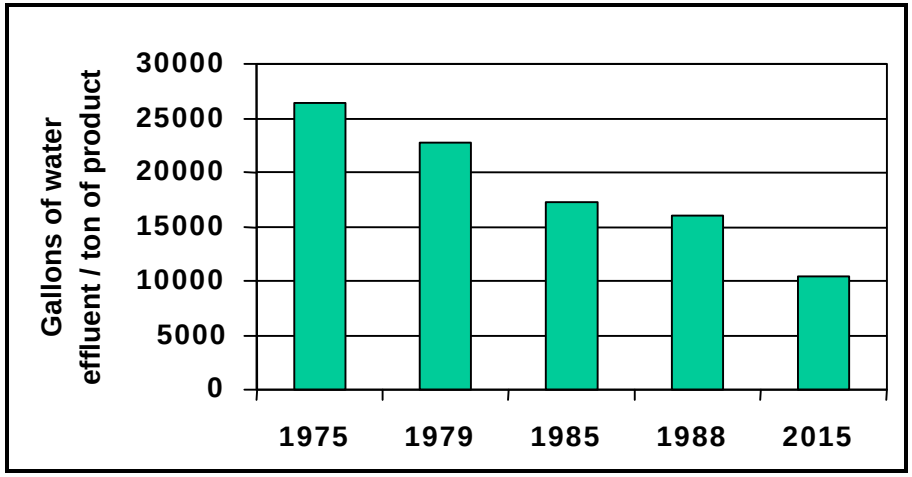
Visions of the Future were completed with the Forest Products, Steel, Aluminum, Metalcasting, Glass, Chemicals, Petroleum, Mining and Agriculture Industries. These partnerships between government and industry were signed by the Secretary of Energy and representatives of the industries. Technology roadmaps were initiated for each of the industries that have completed their visions.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

FOREST & PAPER PRODUCTS INDUSTRY VISION

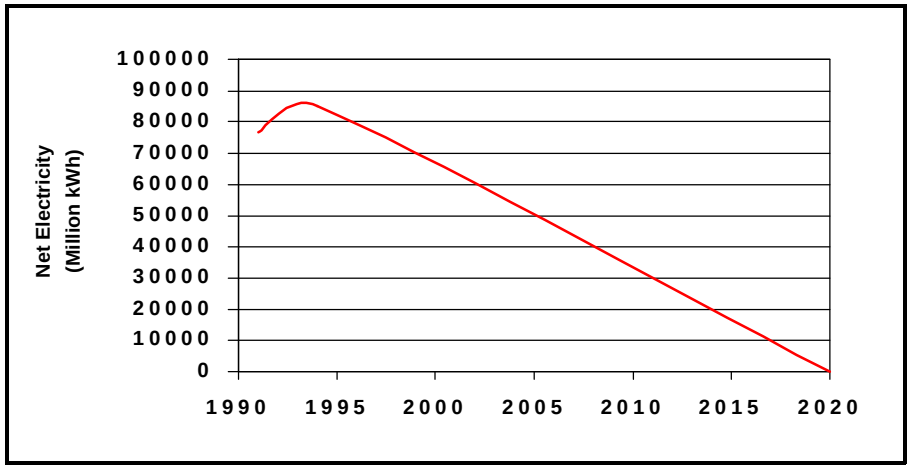
MEASURE

The benefits to the nation from aligning the forest and paper activities with the industry vision include reduced net purchased electricity to zero by 2020, reduced water effluent by 35% by 2010, increased recovered paper utilization rate to 50% by 2010, reduced capital requirements per unit of product, and improved fiber yield and increased fiber growth rates in managed forests. Twenty universities, 11 national laboratories, 10 suppliers, two research institutes and over 30 forest and paper companies are partnering with the DOE to implement the industry vision.



Reduce unit water effluent levels by 35% from 1991 levels.

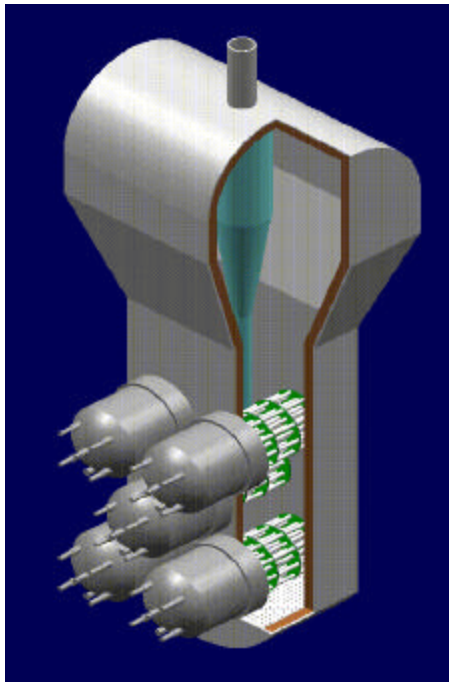
The papermaking process uses large quantities of water, as much as 40,000 gallons/ton of pulp in an older kraft mill and about 10,000 gallons/ton of finished product in a typical newsprint mill. Average water effluent is about 16,000 gallons per ton of product. The industry is pursuing methods to reduce water usage and effluents by developing closed cycle water systems and/or systems that utilize less water. Closed bleaching systems are an important part of this research since the bleaching process is a large water consumer and also introduces pollutants into the water stream. Benefits will include reduced water pollution and lower energy consumption due to reduced water treatment needs.



Reduce net purchased electricity (electricity purchased - electricity sold) in the forest products industry to zero in 2020 from over 80 thousand million kilowatt-hours purchased in 1994.

As the pulp and paper industry has upgraded its manufacturing equipment to achieve greater efficiency and improve the quality of its

I. **Mission Supporting Goals and Objectives**: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)



Pulse Enhanced Steam Reformer

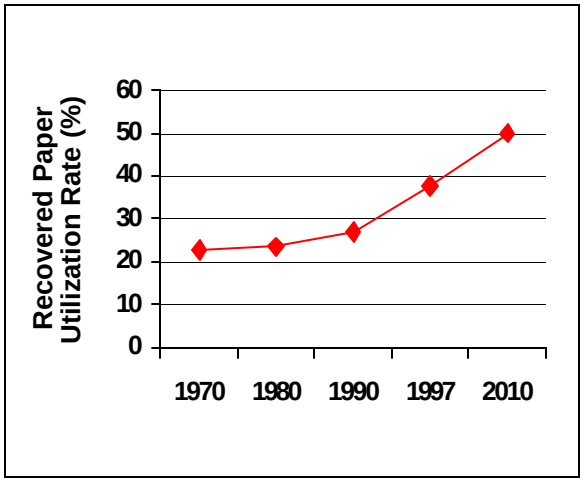
products, energy use has shifted towards electric power. Modern paper machines use 1.5 to 2 times as much electricity as older machines. The forest products industry ranks as the second largest consumer of electric power in the manufacturing sector, behind only chemicals. The industry is pursuing biomass and black liquor combined cycle gasification technologies to make more efficient use of the renewable energy resource base that is readily available to the industry in the form of wood and bark residues and spent pulping liquor. Integrated gasification combined cycle (IGCC) has the potential to improve electricity generation by 300-400% over existing cogeneration systems. Assuming the industry's ability to invest in new equipment, the benefits would include a savings of approximately 1.2 quads of fossil fuel energy use and 31 million metric tons of carbon in the year 2020.

Power Generation Efficiency: 1,500 tpd Integrated Kraft Mill	
Baseline	**Projected (2020)**
Tomlinson recovery boiler, combination boiler and steam turbine generator	Biomass and black liquor gasification system in IGCC configuration
70MW	300MW

Market Performance			
	2010	**2015**	**2020**
Number of units installed	10	31	75

Increase recovered paper utilization rate to 50% by 2010 from 38% in 1998.

As a supplement to the forest resource base, recycled paper and wood products will play an increasingly larger role in meeting the industry's need for raw material. Currently, recycled fiber makes up about 38% of paper and board production in U.S. mills. A drawback to recycling is that recycling processes are typically net energy consumers, whether added to an existing mill or as stand-alone enterprises. Although it requires less total energy to manufacture a ton of de-inked pulp than a ton of virgin pulp, the de-inked pulp process does not produce reusable byproducts and creates a sludge that is not easily dewatered and burned. Therefore, while recycling makes efficient use of materials, it is heavily reliant on fossil fuel. Research aimed at improving the energy efficiency and the fiber separation and recovery process are key to expanding the manufacture of recycled paper and wood products.



I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

FY 1999 Accomplishments

- The Forest Products industry partnered with DOE to initiate 18 new projects in support of Agenda 2020, including a biogasification engineering study, and completed 26 projects with 5 projects identified as near term technical successes. The forest products industry issued a revised roadmap, "Agenda 2020, The Path Forward: An Implementation Plan."

FY 2000 Planned Accomplishments

- The Forest Products industry will sign a new compact with the DOE. In addition, 24 new projects were initiated in support of Agenda 2020, with plans to complete 9 projects and identify 5 projects as near term technical successes.

FY 2001 Planned Accomplishments

- The forest products industry will demonstrate a retrofit technology that has the potential to increase the thermal efficiency of biomass, wood waste and sludge boilers by 2%, while reducing natural gas auxiliary fuel by 25% and air emissions of nitrogen oxides, volatile organic chemicals and carbon monoxide by 50%.

- The forest products industry will partner with the DOE to initiate approximately 20 new research and development projects in support of Agenda 2020. Several near term technical successes will be identified.

FY 2002 - 2005 Planned Accomplishments

- The Forest Products industry will partner with DOE to initiate 20 new projects annually in support of Agenda 2020 and complete 20 projects annually. Each year, near term technical successes will also be identified.

- Technologies to reduce Volatile Organic Compounds will also be in use in paper mills and lumber drying facilities. Innovative energy efficient paper making processes will be available.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

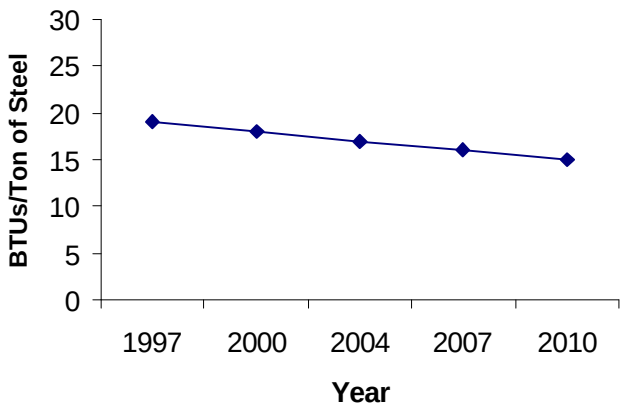
STEEL INDUSTRY VISION

MEASURE

The steel industry will produce better product with overall energy use of 15 million Btu per ton in 2010, representing a 19% reduction from the 1997 level of 18.5 million Btu per ton.

Program efforts include projects to reduce energy use and raise industry productivity through:

- Increased use of net shape casting processes,
- Improved sensing and controls of the major energy intensive unit processes,
- Increased use of iron- and steelmaking byproducts to reduce use of virgin raw materials.



Reductions in energy use assumes that dumping by foreign producers will decrease significantly and the domestic industry will be able to reestablish reasonable profit margins that will enable them to invest in new technology. Also assumes that future environmental regulations will not significantly limit the recycling of iron unit byproducts. The availability of iron from alternate sources is expected to increase the participation of electric arc furnace from 45% in 1997 to 55% in 2010.

Lower carbon dioxide and NOx emissions will be achieved through:

- Improved burners and burner controls.

Continuing efforts are planned to work with the iron and steel industry on the development of performance measures and data sources.

FY 1999 Accomplishments

- The Steel industry signed a new R&D compact with the DOE. In collaboration with the American Iron and Steel Institute, six new R&D projects were initiated to address critical R&D needs.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

- A second generation galvanneal temperature sensor was tested at a steel plant, while the remainder of the Advanced Process Control projects have been completed and final phase of field testing initiated.

<u>FY 2000 Planned Accomplishments</u>

- The Steel industry has developed residual element removal methods for the steel ladle and inclusion removal methods for the tundish will be enhanced. The Steel industry initiated three new projects in support of the Steel Industry Technology Roadmap. Technology for hot oxygen injection into the blast furnace has been tested.

- The Steel Industry will initiate revision of the Steel Technology Roadmap.

<u>FY 2001 Planned Accomplishments</u>

- Development of submerged entry nozzles that resist clogging will be completed.

- The Steel Industry will complete the revision of the Steel Technology Roadmap.

<u>FY 2002 - FY 2005 Planned Accomplishments</u>

- Testing of centrifugally cast nickel aluminide transfer rolls will be completed and rolls will be commercialized. Two different burner designs using methods of lowering NOx by up to 75% and energy use by up to 50% will be commercialized.

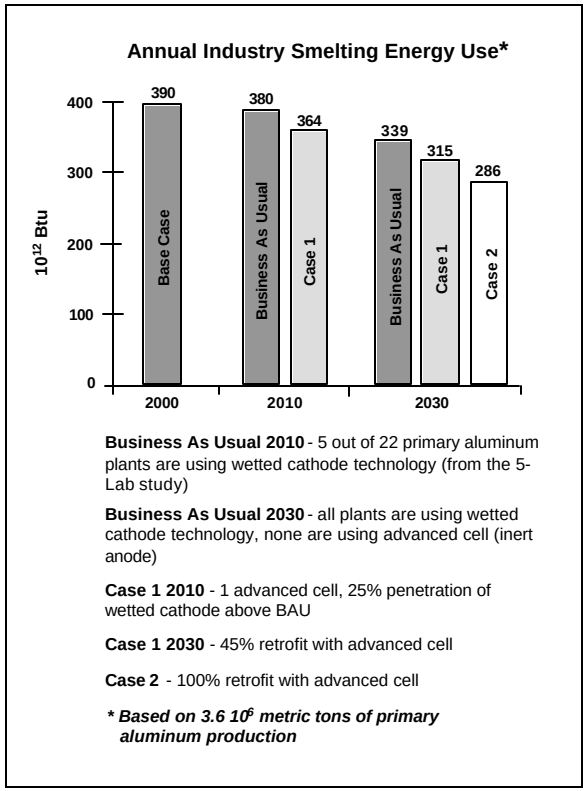
I. **Mission Supporting Goals and Objectives**: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

ALUMINUM INDUSTRY VISION

MEASURE

Reduce unit energy consumption by 27% by 2010 from current best practice.

The production of primary aluminum in conventional electrolytic cells is very electricity-intensive and produces significant emissions of greenhouse gases. The industry has been pursuing the development of inert (or non-consumable) anode systems and wettable cathode systems, technologies that could complement current methods of aluminum production and help resolve these energy and environmental challenges. A unit energy consumption reduction of up to 27% per unit of output is possible in plants installing the new advanced cell technology (including both wettable cathodes and inert anodes).



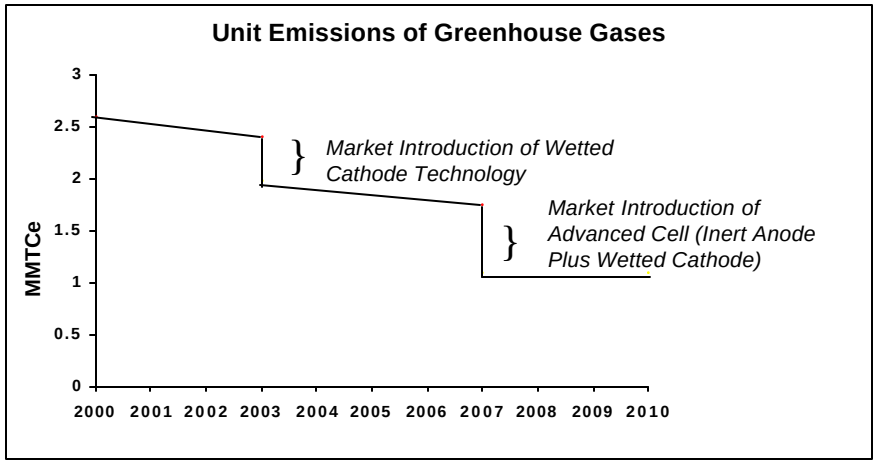
Electricity Use (kWh/kg of Al)	
Baseline	**Projected (2010)**
13.0 (best practice in 2000)	11.0

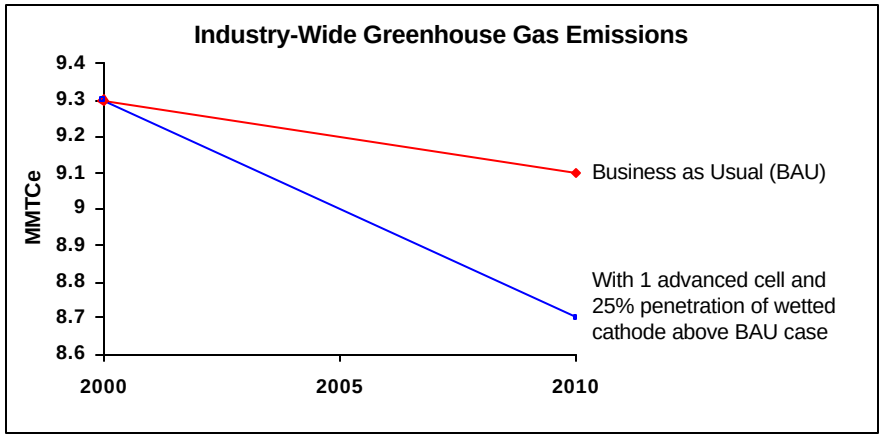
Market Performance		
Measure	**Baseline (2000)**	**Projected**
Wettable Cathodes Installed	None	One by 2003
Inert Anodes Installed	None	One by 2005
Advanced Cells (Anode and Cathode Installed)	None	One by 2010 45% total U.S. capacity retrofit by 2030

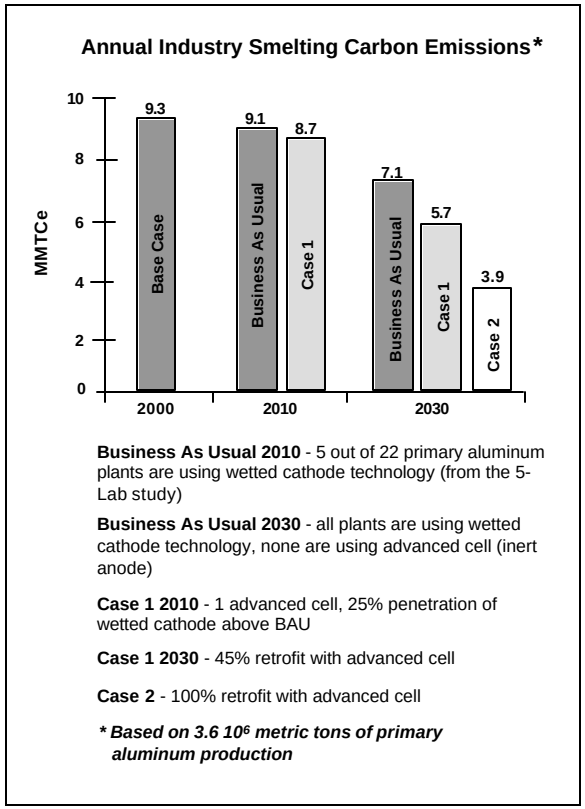
I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Reduce unit emissions of greenhouse gases 58% by 2010 from the 2000 baseline.

The aluminum industry is continually improving its energy and environmental performance. The combustion related CO_2 emissions associated with smelting are directly proportional to electricity use and have therefore dropped accordingly. However, changes to date have been based on incremental improvements to existing technology rather than revolutionary breakthroughs. Potential reductions in unit emissions of greenhouse gases (including combustion and process related CO_2 as well as perfluorocarbon (PFC) emissions) of up to 67% could be realized by plants adopting advanced cell technology. The DOE Aluminum program is being leveraged by the EPA Voluntary Aluminum Industrial Partnership (VAIP). The goal of this partnership, which represents 94% of U.S. production capacity, is to reduce PFC emissions by 45% from 1990 levels by the end of year 2000.



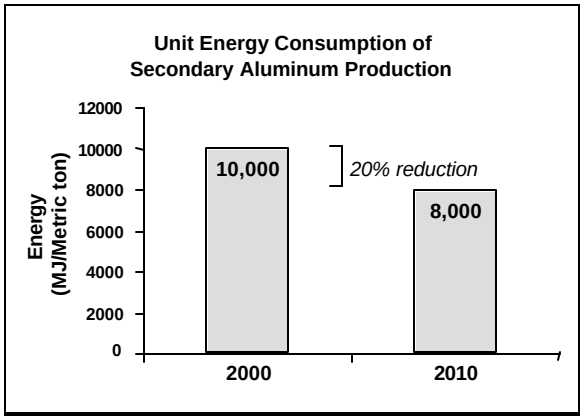


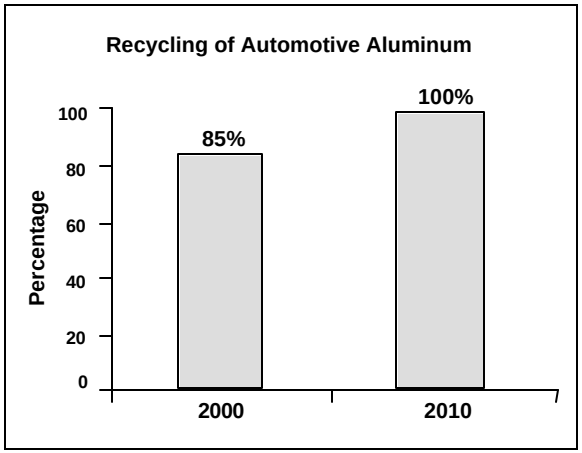


I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Reduce unit energy consumption of secondary aluminum production by 20% by 2010 and increase recycling of automotive aluminum to 100% by 2010 from current levels of 85%.

The production of secondary aluminum from recycled scrap requires only 6% of the energy of primary aluminum production. Accordingly, the energy efficiency and environmental performance of the industry as a whole will continue to improve as the extent of recycling increases.





Aluminum Melting Energy Use (million Btu/ton secondary Al)	
Baseline (2000)	**Projected (2010)**
10.0	8.0

Market Performance		
Measure	**Baseline (2000)**	**Projected**
New Melting Technology Installed	None	One unit each by 2003 of improved grain refiner, new impurity detection system, O_2-enhanced melter, vertical flotation melter

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

FY 1999 Accomplishments

- The Aluminum industry conducted initial tests on new materials and connectors for inert anodes and wettable cathodes. Pilot scale vitrification tests to produce glass fiber from spent aluminum potliners were completed and a commercial-scale, high-efficiency, low NOx combustion system for aluminum scrap pre-melting was demonstrated.

FY 2000 Planned Accomplishments

- The Aluminum industry will develop improved anode and cathode materials for inert anode technology. Two different novel cell designs and electrode materials combinations will be investigated through long term pilot scale tests. In addition, pilot scale tests of a wettable cathode will be performed. Pilot scale tests of a vertical floatation melter and scrap dryer will be completed and full-scale tests at a commercial host site will be initiated.

FY 2001 Planned Accomplishments

- The Aluminum industry will conduct bench and pilot tests for optimum cell materials and conditions for use with inert anode technology.

- The Aluminum industry will continue accelerated R&D on advanced cell development based on most promising designs and anode/cathode materials identified in previous work. Pilot-scale tests of an electrodialysis process for recovery of saltcake constituents will be completed and an industrial commercial scale demonstration of the process will be initiated.

FY 2002 - 2005 Planned Accomplishments

- Commercial scale tests of inert anode/wettable cathode technology will be conducted.

- An integrated pilot line for aluminum scrap sorting will be designed.

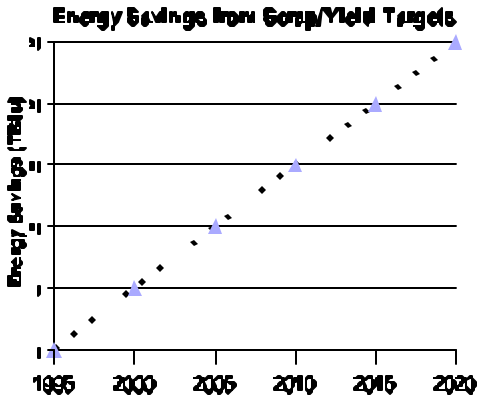
- A novel grain refiner system, which introduces trace elements into a melt for controlling grain structure and alloy properties, will be tested at commercial scale.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

METAL CASTING INDUSTRY VISION

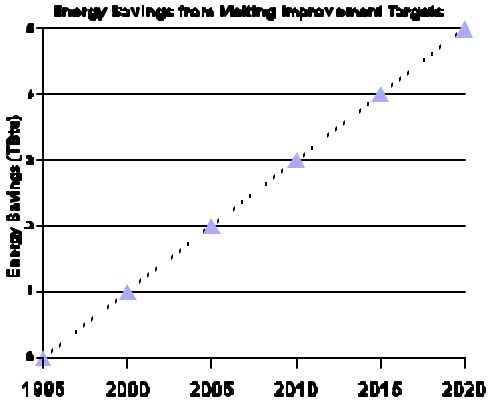
MEASURE

Assist metal casting industry to achieve 10% combined yield increases and scrap reduction by 2020 which will also result in a 10% (0.025 quad) energy savings by 2020 relative to 1995.



The metal casting industry's annual energy use is estimated at 250 TBtu. Approximately 55 percent of energy costs are for melting. Other energy intensive operations include molding and heat treating. The metal casting industry has established as a goal to reduce energy consumption 20% by 2020. To help achieve this goal, the OIT Metal Casting Program is co-funding research to improve energy efficiency in metal casting processes and reduce associated emissions per unit of casting produced. It is funding research in industry defined areas for manufacturing technologies, materials technologies, products and markets, and environmental technologies.

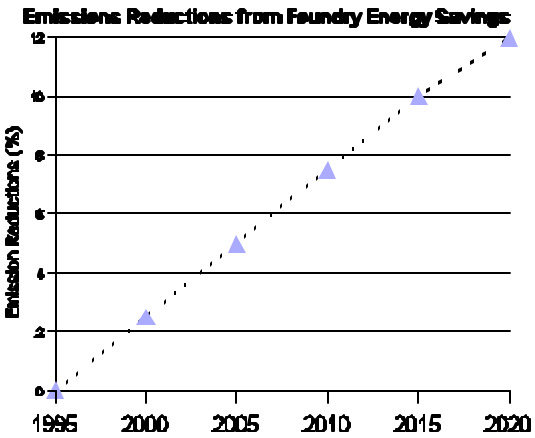
Achieve an estimated 2%(0.005 quad) energy savings industry-wide by 2020 relative to 1995 through program supported research to improve melting efficiency.



Melting accounts for approximately 55% of process energy costs. Among the various types of melting equipment, Cupola Furnaces handle 55% melting capacity for the whole industry. Research into technologies such as an expert control system for the cupola and other efficient melting practices will help to increase energy efficiency in melting.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Achieve a 12% reduction in emissions by 2020 relative to 1995.



The energy savings through yield improvement/scrap reduction and improved melting efficiency will also result in emission reductions.

<u>FY 1999 Accomplishments</u>

- In the Metalcasting industry, a Metalcasting Energy Technology Showcase demonstration was held in Birmingham featuring the benefits of Lost Foam Casting. Lost Foam Casting replicates steel patterns while generating less waste products, improving energy efficiency, and lower costs. Over 200 representatives from lost foam industry suppliers, foundries, and end-users participated. In addition, two technologies developed under the DOE research program, were disseminated to the U.S. Metalcasting Industry: The first technology is a new and unconventional technique for metal pouring using ceramic shrouds developed from the Clean Steel Technology research at the University of Alabama - Birmingham. Plant trials performed at participating foundries demonstrated the benefits of 96% reduction of surface inclusion and improved machinability of casting. The second technology disseminated is CastView, a new computer modeling tool developed for die casting simulation. This visualization tool allows for the evaluation of candidate die cavity gate, vent and overflow locations by showing their impact on die filling behavior. This tool will assist in reducing die try-out iterations, thereby reducing development lead times and scrap associated with die try-outs. The tool will lead to better running dies, increased productivity and reduced production scrap rates. The impact on lead-time and scrap reduction is anticipated to be on the order of 30-50%, each.

<u>FY 2000 Planned Accomplishments</u>

- In Metalcasting, an advanced Neural Network Model for Cupola Process Control will be commercially available to the metalcasting industry. This DOE funded research will lead to lower material and processing costs and has the potential to save 400 million Btus per year, per unit as well as reduce carbon dioxide emission due to decreased coke requirements.

<u>FY 2001 Planned Accomplishments</u>

- A manual developed for un-conventional yield improvement techniques will be transferred to industry for steel casting. Just a 10% increase in yield has the potential benefits of energy savings of 1.8 trillion Btus per year from melting alone.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

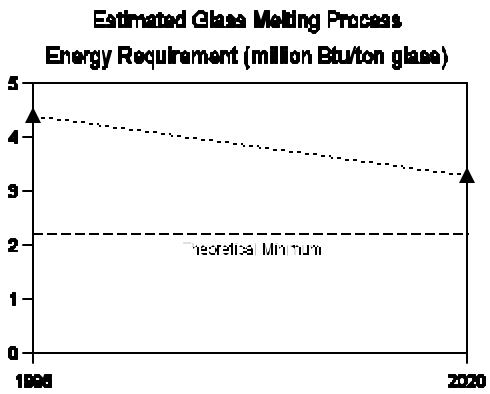
FY 2002 - 2005 Planned Accomplishments

- In Metalcasting, new Lost Foam Casting techniques and binders developed for iron and steel castings will be available. Successful development and application of Advanced Lost Foam Technology to iron and steel castings alone will have a potential energy efficiency improvement of up to 30% over conventional casting methods, reducing cost by 25%, and eliminating binder emission associated with traditional sand casting methods for steel casting.

GLASS INDUSTRY VISION

MEASURE

Reduce the gap between process energy use and theoretical minimum energy use by 50 percent by the year 2020.



To meet future challenges, the glass industry (including flat glass, container glass, fiberglass, and specialty glass) must enlarge the application of its technology and expand its usefulness to society through improvements in energy efficiency and other innovations.

Performance measures shown here are those set by the glass industry through their glass industry vision and road-mapping efforts. Projects supported by OIT will work towards these goals, but are not the only efforts being expended to meet these goals.

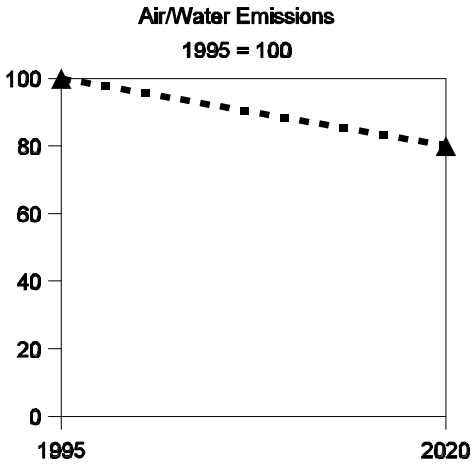
In theory, approximately 2.2 million Btu are required to melt a ton of glass; however, in reality, it takes about 4.4 million Btu—twice the theoretical amount—due to inefficiencies and losses. While melting/refining is the most energy-intensive of the glassmaking process steps, significant amounts of energy are also used in other process steps. Annual energy use in the glass industry is approximately 250 trillion Btu.

Each year, the glass industry spends over $1.3 billion on the energy used in its manufacturing processes. Depending on the type of glass being manufactured, energy costs account for over 10 percent of total production costs. The development of more energy-efficient manufacturing technologies will achieve significant energy savings and help the competitive position of glass in the marketplace.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Reduce production costs by 20 percent below 1995 levels by the year 2020.

An imposing barrier for the glass industry in general is the high capital investments and operating costs to produce glass products. Competitive pressures, both from overseas producers and other materials, are causing price erosion in most glass products. In order for segments of the industry to receive acceptable returns on both long and short term investments, production costs need to be reduced. Improvements in technology are one avenue to decreased production costs. Baseline is measured in dollars/ton of glass produced. Amount varies according to type of glass produced. Baseline data is currently being developed. Current assumption is that 55% of production cost is from materials, 30% from labor, and 15% from energy.



Reduce air and water emissions by a minimum of 20 percent below 1994 levels by the year 2020.

The glass industry has modified its processes and equipment over time to comply with increased government regulations on the emissions of NOx, SOx, and particulates. These changes have increased operating costs and reduced capital available for other improvements. In 1994, the glass industry expended $71 million for capital and $214 million for operations on pollution abatement. Technology that would eliminate the need for additional equipment for pollution control would be extremely beneficial to the glass industry. Baseline is measured in dollars for pollution abatement/ton of glass produced, or pollutants/ton of glass. Amount varies according to type of glass produced. Data is not available for all glass segments, and is currently being developed.

Recycle 100 percent of in-process production wastes and recover and recycle 100 percent of available post-consumer glass where consumption is greater than 5 lb/capita by 2020 from the current 40% level.

The use of recycled glass in the glass manufacturing process reduces both energy use and production costs. Less than 40 percent of glass containers are currently recycled. The development of cost-effective technology that will enable increased post-consumer glass recycling would be beneficial to the industry. Increased emphasis on wise use of natural resources and reduction in solid waste landfilled will also benefit society. Flat glass-makers use 15-30% cullet. Fiberglass companies use 10-40% recycled glass.
Glass containers are assumed to represent about 5.5% of all packaging in the municipal waste stream.

<u>FY 1999 Accomplishments</u>

- The Glass industry will conduct a competitive solicitation for awarding new research projects to the National Laboratories.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

- The Glass industry will improve combustion efficiency and emission reductions by developing a robust sensor for measuring exhaust gases, identifying new sensing techniques for in-process measurement of emissions, and developing refractory models to determine life and defect generation.

<u>FY 2000 Planned Accomplishments</u>

- The Industry Vision *Glass: A Clear Vision for a Bright Future* will be re-visited and updated, and a competitive program solicitation, comprising 8 to 12 projects, and two major technology workshops will be conducted.

<u>FY 2001 Planned Accomplishments</u>

- The Glass industry will initiate roughly 16 new technologies, including work on high temperature sensors for measuring flow temperature and gas composition, predictive emission modeling tools, refractories for melting systems, and low-cost high temperature refractory metals.

- The Glass industry will adopt several new technologies that impact the quality and efficiency of glass making, including high temperature sensors for measuring flow temperature and gas composition, and use of microwaves for controlling glass shape and other critical process variables.

<u>FY 2002 - 2005 Planned Accomplishments</u>

- Over this period, the Glass Industry will incorporate roughly 10 new technologies that greatly impact energy efficiency and environmental performance. These include refractories for melting systems, low-cost high temperature refractory metals, and predictive tools for emissions modeling.

<u>CHEMICAL INDUSTRY VISION</u>

<u>MEASURE</u>

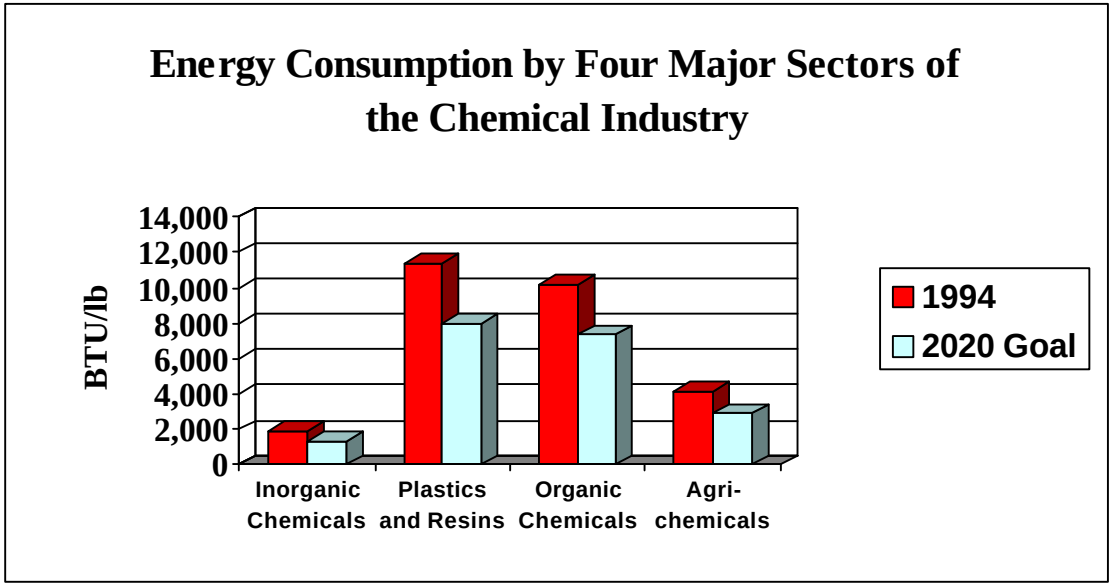
Technology Vision 2020 established several challenges to achieve an energy efficient and sustainable chemical industry by the year 2020. These challenges include: breakthroughs in R&D, development of innovative process technologies, excellence in manufacturing operations, efficient use of energy and raw materials, and investments in technology to promote sustainable development. Through the development of technology roadmaps (e.g., separations, computational fluid dynamics, materials of construction, computational chemistry, et al), the industry established a goal of a 30% reduction in energy consumption, material waste, water use, pollutants, and toxics dispersed per pound of chemicals produced

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

by the year 2020. Currently twenty universities, five industry organizations, three state and federal agencies, eight national laboratories, nineteen suppliers and software developers, and forty-five chemical companies are partnering with DOE to implement *Technology Vision 2020*.

Achieve a 30% reduction in energy consumption per pound of chemicals produced from 1997 levels by 2020.

The chemical industry is the second largest industrial energy consumer (6.3 quads in 1997). Approximately half of the energy consumed by the industry is used as feedstocks, while the other half is used as process energy (heat and power). The chemical industry has established a goal of reducing by 30 % the energy consumed per pound of product by 2020. The OIT Chemicals Industry of the Future is co-funding research with industry to achieve this goal. Current OIT-industry research includes the development of dramatically new techniques that will increase energy efficiency. These new technologies include: new reactors for the chlor-alkali industry, new processes for the production of ethylene, and new separations techniques that increase per pass separations.



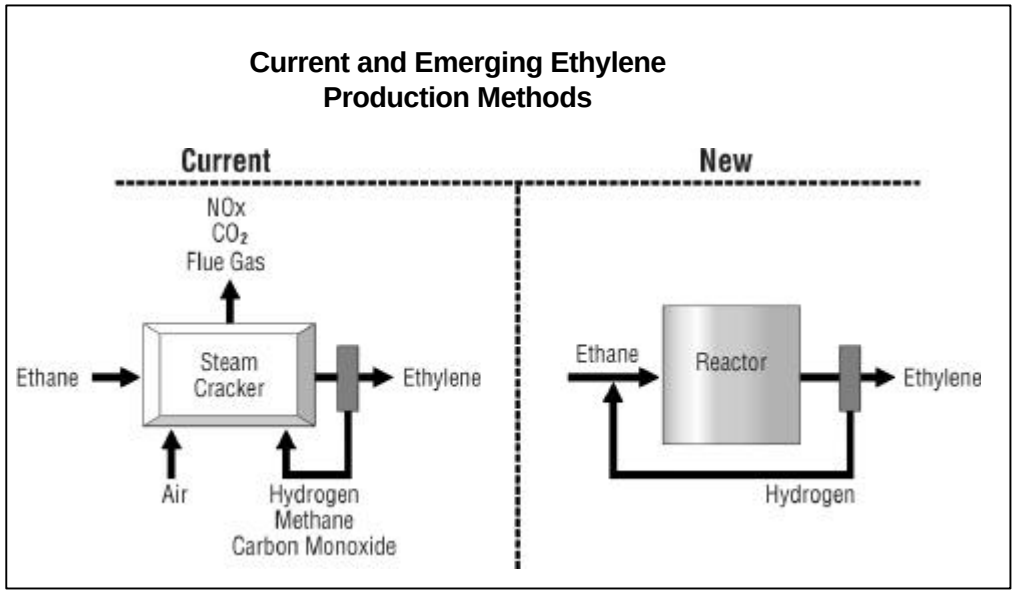
Achieve a 30% reduction in materials use per pound of chemicals produced from 1997 levels by 2020.

One basic goal of the chemical industry is to be a leader in the manufacturing sector for the efficient use of raw materials. Process improvements that result in efficient use of raw materials help to reduce energy consumption and environmental emissions while improving productivity. To accomplish this the industry has set a target of reducing material use, per pound of chemicals produced, by 30% by 2020. OIT and the industry are working towards this goal by supporting cost-shared research that recovers valuable re-useable materials from waste streams, develops better catalyst that will increase the efficiency of raw material conversion to products, and research into new processes and new building block chemicals.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Achieve a 30% reduction in water consumption per pound of chemicals produced from 1997 levels by 2020.

Water is used in nearly all chemical processes, either as part of the reaction or for heating/cooling purposes. The chemical industry recognizes the importance of reducing water consumption in order to decrease energy use, water treatment cost, and achieve sustainability. Thus, it has set a goal to decrease the amount of water used per pound of chemicals produced by 30%. The industry is addressing this goal through research in waste water purification and recycling, replacing steam cracking methods in the ethylene industry with methods requiring less waste, and new bioprocesses that operate with less water at lower temperatures.



Achieve a 30% reduction in pollutant and toxic dispersion per pound of chemicals produced from 1997 levels by 2020.

The chemical industry strives to be a responsible neighbor and a leader in operations that protect the environment. The industry has set a goal of reducing the amount of pollutants and toxics dispersed by 30% by 2020. The chemical industry is currently conducting research that will help reach the 30% reduction goal by 2020. OIT and industry are performing cost-shared research to develop new processes, new starting materials, improved catalysts, and improved separations techniques that will further reduce pollutants and toxics and increase efficiency.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

<u>FY 1999 Accomplishments</u>

- In FY 1999, the chemical industry published technology roadmaps in separations, materials of construction, computational fluid dynamics, and computational chemistry. OIT facilitated the workshops.

- OIT's Chemical Program launched seventeen new projects to improve energy efficiency and environmental performance, including a project that builds on research previously funded through OIT's Advanced Industrial Materials program to develop a microporous membrane for separation of para-xylene – potential energy savings are 90 trillion Btus by 2020.

- The Computational Fluid Dynamics (CFD) Consortium, a team of industry, universities, and government, was established to address technology barriers in CFD. 2020 goals for the CFD roadmap include a reduction in plant downtime by 50-70% and a 20% improvement in separation efficiency.

<u>FY 2000 Planned Accomplishments</u>

- A new process for using catalytic autothermal oxydehydrogenation for the production of ethylene will be demonstrated in laboratory tests. Ethylene production is the most energy intensive process in the chemical industry, but this technology could change the way ethylene is produced and significantly reduce energy consumption.

- A project with the American Institute of Chemical Engineers' Center for Waste Reduction Technologies to establish baselines for sustainability metrics (energy, materials, water, pollutants, and toxics) for the top 50 chemicals by production will be completed. Results of the project will be presented at an industry workshop hosted by the University of Texas.

- The Chemical Program will solicit and award between 8 to 14 new energy-efficient projects based on the R&D priorities identified in industry roadmaps. The Program will also launch the *Technology Vision 2020* Challenge for a project that promises specific advancements in energy efficiency and greenhouse gas reductions.

- As a result of workshops held in FY 1999, the chemical industry will publish roadmaps covering new chemical materials, reaction engineering, biocatalysis, and alternative media, conditions, and raw materials. These roadmaps will outline R&D technology priorities that will lead the industry to its goal of increased energy efficiency and sustainability.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

<u>FY 2001 Planned Accomplishments</u>

- Three projects using new separations technologies to recover valuable materials from waste streams, and separate valuable isomers from mixed isomer streams will be completed. Once commercialized these new technologies have the potential to save over 100 trillion Btu by year 2020.

- The Chemical Program will award new projects based on the technology R&D priorities identified in industry roadmaps.

- The Chemical Program will co-sponsor a national video conference with the American Institute of Chemical Engineers, the American Chemical Society, and the Council for Chemical Research to showcase industry's achievements in energy efficiency and sustainable development as a result of *Technology Vision 2020*.
- A new design guideline to minimize residential stress in a die casting die will be commercially available to the U.S. metalcasting industry. The guideline will enable designer to improve dimensional accuracy, minimize heat checking of die and extend die life. Potential benefits of the productivity improvement and die life is estimated to be 15%.

<u>FY 2002-2005 Planned Accomplishments</u>

- The chemical industry will demonstrate low temperature dehydrogenation of alkanes to olefins. This technology could save as much as 126 trillion Btu in 2020.

- The chemical industry will demonstrate a new electrochemical reactor to produce chlor-alkali. This new reactor could reduce energy consumption by 30% in the chlor-alkali industry. Current production of chlor –alkali uses 2% of all electricity used in the U.S.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

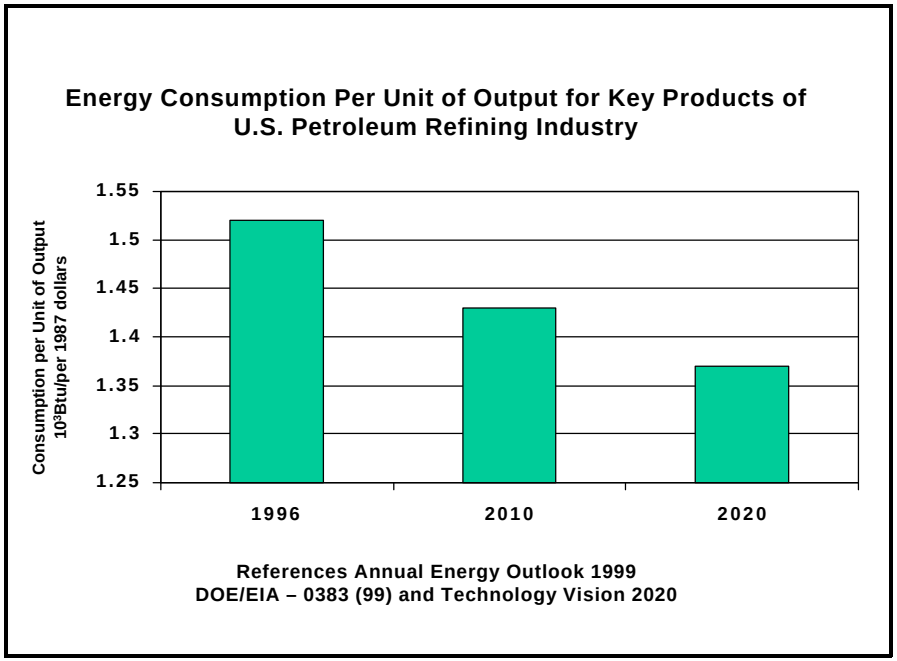
PETROLEUM INDUSTRY VISION

MEASURE

Improve manufacturing energy efficiency by 10% by 2020 relative to 1996, despite increased processing severity needed to produce cleaner fuels.

Petroleum refining is the most energy-intensive manufacturing industry in the United States, and accounted for about 7 percent of total U.S. energy consumption in 1994. Small percentage gains in manufacturing energy efficiency translate into very large total energy savings on a national level.

Calculations assume that crude quality will continue to decline and that transportation fuels will continue to be made cleaner, increasing energy use.

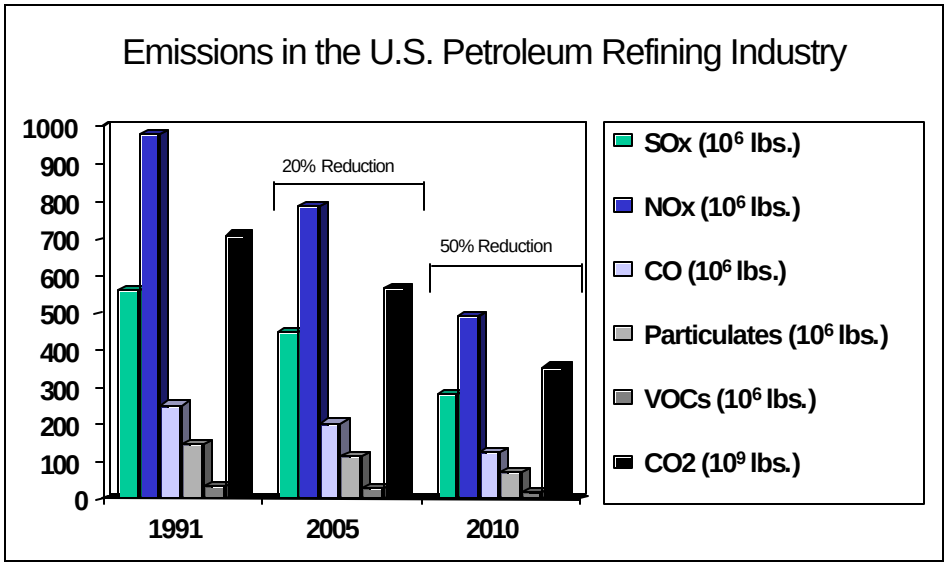


The efficiency gain shown will result in a savings of 1/3 of a quad each year by 2020. This translates to a reduction of over 50 million barrels/year of imported petroleum.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Reduce combustion and fugitive emissions by 20% by 2005 and by 50% by 2010 relative to 1990.

The petroleum refining industry has been challenged with improving environmental performance and complying with a substantial array of environmental, health, and safety regulations. An aggressive approach to reducing emissions will allow the industry to take a proactive, rather than reactive, stance in the face of even more stringent emissions standards and significantly improve the manufacturing sector's overall environmental performance. Assumes that advanced leak detection systems are in use as well as the availability and widespread use of Very Low Emissions (VLE) combustion systems or VLE-type burners.



<u>FY 1999 Accomplishments</u>

- The Petroleum industry completed its vision, Technology Vision 2020, and held a roadmapping workshop leading to completion of the roadmap.

<u>FY 2000 Planned Accomplishments</u>

- The Petroleum industry will conduct a solicitation for new research projects based on vision goals and guided by roadmap priorities. Two or three projects are expected to be started.

- Complete "construction" of a gasoline biocatalyst and begin testing in a bench-scale system.

<u>FY 2001 Planned Accomplishments</u>

- A laser-based hydrocarbon leak detector made into a person portable system will be demonstrated in cooperation with several refining companies, American Petroleum Institute, and the Environmental Protection Agency. If the project is continued, a gasoline biodesulfurization catalyst is expected to be identified.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

- Continue successful projects from the FY 2000 competitive solicitation. Initiate additional projects as warranted and as funding permits.

FY 2002 - 2005 Planned Accomplishments

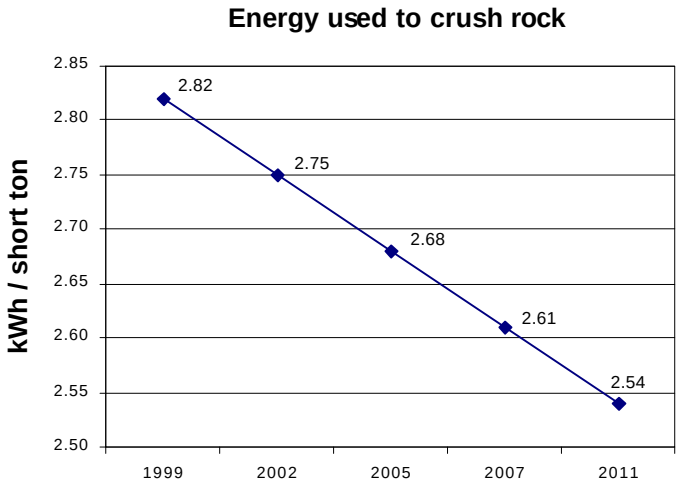
- The first of the new research projects begun in the FY 2000 solicitation and which are expected to be in Energy Efficiency and Process Improvement, Materials and Inspection, and Environmental areas will be nearing completion. Results will be turned over to industry for subsequent development. If the project is continued, a gasoline biodesulfurization catalyst is expected to be improved in terms of rate, extent, and gasoline compatibility, and made ready for commercial application.

MINING INDUSTRY VISION

MEASURE

Working closely with the mining industry, save ten percent of the energy used to crush a short ton of rock in the United States by 2010.

A return to the US economy on the government investment of a minimum of five to one will be realized by the implementation of the safe, efficient, and innovative technologies supported under current budgets to characterize rock structures and improve fragmentation and crushing. Energy used in the mining industry measures the efficiency of mining processes. Energy is critical to this industry because several of the most basic of these processes - including comminution - are highly energy intensive. Comminution is the reduction of excavated rock to fine particles in preparation for further processing. Improvements in comminution efficiency will not only save energy, but will also decrease environmental disturbance, atmospheric and water emissions, and solid waste produced. The Bond work index, a standard test, is used to measure energy needed to crush rock.



FY 1999 Accomplishments

- The Mining industry widely distributed its vision *The Future Begins with Mining*, and published a *Mining Industry Roadmap for Crosscutting Technologies*. The Mining industry initiated 10 projects that support the implementation of this technology roadmap.

I. Mission Supporting Goals and Objectives: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

FY 2000 Planned Accomplishments

- The Mining industry will begin 3 to 9 new projects that support the crosscutting technology roadmap. The team will facilitate development of two more specific roadmaps, aimed directly at processing technology and at mining methods.

FY 2001 Planned Accomplishments

- The Mining Industry will implement new technologies for underground imaging, mineral separations, and process modeling to increase productivity, save energy, and reduce environmental disturbances. Projects begun in FY 2000 will continue, as warranted.

FY 2001 - 2005 Planned Accomplishments

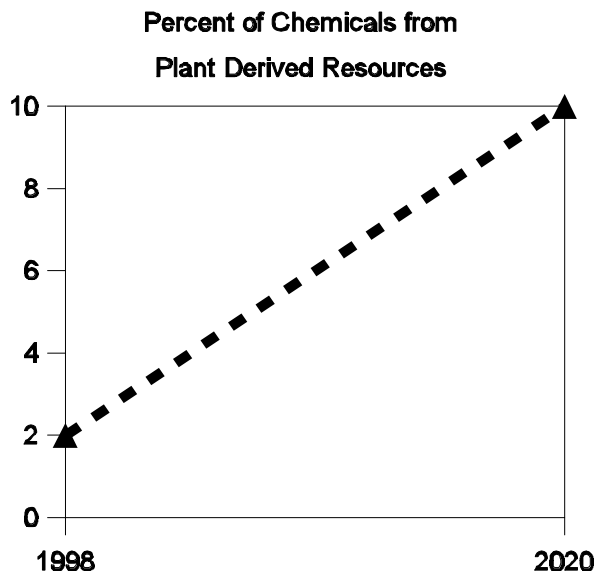
- The Mining Industry will implement new technologies for underground communication, advanced mining vehicle propulsion systems, and new materials to increase productivity, save energy, and reduce environmental disturbances.

AGRICULTURE INDUSTRY VISION

MEASURE

Achieve a 5-fold increase in the percentage of basic chemical building blocks derived from plant/crop-based renewables by 2020, increasing from roughly 2 percent in 1998 to 10 percent in 2020.

"Biological sciences are likely to make the same impact on the formation of new industries in the next century as the physical and chemical sciences have had on industrial development through the century now coming to a close. The biological sciences, when combined with recent and future advances in process engineering, can become the foundation for producing a wide variety of industrial products from renewable plant resources." National Research Council, 1999



I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

The Nation needs an additional source of durable, high-performance materials as demand for petrochemicals increase worldwide and this non-renewable source depletes. Renewable materials from home-grown crops, trees, and agricultural wastes can provide many of the same chemical building blocks — as well as others that petrochemicals cannot provide.

Despite the expertise and ingenuity of U.S. industry and tremendous productivity of U.S. agriculture and forestry, plant-based sources cannot automatically shoulder a major share of the Nation's chemical feedstock demand. Today, U.S. industry only makes portions of some classes of chemicals products from plant-derived materials. Important scientific and commercial developmental breakthroughs are needed. Petrochemicals, agriculture, forestry, life sciences and other industries — as well as government — must make major coordinated efforts to most effectively increase the use of plant-derived chemicals. Maintenance of a leadership position in agriculture, forestry, and manufacturing, depend on current and near-term support of multi-disciplinary research for the development of a reliable renewable feedstock resource base.

<u>FY 1999 Accomplishments</u>

- Agriculture's technology roadmap for renewable bioproducts was published. New partners continued to sign the compact and join the partnership. Agriculture issued its first solicitation for new R&D projects and selected six cost-shared proposals. The industry-established Executive Steering Group continued to evolve into a more formal oversight entity. Participated in the new BioEnergy Initiative which encourages greater integration of the private sector's use of crops, trees and agricultural residue to make transportation fuels, electric power, industrial chemicals and consumer goods.

<u>FY 2000 Planned Accomplishments</u>

- The Agriculture industry will start full-scale R&D on the projects selected under the FY99 solicitation. A second solicitation will be issued for proposals addressing again high priorities in the processing and utilization roadmap barrier areas. A new educational initiative will be launched, with a small separate solicitation targeted to universities and colleges to promote multi disciplinary graduate research. New approaches for seeking innovative R&D ideas from our partners will also be developed for competitive solicitations. R&D in renewable bioproducts will be better integrated with the goals laid out in the vision and roadmaps for the BioEnergy initiative.

<u>FY 2001 Planned Accomplishments</u>

- R&D in renewable bioproducts will be fully integrated and links not only with all four of the high priority areas (processing and utilization plus plant science and production) of its industry's roadmap, but also with the broader BioEnergy industry.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

- A second, larger academic solicitation will be launched to expand our efforts to encourage more graduate course-work and participation in renewable bioproducts research. Close collaboration in R&D decisionmaking will be underway with other offices in this Department, the Department of Agriculture, and other pertinent agencies of the Executive Branch to maximize complementarity and prevent redundancy. Our industry and grower partners will point to the Agriculture Team's efforts as a model for bringing resources elsewhere in the Federal government to bear on their vision's ambitious goal of winning a five-fold increase in market share by 2020 for biobased industrial chemicals. The Agriculture team will be contributing funds to and participating in new BioEnergy Initiative's R&D solicitations for integrating technologies, policies and markets.

<u>FY 2002 - 2005 Planned Accomplishments</u>

- Projects begun under the FY 1999 solicitation will be finishing their R&D phase and beginning to find commercial applications. New projects continue to enhance a robust and balanced R&D portfolio, targeting and linking the full range of the highest priorities in industry's roadmaps in both renewable bioproducts and bioenergy. A technology momentum is clearly starting to grow, with new projects seeking to build on successful early improvements in existing chemistry and others beginning to leapfrog into completely new crop development and processing systems. Our educational initiative is beginning to bear fruit with the first graduate students who received our stipend moving into industry and participating academic institutions formalizing course work cutting across traditional fields of study. The coalition of industry, grower, academic, non-profit and other governmental partners continues to expand into new markets, regions and disciplines. Relations with a new, more formal organizational structure representing corporate interests in renewable bioproducts are well-established and active on a wide range of issues. Integration with other offices in Energy Efficiency and Renewables as well as across the Department and the Executive Branch has lead to routinely full collaboration across-the-board in policymaking, R&D selections, and career development in bioproducts and bioenergy.

<u>SUPPORTING INDUSTRIES</u>

<u>MEASURE</u>

Support and enhance the success of Industries of the Future (IOF) industries by providing competitive solicitations for cost shared research and development with IOF supplier industries. Suppliers to the IOF industries use many energy intensive processes for material forming and fabrication, and/or for downstream processes such as heat treating, forging, and welding. These fabrication and downstream processes are used

by material suppliers as well as IOF industries during the manufacturing processes. Thus, energy efficiency and other improvements in these processes would be quickly deployed and have widespread use.

Several IOF supplier industries (e.g., Heat Treating, Forging, Carbon Manufacturers) have completed industry visions and roadmaps based on the models provided by the IOF Industries, and are actively involved in roadmap implementation. Implementation activities include formation of research consortia, alliances, initiation of projects, and meetings with IOF industry for closer coordination and collaboration. Other industries (e.g., Welding, Industrial Heat Equipment, Powder Metallurgy) have roadmaps in preparation. These supplier industries have been strong supporters of and participants in the OIT IOF programs and activities.

FY 1999 Accomplishments

C Not applicable.

FY 2000 Planned Accomplishments

- Not applicable.

FY 2001 Planned Accomplishments

- Identify initial process improvement targets and issue a competitive solicitation.
- Facilitate development of two or more specific roadmaps, aimed at programs that may provide significant cost and energy savings.

FY 2002 - 2005 Planned Accomplishments

- Integrate 3 or more supplier industries into IOF (Specific) and (Crosscutting) programs.

II. A. Funding Table: INDUSTRIES OF THE FUTURE (SPECIFIC)

Program Activity	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request	$ Change	% Change
Forest and Paper Products Vision	$ 11,753	$ 12,076	$ 17,100	$ 5,024	41.6%
Steel Vision	10,308	10,627	10,900	273	2.6%
Aluminum Vision	7,925	11,178	11,000	-178	-1.6%
Metal Casting Vision	5,675	5,797	5,800	3	0.1%
Glass Vision	4,701	4,830	4,800	-30	-0.6%
Chemicals Vision	12,123	12,492	12,500	8	0.1%
Petroleum Refining Vision	0	2,000	3,000	1,000	50.0%
Mining Vision	1,981	3,000	4,000	1,000	33.3%
Agriculture Vision	1,981	4,000	13,000	9,000	225.0%
Supporting Industries	0	0	1,800	1,800	>999%
Total, Industries of the Future (Specific)	$ 56,447	$ 66,000	$ 83,900	$ 17,900	27.1%

Note: Industries of the future (specific) includes $1,340 for the State Energy Program Special Projects State Grants in FY 2001, $1,200 in FY 2000, and $800 in FY 1999.

II. B. **Funding Table**: INDUSTRIES OF THE FUTURE (SPECIFIC)

Program Activity	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request	$ Change	% Change
Ames	$ 143	$ 167	$ 213	$ 46	0.0%
Argonne National Lab (East)	3,861	4,514	5,739	1,225	27.1%
Brookhaven National Lab	0	0	0	0	0.0%
Idaho National Engineering Lab	60	70	89	19	27.1%
Lawrence Berkeley Lab	940	1,099	1,397	298	27.1%
Los Alamos National Laboratory	2,705	3,163	4,021	858	27.1%
National Renewable Energy Lab	1,622	1,897	2,411	514	27.1%
Oak Ridge National Lab	6,738	7,878	10,015	2,137	27.1%
Pacific Northwest Lab	1,711	2,001	2,543	542	27.1%
Sandia National Laboratories	3,202	3,744	4,759	1,015	27.1%
All Other	35,465	41,467	52,713	11,246	27.1%
Total, Industries of the Future (Specific)	$ 56,447	$ 66,000	$ 83,900	$ 17,900	27.1%

III. <u>Performance Summary</u>: (New BA in thousands of dollars)

Program Activity	FY 1999	FY 2000	FY 2001
Industries of the Future (Specific)			
Forest and Paper Products Vision	**Energy Performance:** The Multiport Cylinder Dryer project developed technology to have steam flow through multiport passages that are in close proximity to the cylinder drying surface increasing the drying rate over conventional drying cylinders. ($2,160)	**Energy Performance:** Research in this area is targeted to increase the industry's fuel flexibility, improve process energy efficiency, and ultimately allow the industry to become essentially independent of fossil fuels. Projects will focus on fuel flexibility, fuel conversion and electricity production, heat recovery, manufacturing process efficiency, wider use of renewable resources, environmental impacts of energy production. A reburner technology to improve energy efficiency and decrease NOx emissions in Stoker boilers will be demonstrated. ($1,471)	**Energy Performance:** Research in this area is targeted to improve energy efficiency and utilization, develop new techniques to extract maximum energy from waste streams and increase the industry's fuel flexibility. Approximately 12 projects will focus on industrial energy efficiency, low level heat recovery, new approaches to water removal in wood and paper drying, and the environmental impacts of energy production. One of the energy reduction projects is developing a wood chip microwave pretreatment technology to increase the yield, efficiency and quality of Kraft pulping while decreasing chemical consumption and cooking temperatures. ($3,280)
	Environmental Performance: The Low Lignin Content Pulp project developed advanced control systems specifically targeted at producing low lignin pulps of greatly enhanced bleachability offering a route to integrated pulping and bleaching for	**Environmental Performance:** Research in this area is targeted to develop advanced pollution prevention technologies, decrease pollution abatement costs, ensure manufacturing facilities are acceptable to industry workers and local communities. Projects will focus on	**Environmental Performance:** Collaborative research in this area is targeted to develop advanced pollution prevention technologies, decrease pollution abatement costs, and ensure manufacturing facilities are acceptable to industry workers and local communities.

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Forest and Paper Products Vision (Cont'd)	an environmentally neutral mill of the future. ($2,329)	improving margins of environmental safety, and developing process alternatives consistent with pollution prevention. New high efficiency chlorine dioxide delignification procedures will be employed in mills. An energy efficient, low volatile organic compound wood drying technology will be demonstrated in a lumber yard. Polyoxometalate Bleaching will develop a new bleaching technology to save energy, allow mills to eliminate water discharge, and eliminate the need for chlorine use in bleaching. ($2,548)	Approximately 10 projects will be funded. An example of this research includes a Volatile Organic Compound (VOC) reduction model that will be used for emissions control in kraft mills. In addition, a technology to extract and collect VOC's from lumber drying processes will be commercialized, eliminating the need for expensive, energy intensive emissions control technologies. ($2,073)
	Improved Capital Effectiveness: A project was continued to provide the basis for improving the design of new high solids concentrators, modifying the design of existing high solid concentrators, and improving operating strategies to minimize sodium carbonate and sodium sulfate fouling in concentrators. ($1,026)	**Improved Capital Effectiveness:** Research in this area is targeted to reducing the capital requirements per unit of production and sales. Approximately 7 projects will be funded and will focus on system and process efficiency, materials of construction, and fabrication. A study to assess and eliminate corrosion in Kraft digesters will be initiated. ($1,355)	**Improved Capital Effectiveness:** Research in this area is targeted to reducing the capital requirements per unit of production and sales. Approximately 7 projects will be funded and will focus on system and process efficiency, materials of construction, and fabrication. An example of one of these projects is a tool to predict the corrosion rates in a kraft chemical recovery boiler that will be commercialized. This tool will decrease maintenance downtime and increase the safety of the chemical recovery boiler operation. ($2,172)

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Forest and Paper Products Vision (Cont'd)	**Recycling:** Applications were evaluated to use mechanically initiated shock waves in recycling processes: shocking starch tanks to replace biocides, dispersing contaminants in recycle process waters, removing contaminants from recycled papers, and refining fibers. ($576)	**Recycling:** Research in this area is targeted to improving separation technologies, reducing energy usage and fiber deterioration, determining optimal combinations of recycled and virgin fibers, and expanding the use of recycled products. Projects will focus on sludge use and disposal, surface chemistry, fiber bonding, sorting and collection methods, improved separation technologies, and environmentally benign pressure sensitive adhesives. A revolutionary screening device will be explored. ($1,099)	**Recycling:** Research in this area is targeted to improving separation technologies, reducing energy usage and fiber deterioration, determining optimal combinations of recycled and virgin fibers, and expanding the use of recycled products. One of the approximately 8 projects to be funded will develop a new screening technology that will reduce energy requirements by as much as 80% while improving the screen performance and reliability. Screening technologies are used to remove contaminants from recycled fiber. ($1,678)
	Sensors and Controls: This was the first year of a two-year project to develop a real time, on-line, ultrasonic instrument to characterize pulp fiber changes and paper stock composition. ($3,588)	**Sensors and Controls:** Research in this area is targeted to optimize mill operations, evaluate the characteristics of raw materials and final products, and detect emissions. Projects will focus on the development of actuators and control devices, process and product models, process measurement, data interpretation, and control system effectiveness. A tool and methodology will be commercialized for characterization of the raw material to the products in the paper making process. ($3,941)	**Sensors and Controls:** Research in this area is targeted to optimize mill operations, evaluate the characteristics of raw materials and final products, and detect emissions. An example of the projects in this area is the development of an intelligent, vision-based apparatus for measuring properties on the wet end of the paper machine. Knowledge about the wet end of process parameters will improve the efficiency of the most energy intensive process in the forest products industry for paper making.

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Forest and Paper Products Vision (Cont'd)			Eight projects will be funded. ($2,073)
	Sustainable Forestry: A study was continued to improve the understanding of mechanisms controlling tree growth and recommend refined silvicultural practices aimed at maximizing wood and fiber production through resource management. 11 projects were funded focusing on biotechnology, tree physiology, and soil productivity with a goal to increase the growth rate of the fiber supply to the industry by 4 times. ($2,074)	**Sustainable Forestry:** Collaborative research in this area is targeted to increase the forest growth rates and enhance the fiber quality from trees. Projects will focus on biotechnology, tree physiology, and sustainable soil productivity. Marker aided selection methods for selection of genotypes for cloning will be commercialized. ($1,662)	**Sustainable Forestry: Bioenergy/Bioproducts Initiative-** Research in this area is targeted to optimize raw material supply by improving wood quality and increasing the conversion rate of solar energy to woody biomass. Results will reduce costs and increase efficiencies in manufacturing processes for pulp, paper, and building materials by 10%. Environmental benefits will include increased rates of carbon sequestration in forests and forest products; reduced consumption of pulping and bleaching chemicals; and new supplies of wood and manufacturing residues necessary to support increases in the production and utilization of renewable biomass energy. An example of this research includes the development of a process to increase the stem growth rates of loblolly pine and study the molecular mechanisms of cell division to improve the efficiency of wood pulping. Approximately 5 projects will be funded. ($824)

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Forest and Paper Products Vision (Cont'd)			As part of the EERE team, the forest products industry will implement the relevant portion (sustainable forestry) of the Bioenergy/Bioproducts Initiative ($2,000), bringing R&D into alignment with the new vision and technology roadmap. An additional 7 projects will be funded. (Bioenergy/Bioproducts Initiative $2,000) ($2,824) **Bioenergy/Bioproducts Initiative-** As part of the EERE team, the forest products industry will implement the relevant portion of the Bioenergy/Bioproducts Initiative ($2,000), bringing R&D into alignment with the new vision and technology roadmap. A solicitation will be issued based on the Bioenergy/Bioproducts roadmap in FY 2001. It is anticipated that approximately 8 new projects will be initiated in areas related to forest products such as forestry and biobased evergy. The Bioenergy/Bioproducts Initiative looks to integrate technology, markets and policies for using local crops, trees, and agricultural wastes to make transportation fuels, electrical power and biobased

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Forest and Paper Products Vision (Cont'd)			industrial chemicals and consumer goods in "biorefineries" across the country. Achieving the President's recently announced goal of tripling the use of bioenergy and bioproducts by 2010 would create $15 billion to $20 billion in new income for farmers and rural communities and cut back significantly on the use of imported oil. Greater integration of government and industry efforts in policy, market and technology development will lay the groundwork for the rapid growth of this new industry for the next century. (Bioenergy/Bioproducts Initiative $2,000) ($3,000)
		Participants include: The American Forest and Paper Association and their member companies, National Laboratories, the Institute of Paper Science and Technology, the Pulp and Paper Education and Research Alliance Members and Partners, and others.	Participants include: The American Forest and Paper Association and their member companies, National Laboratories, the Institute of Paper Science and Technology, the Pulp and Paper Education and Research Alliance Members and Partners, and others.
	$11,753	$12,076	$17,100

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Steel Vision	**Production Efficiency:** Collaborative R&D with the industry to improve the efficiency of steel making, casting, and rolling processes was continued. R&D initiated in late FY98 continued on subjects such as advanced casting technologies and improved materials properties. ($4,200)	**Production Efficiency:** Collaborative R&D with the industry to improve the efficiency of energy efficient, low carbon dioxide emission alternate iron making processes and steel making processes will be supported. R&D on subjects such as advanced shaping technologies, improved process control including sensors for the blast furnace, basic oxygen furnace, and electric arc furnace (EAF) will be initiated. R&D on improved steel quality and consistency using lower cost raw materials will continue. ($3,800)	**Production Efficiency:** Introduction: Research to reduce energy while lowering emissions and increasing productivity in steel processing focuses on a wide range of topics as identified in the Steel Industry's Technology Roadmap. Currently, key efforts are being made through improved sensing and control, increased use of byproducts and recycling, and through process improvement. These activities will support the industry's reduction of energy use by 19% while increasing their use of recycled steel and byproduct to 60% of production. Collaborative R&D with the industry to improve the efficiency of energy efficient, low carbon dioxide emission, alternate iron making processes and steel making processes will be supported. R&D will be conducted to improve the efficiency and productivity of the blast furnace, basic oxygen furnace, and electric arc furnace by developing modifications to hardware and operational practices. These modifications will result from analysis and laboratory studies based on initial efforts in computational fluid dynamics and

Program Activity	FY 1999	FY 2000	FY 2001
Steel Vision (Cont'd)			other design technologies leveraged from the Chemicals Vision. ($4,000)
	Recycling R&D: R&D on methods of increasing the rate of steel scrap recycling from currently marginally tapped waste streams continued. Follow-on activities were conducted in collaboration with the Electric Power Research Institute (EPRI) to minimize electric arc furnace dust emissions. Other R&D projects were responsive to the R&D needs identified in the chapter "Iron Unit Recycling" of the Iron and Steel Industry Technology Roadmap. ($2,500)	**Recycling R&D:** R&D on methods of increasing steel production based on recovery of iron units from all waste streams will be conducted. R&D will improve methods of recovering iron units and other metals (e.g., zinc, lead), from EAF dust and waste oxides. R&D will include improved methods for recycling spent refractories and for recycling acid and metal salts from pickling liquors. ($3,000)	**Recycling R&D:** R&D on methods of increasing steel production based on recovery of iron units from all waste streams will be conducted. R&D will identify methods of increasing the efficiency of recycling steel from in-plant wastes. Processes will be analyzed to identify ways to use other in-plant wastes as feedstock to reduce energy use. ($3,000)
	Environmental Engineering: R&D on methods to lower emissions per unit of output associated with steel production in the blast furnace continued. ($3,608)	**Environmental Engineering:** R&D will focus on lowering carbon dioxide and NOx emissions from heating and reheating processes associated with steel production. Research will concentrate on advanced burners and burner sensing controls, and on methods to reduce coke use in the blast furnace through hot oxygen injection. ($3,827)	**Environmental Engineering:** R&D will develop methods of reducing the amount of consumables used in the steel making process. Consumables such as refractories can become an environmental disposal problem at the end of their lifetime. Efforts will continue to reduce NOx and CO2 levels from the various unit operations in the steel mill. ($3,400)
			Feasibility Studies on Innovative Steel Production: Significant cross-over of technologies between Electric Arc Furnace (EAF) and Basic

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Steel Vision (Cont'd)			Oxygen Furnace (BOF) steel making indicate that there are significant opportunities to improve the steel making process by, at a minimum, combining and optimizing the best features of both. The development of a recuperated, continuous (as opposed to batch) steelmaking process could result in saving half the energy currently used in the steel conversion/melting operation. These activities would initiate the feasibility and design studies to develop a new steel conversion process. ($500)
		Participants: R&D participants in the Steel Vision include: American Iron and Steel Institute (member and associate member companies); the Steel Manufacturers Association (member and associate member companies); National laboratories, universities.	**Participants:** R&D participants in the Steel Vision include: American Iron and Steel Institute (member and associate member companies); Steel Manufacturers Association (member and associate member companies); National laboratories, universities.
	$10,308	$10,627	$10,900

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Aluminum Vision	**Primary Production Technologies:** R&D included continued evaluation of inert/wettable electrode material and advanced cell designs for primary aluminum production, and development of robust sensors and controls for harsh environments. A pilot-scale plant for saltcake recycling was being designed and built. R&D was initiated to develop methods of recycling aluminum scrap and waste, and to improve the operational efficiency of cell potlining materials. ($5,860)	**Primary Production Technologies:** Accelerated research program will be initiated for the development and implementation of an advanced cell which would be the most significant advancement in aluminum production technology since the development of the Hall-Heroult process in 1886. Activities will include pilot cell tests of two different novel Hall-Heroult cell designs and inert anode/cathode materials combinations, as well as 12 kiloAmpere pilot cell tests of wettable cathode materials with a drained cathode design. In addition, an investigation will be initiated into the feasibility of a novel smelting process based on fuel cell technology. Saltcake recycling will be demonstrated at pilot-plant scale and R&D will be conducted to develop sensors and controls to sort aluminum scrap at high speeds. ($7,377)	**Primary Production Technologies:** Accelerated research program will continue for the development and implementation of an advanced cell with the potential to reduce energy consumption by 27% and greenhouse gas emissions by 5.5 MMTce over a business as ususal scenario. Implementation of an advanced cell of this kind would be the most significant advancement in aluminum production technology since the development of the Hall - Heroult process in 1886. Scale-up of Advanced Cell development and testing will take place based on most promising cell designs and anode - cathode materials combinations identified in previous work. Feasibility of using fuel cell technology for development of a non-consumable anode will be evaluated, and a controls strategy using sensors will be developed for aluminum smelting cells. A commercial demonstration of saltcake recycling technology will be initiated. Laser and optical techniques for scrap sorting will be evaluated. ($8,000)
	Semi-Fabrication Technologies: R&D to develop a vertical floatation	**Semi-Fabrication Technologies:** A vertical floatation melter and a	**Semi-Fabrication Technologies:** Year long tests of potlinings

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Aluminum Vision (Cont'd)	melter continued and a new grain refining process was demonstrated. ($2,065)	commercial-scale high-efficiency, low NOx combustion system for aluminum scrap remelting will be demonstrated. ($3,801)	containing additives for improved performance and life, will be initiated in full scale industrial cells. ($3,000)
		Participants: R&D participants include Advanced Refractory Technologies, Alcan, Aluminum Company of America, Argonne National Laboratory, Brooks Rand Laboratories, Century Aluminum, EMEC Consultants, Energy Research Company, Goldendale Aluminum, Kaiser Aluminum Company, Northwest Aluminum, NSA Aluminum, Oak Ridge National Laboratory, Michigan Technological University, Reynolds Metals Company, Worcester Polytechnic Institute.	**Participants:** R&D participants include Alcan, Alcoa Inc., Applied Industrial Solutions, Inc., Argonne National Laboratory, Century Aluminum, Cornell University, EMEC Consultants, Energy Research Company, Gas Research Institute, Kaiser Aluminum Company, Michigan Technological, NSA Aluminum, Oak Ridge National Laboratory, Siemens Westinghouse Co., The Ohio State University Research Foundation, University, West Virginia University.
	$7,925	$11,178	$11,000

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Metal Casting Vision	Introduction: The objective of the metal casting vision is to support metal casting as the preferred supplier of net or near-net shape metal components beyond the year 2000. Specific challenges which were to be achieved by the year 2020 and include: increasing productivity by 15 percent though the development of advanced manufacturing technologies, reducing energy consumption per unit value of shipments by 20 percent, reducing average lead time by 50 percent, achieving 100 percent pre- and post-consumer recycling and 75% beneficial reuse of foundry by-products, and increasing industry reinvestment in research, education and marketing programs by 10 percent. By the year 2020 the projected benefit that results from the Metal Casting Industries of the Future Program will include energy savings of .018 quads of energy saving, and 0.51 million tons carbon equivalents (MMTCE) while achieving productivity savings of over $1 billion.	Introduction: Continue a balanced portfolio of high priority research responsive to the goals and challenges identified in the metalcasting vision and metalcasting technology roadmap.	Introduction: Continue a balanced portfolio of high priority research responsive to the goals and challenges identified in the metalcasting vision and metalcasting technology roadmap. Each of the projects is cost shared 50% with industry partners. There are over 130 industry partners in at least 24 States across the U.S. working on program-funded research projects. The continued research projects from previous year's competitive solicitations include the following education institutions and National Laboratory: University of Alabama-Birmingham, University of Alabama-Tuscaloosa, Case Western Reserve University, University of Iowa, Mississippi State University, University of Missouri-Rolla, Ohio State University, Penn State University, Oak Ridge National Laboratory, and Worcester Polytechnic Institute.
	Manufacturing Technologies: Eighteen projects were funded to	**Manufacturing Technologies:** Research will focus on new models,	**Manufacturing Technologies:** Research will continue to develop

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

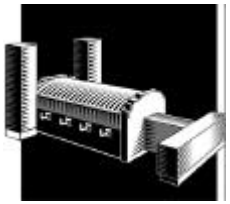
Program Activity	FY 1999	FY 2000	FY 2001
Metal Casting Vision (Cont'd)	support research to develop tools and new sensors to improve die-cavity filling for higher quality castings, extend die life, and minimize part distortion for die-casting process used for aluminum, magnesium, and zinc alloys. ($3,197)	tools and guidelines in order to advance casting technologies to produce high quality, high integrity castings. A new guideline for unconventional yield improvement techniques will be available for the steel casting industries. A 10% increase in yield alone has the potential benefit of energy savings of 1.8 trillion Btus per year for melting. ($2,400)	<u>advanced casting technologies</u> for producing high quality castings. Research will focus on Advanced Lost Foam Casting technology and binders (chemicals that holds sand molds together) for iron and steel casting. The Lost Foam Casting process uses polymer foam patterns, which are decomposed by the molten metal poured. The molten metal replaces the pattern, duplicating all the details of the pattern, and solidifies to the product form. Less metal is melted because of reduced assembly size and less machining of the castings. Technical challenges include the removal of gaseous residuals during the step of pouring metal, better and cheaper foam materials, and rapid prototyping of the patterns. Successful development and application of Advanced Lost Foam Technology to iron and steel castings alone will have a potential energy efficiency improvement of up to 30%, reduce cost by 25%, and eliminate binder emission associated with traditional sand casting methods for steel casting. In addition, research will continue in Semi-Solid Metals Processing (SSM) for models, material property characterization

Program Activity	FY 1999	FY 2000	FY 2001
Metal Casting Vision (Cont'd)			needed to address the technological barriers for producing higher integrity, high volume light weight castings, while enabling new castings design of thinner walls and reduced machining requiring. ($3,100)
	Materials Technologies: Activities focused on advancing the use of new and improved materials for castings. Research established methodologies and structural characterization as well as data needed for production of quality castings utilizing cast particulate metal matrixes. R&D efforts continued on technologies needed to consistently produce machinable, high strength, thin-walled gray and ductile iron castings. ($2,046)	**Materials Technologies:** Activities are focused on advancing the use of new and improved materials to produce defect-free, high quality casting while achieving longer life for mold, refractory lining, and casting dies. Innovative research developed in new coatings will be developed to extend the useful life of casting dies ten fold in comparison with current conventional methods. ($1,897)	**Materials Technologies:** Activities are focused on advancing the use of new and improved materials to produce defect-free, high quality casting while achieving longer life for mold, refractory lining, and casting dies. Continue to focus on innovative research to develop advanced coatings capable of extending the useful life of casting dies ten fold in comparison with current conventional methods. In addition, R&D efforts will continue on technologies needed to consistently produce machinable, high strength, thin-walled gray and ductile iron castings. ($1,800)
	Environmental Technologies: Began developments in waste characterization, reduction, reuse, and alternate use of foundry waste. R&D will continue to advance the Lost Foam Casting Process, which requires less metal to be melted than	**Environmental Technologies:** Balanced portfolio will include critical research needed to develop design guidelines for advanced modeling design for thin wall iron casting will be available to the metal casting industry. In addition, a state-of-the-	**Environmental Technologies:** Balanced portfolio will include critical research needed to develop design guidelines for thin wall iron casting. Thin-wall iron castings, on the order of 3-5 mm thickness, will enable the automotive engineers to

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Metal Casting Vision (Cont'd)	other processes. An estimated 30% percent reduction in energy requirements for melting alone could save about 37 trillion Btu per year. ($432)	art Neural Network Model for processing and control of cupola furnace will be available. Potential benefits include energy savings of 400 million Btu per year per unit, revitalization of environmentally enhanced cupola operation in the U.S., decreased coke requirements, reduced carbon, sulfur and manganese losses and elimination of associated emissions. ($500)	design car components with significant reductions in weight and resulting in tremendous reductions in energy use and environmental burden, in both casting production and transportation fuel. ($570)
		New Casting Applications: New design tools, improvements in casting techniques and models will be developed to enable new applications of advanced casting technologies which will reduce energy usage, reduce cost and minimize waste generated. New techniques developed for metal handling will enable U.S. metalcasters to reduce casting defects, improve quality of castings by removing/minimizing oxide defects that require weld repair and improve the competitiveness of the U.S. metal casting industry. ($1,000)	**New Casting Applications:** New design tools, improvements in casting techniques and models will be developed to enable new applications of advanced casting technologies which will reduce energy usage, reduce cost and minimize waste generated. New techniques developed for metal handling will enable U.S. metalcasters to reduce casting defects, improve quality of castings by removing/minimizing oxide defects that require weld repair and improve the competitiveness of the U.S. metal casting industry. ($330)
	$5,675	$5,797	$5,800

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Glass Vision 	**Production Efficiency:** Controls for process optimization for desired glass properties; furnace refractory thickness and temperature, on-line stress measurements; and process simulation models that actually simulate the glass manufacturing process. ($1,800)	**Production Efficiency:** Modeling of refractories (the main structural materials in glass melting furnaces); improvement of combustion and melting technology initiate new fundamental knowledge of glass physics; better means of removing heat faster; better understanding of integrated product and process controls. ($1,900)	**Production Efficiency:** Continue modeling of refractories (the main structural materials in glass melting furnaces) and improvement of combustion and melting technology. Initiate new fundamental knowledge of glass physics; better means of removing heat faster; better understanding of integrated product and process controls; and develop advanced sensor technologies and measurement techniques. ($2,100)
	Energy Efficiency/Conservation: Glass furnaces with lower net production cost; in-situ testing of furnace refractories; and combustion laboratory characterization of flames from different burner configurations. ($1,100)	**Energy Efficiency/Conservation:** Combustion of space/glass furnace and control for optimal melter performance will be coupled. Develop better refractories; develop user facility to validate new and existing models. ($1,200)	**Energy Efficiency/Conservation:** Continue to perform activities to validate new and existing models. Initiate new technologies that support innovative glassmaking, improved combustion efficiency, or improved heat recovery; and develop accurate, validated melter models. ($1,000)
	Environmental Protections and Recycling: Used prior-year funds, initiated/continued projects: improved oxy-fuel firing technology to reduce air emissions; alternate raw materials, batch preparation, and/or furnace designs with lower particulate and gaseous emissions. ($900)	**Environmental Protections and Recycling:** Will complete non-hazardous waste refractory materials and solid waste reuse. Develop process mechanisms that influence particulates; develop predictive emissions modeling tools. ($800)	**Environmental Protections and Recycling:** Develop predictive emissions modeling tools. Identify emission mechanisms from glass and raw materials. Identify emission management mechanisms from glass and raw materials - develop a relationship of the effects on furnace emissions from parameters including cullet quantity, size and composition

Program Activity	FY 1999	FY 2000	FY 2001
Glass Vision (Cont'd)			in the batch; identify and quantify the emission sources within the furnace environment; evaluate furnace firing profile and rates versus NOx (Nitrogen Oxides), SOx (Sulfur Oxides), PM (Particulate Matter) and CO (Carbon Monoxide) formation and overall emissions. Develop predictive emissions modeling tools for process emissions - high temperature sensors for flow, temperature and gas composition; integrated system to link production parameters. ($750)
	Innovative Uses: Explored innovative glass compositions and processes to enhance performance and new material-design models to improve properties. ($701)	**Innovative Uses:** Improvement of glass properties using integrated ion exchange. Will continue innovative glass compositions and processes to enhance performance and new material-design models to improve properties. ($730)	**Innovative Uses:** Initiate new technologies that produce high strength glasses and glasses with functional surfaces. Will continue innovative glass compositions and processes to enhance performance and new material-design models to improve properties. ($750)
	Deployment Logistics: Conducted two technical workshops. Conducted technology roadmap assessment. ($200)	**Deployment Logistics:** Will conduct two technical workshops. Review/update technology roadmap assessment. ($200)	**Deployment Logistics:** Will conduct two technical workshops. Review/update technology roadmap assessment. ($200)
		Participants in the Glass vision include: Praxair, Institute for Glass Technology, Brigham Young University, Accu-Tru Intl., Alfred	Participants in the Glass vision include: Praxair, Institute for Glass Technology, Brigham Young University, Accu-Tru Intl., Alfred

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Glass Vision (Cont'd)		University-Center for Glass Research, PPG, Air Products, Los Alamos National Laboratory, Oak Ridge National Laboratory, Sandia National Laboratory, Pacific Northwest National Laboratory, Argonne National Laboratory, Ames, and the Federal Energy Technology Center.	University-Center for Glass Research, PPG, Air Products, Los Alamos National Laboratory, Oak Ridge National Laboratory, Sandia National Laboratory, Pacific Northwest National Laboratory, Argonne National Laboratory, Ames, and the Federal Energy Technology Center.
	$4,701	$4,830	$4,800
Chemicals Vision	**New Chemical Sciences and Engineering:** Supported 17 R&D projects awarded to advance the implementation of the chemical industry's vision *<u>Technology Vision 2020</u>* and the associated technology roadmaps covering catalysis, bioprocessing, and separation. Total project awards over two years amounted to about $15 million in federal funds and up to $7.5 million in private resources. Some industrial partners are: General Electric, Dow, Raytheon, Applied CarboChemicals, Arkenol, and Praxair. Awards included projects such as: selective catalytic oxidative dehydrogenation of alkanes to olefins, direct production of silicones to sand, and advanced sorbents as a versatile	**New Chemical Sciences and Engineering:** Conduct second *<u>Technology Vision 2020</u>* solicitation to support industry-developed roadmaps in: separations catalysis, computational chemistry, materials, and alternative synthetic pathways.	**New Chemical Sciences and Engineering:** Continue R&D to support *<u>Technology Vision 2020</u>* in separations, catalysis, computational chemistry, and alternative synthetic pathways.

Program Activity	FY 1999	FY 2000	FY 2001
Chemicals Vision (Cont'd)	platform for gas separation. ($10,123)		
		Advances in separations technologies such as adsorption, crystallization, distillation, extraction and membranes offer prospects of multi-trillion Btu per year energy savings. Cost shared research on more energy efficient separation processes will be conducted on olefin recovery from waste streams, sorbent separation, and selective surface membranes.	**Separations:** Demonstrate advanced electrodeionization separation technology in pilot-scale - potential energy savings of 4 trillion Btu/yr by 2020. Conduct full-scale demonstration of novel membrane-based process to recover propylene from propane - energy savings from displaced feedstock are estimated to be 23 trillion Btu/year by 2020. Complete design of commercially-scalable thin-film membrane to separate p-xylene from mixed xylene streams - potential energy savings of 100 trillion Btu/year by 2020. ($3,100)
		Advances in catalytic processes offer the potential for multi-trillion Btu per year energy savings. Cost shared research projects include: development of catalysts for the production of commodity chemicals, selective oxidative conversion of alkanes to olefins, and direct conversion of sand to silicone.	**Catalysis:** Improvements in catalytic process yields integrated with process engineering designs can produce significant energy savings. Demonstrate 6-month operation of pilot-scale electrochemical cell for production of chlor-alkali - potential to reduce total U.S. demand for electricity by 0.6%. Conduct pilot plant demonstration of styrene, diesel hydrodesulfurization, or hydro- to para-alkane conversion processes

Program Activity	FY 1999	FY 2000	FY 2001
Chemicals Vision (Cont'd)			using nanoscale carbide catalysis - potential energy savings of 45 trillion Btu/yr by 2020. ($3,100)
		Alternative synthetic pathways can significantly improve the energy intensity and reduce the resources required to manufacture chemical products. Key R&D needs involve using alternative conditions, new reaction media (such as dense phase fluids) and alternative raw materials like single-carbon molecules. ($10,192)	**Alternative Synthesis:** Complete initial research on alternative pathway projects using alternative conditions, new reaction media, (such as dense phase fluids), and alternative raw materials like single-carbon molecules. ($2,000)
			New Solicitation: Conduct third solicitation supporting industry-developed technology roadmaps in: separations, catalysis, computational chemistry, and alternative synthetic pathways. ($2,000)
	Manufacturing and Operations: Supported development of materials technologies technology roadmap working with Materials Technology Institute of the Chemical Process Industries, Inc. Conducted R&D to develop a new electrochemical reactor for the production of chlor-alkali which could reduce the total annual U.S. electric power consumption and associated carbon	**Manufacturing and Operations:** Support projects that address technology roadmap for materials of construction including: new materials for high-temperature, corrosive environments, improved models for predicted material behavior, new/improved materials, and better joining and fabricating methods. Facilitate development of technology roadmap for manufacturing and	**Manufacturing and Operations:** Conduct solicitation to support development and implementation of energy saving technologies identified in technology roadmap for manufacturing and operations. Continue R&D to develop: new materials for high-temperature, corrosive environments, improved models for predicted material behavior, new/improved materials,

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Chemicals Vision (Cont'd)	dioxide emissions by 0.6%. ($1,000)	operations. ($1,000)	and better joining and fabricating methods. ($1,000)
	Computational Technologies: Launched two computational fluid dynamics (CFD) projects through industry-lab consortiums: 1) simulation of a chemical production facility and 2) development/validation of a turbulent multiphase fluid flow model. ($1,000)	**Computational Technologies:** Continue CFD consortium projects to establish an industrial user center, commercialize a sensor for multiphase measurements, begin testing beta-version of multiphase computer model and release visualization package. Computational technologies can optimize process energy requirements and shorten the lead time from research to plant design by several years. Cost shared research will be conducted on simulating industrial scale turbulent gas solid flows and adapting multi-phase computational fluid dynamics to fluid-particle processes. Completed design of experimental test loop. Consortium participants include: Dow, DuPont, Dow Corning, Exxon Chemicals, Chevron, Fluent, AEA Technology, Silicon Graphics, Westinghouse, FETC, Sandia National Laboratory, Lawrence Berkeley National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, and Pacific Northwest National Laboratory, et al. ($1,300)	**Computational Technologies:** Continue advancement of multi-phase CFD consortium projects. Computational technologies can optimize process energy requirements and shorten the lead time from research to plant design by several years. Conduct R&D on simulating industrial scale turbulent gas solid flows and adapting multi-phase computational fluid dynamics to fluid-particle processes. Complete installation of experimental test loop. Complete improvements to MIFX software code. Annual energy savings are estimated to be 100 trillion Btu/yr by 2020. ($1,300)

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Chemicals Vision (Cont'd)	$12,123	$12,492	$12,500
Petroleum Industry Vision	The industry was preparing an industry-wide vision, and would use the vision as the basis for a technology roadmap, that was to be initiated in FY 1999. The industry will sign a compact to work with the Department in February of FY 2000. The vision was expected to focus on energy efficiency, safety and reliability, and the environment. ($0)	The Petroleum industry has developed a vision and technology roadmap, signed a compact, and will work with DOE to implement the roadmap. In FY 2000, a competitive solicitation will be conducted which will initiate projects in accordance with the Petroleum industry vision and roadmap.	The Petroleum industry vision and roadmap focus on environment, process improvement and energy efficiency. A competitive solicitation in FY 2000 initiated activities to address key needs in these areas. FY 2001 funding will continue to address downstream petroleum needs.
		Possible projects could include remote sensing of equipment leaks, which is expected to reduce these fugitive emissions, saving 12 trillion Btu annually; biocatalytic desulfurization of gasoline, expected to lower desulfurization energy use by over 20 trillion Btu/year; and an advanced fluid catalytic cracking model which can guide industry to savings in excess of 6 trillion Btu/year. Select efforts are being conducted in cooperation with the Office of Fossil Energy. ($2,000)	Examples of possible projects include a portable hydrocarbon leak detector, expected to save well over 12 trillion Btu annually; biocatalytic desulfurization of gasoline, expected to lower energy use by over 20 trillion Btu/year; and, in cooperation with Office of Science, an advanced fluid cracking model which can guide industry to savings in excess of 36 trillion Btu/year. Select efforts will be conducted in cooperation with the Office of Fossil Energy. ($3,000)
	$0	$2,000	$3,000

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Mining Vision	Implemented the industry's vision and roadmap through improvement of current processes for low cost and efficient production, exploration and resource characterization, safe and efficient extraction and processing, and responsible emission and by-product management. Began development of technologies for exploration, mining, and processing which demonstrate crosscutting benefits for the entire Mining industry. Initiated planning for advanced product development and improved communication and education. ($1,981)	Will leverage research funds with industrial cost sharing as well as state and other federal funding to support the industry's vision and roadmap. Will develop technologies for exploration, mining, and processing which demonstrate accountable benefits for specific sectors of the Mining industry. Technologies that could be funded include real-time mineral content sensors, mining technologies for difficult conditions (deeper mines, thinner seams, lower-grade ores), and new materials for transportation and handling. ($3,000)	Will leverage research funds with industrial cost sharing as well as state and other federal funding to support the industry's vision. Will facilitate interagency roadmaps for technologies such as exploration and excavation. Will develop technologies for resource characterization, mining, and processing which demonstrate accountable benefits for the US mining industry. Technologies that could be funded include advanced minerals characterization, integrated mining systems, and low-energy metals processing, expected to save over five trillion Btus annually. ($4,000)
	Partners include: major mining and mineral processing companies, equipment manufacturers, universities, and national laboratories.	Partners include: major mining and mineral processing companies, equipment manufacturers, universities, and national laboratories.	Partners include: major mining and mineral processing companies, equipment manufacturers, universities, and national laboratories.
	$1,981	$3,000	$4,000

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Agriculture Vision	**Biobased Industrial Feedstocks:** R&D focused on increased or expanded use of the current base of renewable bio-resources; and promoting, developing and implementing new and innovative processing technologies. First, the solicitation targeted highest priorities in plant processing and utilization categories identified as key barriers in industry technology roadmap. Began to integrate R&D approach with other biomass efforts for making fuels and power under the new EERE Bioenergy/ Bioproducts Initiative. ($1,981)	**Biobased Industrial Feedstocks:** Conduct R&D building on results from the initial solicitation in FY 1999 and filling the many technology gaps identified by the technology roadmaps which were not addressed by the first solicitation. Look to use a more flexible and creative solicitation process that maximizes the number of proposals and outside funding; builds new multi-disciplinary and cross-industry partnerships; encourages highly innovative ideas.	**Biobased Industrial Feedstocks: Bioenergy/Bioproducts Initiative-** Progress in achieving industry's ambitious target of a five-fold increase in market share for renewable bioproducts will begin to help add to farmers' incomes, create new jobs in rural communities and markets overseas, as well as reduce overall industry's costs of production. Support project R&D from first two solicitations and issue next request for proposals that build on the "lessons learned" from those earlier solicitations. Emphasis will be on projects that show clear linkages across all of the highest priorities in the roadmap in an integrated and coordinated approach to make better use of public and private funding and faster progress toward industry's ambitious goal of winning 10% of the market for industrial chemical feedstocks from plant material by 2020.

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Agriculture Vision (Cont'd)		Also launch a new educational initiative that promotes multi-disciplinary research at Universities and Colleges and provides stipends to select graduate students. As part of the EERE team implementing the Bioenergy/Bioproducts Initiative, also bring R&D into alignment with new vision and technology roadmaps for overall biomass industry.	Solicitation process will broaden our base of partners in the agricultural, chemical and forestry communities. Continue to provide support to those higher education institutions with winning proposals for new multidisciplinary approaches from FY 2000 and run second such solicitation to broaden participation to other colleges and universities in the Renewables 2020 educational initiative. Seek deeper collaboration on R&D decisionmaking and public outreach with other parts of the Department of Energy; the U.S. Department of Agriculture; and other pertinent agencies in the federal government, as well as state governments. (Bioenergy/Bioproducts Initiative $5,000) ($8,000)
		The Bioenergy/Bioproducts Initiative looks to integrate technology, markets and policies for using local crops, trees, and agricultural wastes to make transportation fuels, electrical power and biobased industrial chemicals and consumer goods in "biorefineries" across the country. Participate fully in implementing the new Executive	**Bioenergy/Bioproducts Initiative-** A key element of the Bioenergy and Bioproducts initiative is Integrated Bioenergy. This activity will support comptetively-awarded projects to integrate technology, markets, and policies for using crops and agricultural wastes to make fuels, electrical power, and biobased products in "biorefineries" around the

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Agriculture Vision (Cont'd)		Order on Biobased products and BioEnergy. ($4,000)	country. (Bioenergy/Bioproducts Initiative $3,000) ($5,000)
	$1,981	$4,000	$13,000
Supporting Industries			Issue competitive solicitations to the IOF supporting industries to support technology R&D not covered by other IOF specific programs that can help provide significant cost and energy savings. Examples are the Forging and Heat Treating industries which directly support the Steel and Aluminum industries, and have developed their own visions and roadmaps that can be correlated to the priority needs of the Industries of the Future.
	$0	$0	$1,800

Technical/Prog. Management Support

INTRODUCTION: Consistent with other DOE programs under the jurisdiction of the Interior and Related Agencies Appropriations Committees, the Energy Conservation programs provide funding for: (a) Technical/Program Management Support; (b) and Management Support Services.

Technical/Program Management Support includes activities such as R&D feasibility studies; R&D option development and trade-off analysis; and technical, economic, market evaluations of R&D, and contract audit costs. These activities provide important benefits directly to the R&D program described above and are therefore an integral part of the R&D program.

As directed by Congress, the FY 2001 Congressional Budget Request identifies the funding requirements for Technical/Program Management Support as shown below.

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (SPECIFIC) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Technical/Prog. Management Support (Cont'd)	Funding of $551,850 from within the Industries of the Future (Specific) Program described above was used to provide Technical/ Program Management Support.	Funding of $551,850 from within the Industries of the Future (Specific) Program described above was used to provide Technical/ Program Management Support.	A total of $706,000 from within the Industries of the Future (Specific) Program described above provides for the continuation of critical Technical/ Program Management Support.
Industries of the Future (Specific), Total	**$56,447**	**$66,000**	**$83,900**

INDUSTRIAL TECHNOLOGIES
INDUSTRY SECTOR
(Dollars in Thousands)

INDUSTRIES OF THE FUTURE (CROSSCUTTING)

I. Mission Supporting Goals and Objectives:

I. A. Statement of Mission:

The industry visions and technology roadmaps developed by OIT's industry partners have identified cross industry needs common to more than one of the vision industries. The Industries of the Future (Crosscutting) objective is to work with IOF industry partners and suppliers to: 1) conduct cost-shared R&D to develop crosscutting and enabling technologies which have applications across all of the vision industries; and 2) to provide the tools and technical assistance industry needs to speed the implementation of energy efficient, clean manufacturing technologies. Technologies such as advanced materials and coatings, high efficiency combustion systems, sensors and controls, and new distributed generation systems can be most efficiently developed by using R&D resources in specialized programs designed to address these crosscutting needs. To support the implementation of new energy efficient technologies, and to meet industry needs for better, more accessible technical assistance and tools -- OIT will provide industry with technical and financial assistance that is delivered in an integrated fashion through the National Competitiveness through the Energy, Environment, and Economics (NICE^3), Inventions and Innovations, and the Best Practices Program (including Motors, Compressed Air, Steam, and Combined Heat and Power industry partnerships).

The goal of the IOF Crosscutting program is to significantly improve the resource efficiency and competitiveness of energy and waste intensive U.S. industries by developing and implementing the crosscutting technologies, practices, and materials that can lower raw material and depletable energy use per unit produced; improve productivity; and reduce the generation of wastes and pollutants. Working in collaboration with industry, national laboratories, and university partners, the IOF Crosscutting Program goal is to save almost 1 quadrillion Btu of energy in the year 2010.

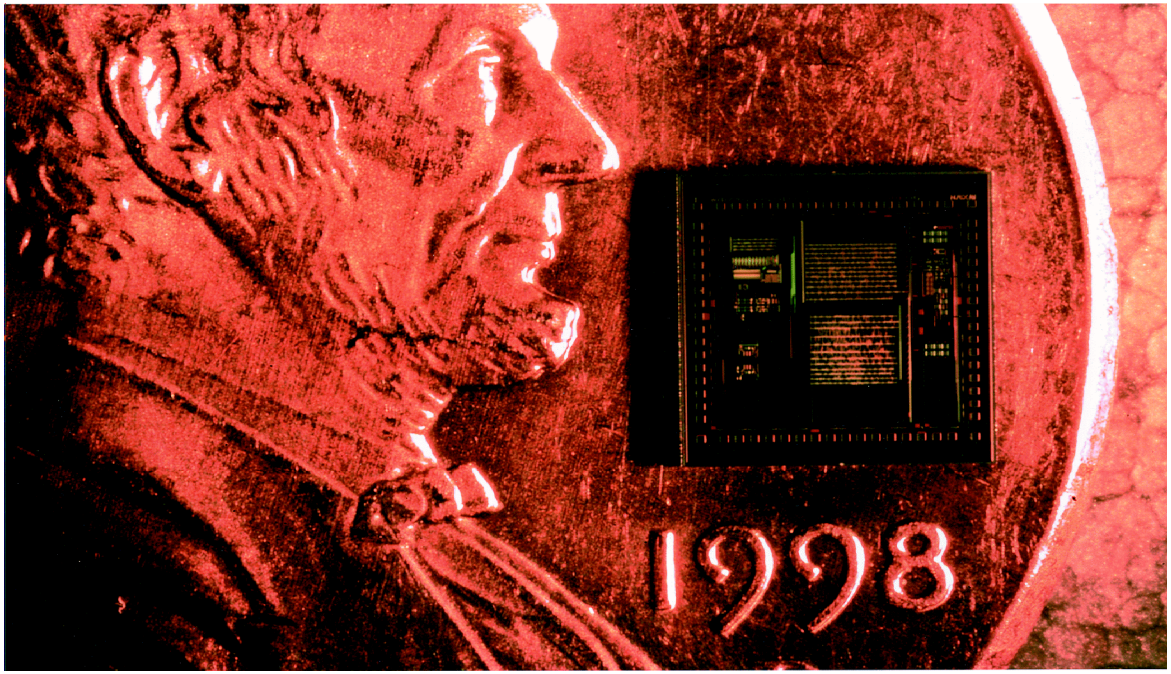
In FY 2001, OIT will spend a total of about $1,460,000 of IOF crosscutting funds on specific projects through the State Energy Program Special Project State Grants, which is a collaborative effort with the Office of Building Technology, State and Community programs. These activities are directed toward developing partnerships between states, energy-intensive industries in those states and the Federal government in order to implement IOF at the state level. In FY 1999, grants to 27 states focused on implementing IOF in specific states taking a variety of approaches appropriate to state needs, state industries and available resources.

The IOF Crosscutting planning units include enabling technologies, distributed generation, financial assistance and technical assistance.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

Enabling Technologies: Addresses the critical technology challenges IOF industries face for developing: 1) new, advanced industrial materials and ceramics that can reduce energy use, lower emissions, increase component life, optimize process operating conditions, and reduce down time; 2) high-efficiency, clean combustion technology that can produce uniform, high-quality end products at high production rates; and 3) sensors/control systems that can operate in high temperatures and harsh environments while increasing process efficiency.

Sensor and control technologies are ubiquitous in industrial processing, as shown by approximately 76% of the estimated worldwide market of $26 billion annually is in process control applications related to the IOF industries. Recognizing this importance, the Panel on Manufacturing Process Controls of the National Research Council, National Materials Advisory Board recommended that OIT continue to lead the interagency and intra-agency coordination of progress in complementary (sensor and control) technologies to avoid duplications.



"Wireless Sensor on a Chip"

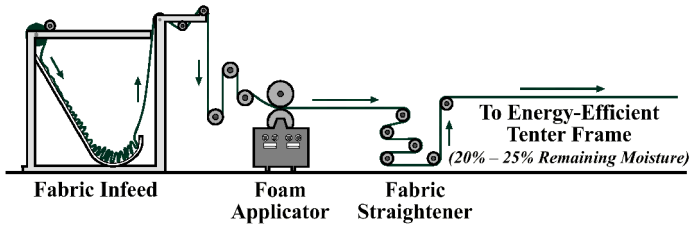
Distributed Generation: Industrial end users need and want new options for producing on-site electricity or to produce two forms of power such as electricity and steam from the same fuel source. This program seeks to develop: 1) new high-efficiency, industrial power generation/ cogeneration systems including microturbines, and reciprocating engines and; 2) industrial distributed generation systems (utility and IOF R&D partnerships).

Financial Assistance: In FY 2001, OIT continues the integrated delivery of grant services initiated in FY 2000. The goal of the program, which includes the Inventions and Innovation (I&I) Program and the NICE^3 Program, is to provide critical financial assistance in the form of grants to: 1) speed the development of new energy efficient technologies and 2) leverage industry and other resources to demonstrate and promote the benefits of energy savings, pollution prevention, and cost savings possible through the adoption of clean, energy-efficient industrial technology.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

By continuing to reduce overhead activities and running parallel solicitations, additional worthy projects will be supported, and it will be easier for industry and states to participate. The programs use regional centers to more effectively leverage local resources and to better tailor assistance to specific regional needs and situations.

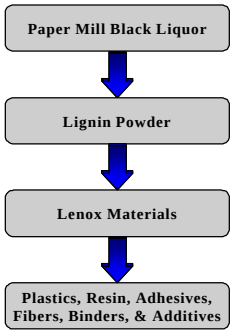
Brittany Dyeing and Printing Corporation



With a NICE[3] grant of $425,000 and over $750,000 of its own money, Brittany Dyeing and Printing Corporation developed and demonstrated a new fabric finishing process that reduced energy consumption more than 60% and reduced water usage by 65%. The annual cost savings from the energy and water savings alone amount to more than $140,000. The new process, developed and demonstrated at its New Bedford, MA. facility in an empowerment zone, is twice as fast as the conventional technology which allows the company a competitive edge against imported fabrics. The new technology is now available throughout the country.

Lenox Polymers, Inc.

With an initial $61,739 from the Inventions and Innovation Program, Lenox Polymers, Inc., found a replacement polymer for petroleum-based resins which emit hazardous fumes during production and use. The new polymer, now used in over 20 different products including canoe seats, car spoilers, and an aerosol spray which increases tire traction, is recycled from black liquor, a byproduct of the pulp and paper industry. The polymer is environmentally friendly and emits no hazardous materials. Uses have been found for the polymer in the automotive, foundry, plastics, and marine industries and also as binders for plywood and particle board used in the construction and furniture industries. The pulp and paper industry generates 500 billion pounds of black liquor annually.



- Non-toxic, specialty performance resins created from pulp mill waste (black liquor)
- Applications include foundry resins for metal casting, wood particulate binders (for plywood and particle board), and compression molding polymer systems
- Save petrochemical resources by using a renewable-source, lignin--the natural glue that holds the cellulosic fibers of trees together
- Free of formaldehyde, phenol, and styrene

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

Technical Assistance: In FY 2001, the integrated delivery program will continue to provide a means of bringing the full range of tools, technical assistance and technology to thousands of plant sites. OIT calls this mechanism integrated delivery because information and technology are delivered at the corporate, managerial, technical, and plant levels of U. S. industry. This new approach will have an important role in launching new industrial technologies from the research and development stage to the manufacturing plant where the technology can be used to boost the productivity and competitiveness of U.S. industry. In this integrated delivery process, OIT works with industrial firms to host a plant-level showcase of as many OIT and DOE technologies as possible. The showcase demonstrates successful technologies to other companies and increases awareness of and confidence in these technologies. Two examples of the way this process works are:

Recommendations by Industrial Assessment Center students at San Diego State University helped Precision Products of Rancho Cucamonga, California, reduce costs by $81,450 per year. One suggestion alone to filter and reuse its blasting water saved over $7,800 a year with a one-time investment of only $750.

By installing new energy-efficient motors in both existing and new assembly lines, one engine manufacturer saved an estimated $208,000 per year in annual motor system energy costs, and reduced carbon emissions by over 200 tons per year. This upgrade was a direct result of Motor Challenge partnerships and tools such as the MotorMaster+ software which helps companies to compare motor systems and estimate their investment costs vs. energy savings.

1) At Bethlehem Steel's Burns Harbor Plant, OIT and plant site personnel developed an ongoing partnership that allowed OIT to deliver its applicable programs, technical assistance, tools, and expertise in an integrated fashion. Through the aggressive use of these services, the plant achieved significant energy, environmental, and productivity gains and has become an industrial showcase of energy efficiency in steel production.

2) Working with the American Foundrymen's Society and three manufacturing plants, OIT developed a showcase for a new metal casting technology known as the lost-foam process. This is an improved, energy efficient casting process that relies on foam patterns to produce metal castings of higher-quality and in more complex shapes than can be achieved in most other casting technologies. By providing technical assistance, and showcasing the foam pattern manufacturer and two plants currently using the new process (a cast-iron caster and an aluminum caster), OIT and its industrial partners were able to demonstrate throughout the metal casting industry the value of this new technology.

I. **Mission Supporting Goals and Objectives**: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

The goal of the integrated delivery program is to facilitate and promote the introduction to industry of near-term and emerging energy efficiency, renewable energy, and pollution prevention technologies. This initiative was developed to respond to OIT's industry partners' requests for a simpler, integrated package of industrial energy efficiency technologies, technical and financial services that is both flexible and easy to access. The strategy and implementation plans for this coordinated, integrated delivery approach will concentrate on outreach and technical assistance to IOF companies and plants. In addition to deploying specific emerging technology from the R&D technology portfolio, OIT will depend heavily upon the technology resources offered from several key OIT technical assistance programs. These programs include: Best Practices Program (Combined Heat & Power or CHP, Motors, Steam, and Compressed Air), and the Industrial Assessment Centers (IACs).

By simply switching off one of four fans in each system in its pot-line fume collection system and regulating the flow from the remaining three fans, Alcoa increased fan efficiency to 84% and reduced energy consumption 12%, saving $103,736 per year. By serving as a Showcase Demonstration site for the Motor Challenge program, this simple yet effective solution to energy waste, and other solutions like it, are taught to thousands of other plants which use similar processes.

The Best Practices Program (which includes Motors, CHP, Steam and Compressed Air industry partnerships) will help U.S. manufacturers by providing credible technical information and assistance that helps them lower energy bills with little to no capital investment through the adoption of new technology. These programs alone could help manufacturers save over 150 trillion Btu in 2010, which also increases U.S. productivity and competitiveness while preventing over 3.0 MMTCE emissions of greenhouse gases. The CHP goal is to double the amount of CHP installed capacity in the U.S., approximately 46 gigawatts by 2010.

I. B. Program Benefits

Industries of the Future (Crosscutting)			
	2005	**2010**	**2020**
Total Primary Energy Displaced (Quads)	.22	.51	1.38
Total Energy Cost Savings (Billion $)	.98	2.44	6.20
Total Carbon Reduction (Million metric tons)	4.60	11.73	34.60

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

OIT (IOF Crosscutting) Office of Energy Efficiency and Renewable Energy Energy Efficiency Accomplishments through the Year 1999		
Metric	**1999 Benefits**	**Cumulative Benefits through 1999**
Primary Energy Displaced (quads)	0.155 (projected for 1999) 0.130 (1997, estimated)	1.46 (projected for 1999) 1.16 (1997, estimated)
Energy Savings ($ billions)	$0.75 billion (projected for 1999) $0.63 billion (1997, estimated)	$4.06 billion(projected for 1999) $3.37 billion (1997, estimated)
Carbon Reduction (million metric tons)	2.64 MMTCE (projected for 1999) 2.21 MMTCE (1997, estimated)	25.4 MMTCE (projected for 1999) 20.2 MMTCE (1997, estimated)
Note: Not all benefits are captured. Productivity benefits to industry and benefits relating to waste minimization and the environment are considerably larger than the direct energy benefits. For the IAC program alone, annual non-energy cost benefits are projected to be $228 million in 1999 (with a cumulative total of $1.7 billion through 1999).		

Productivity improvements could result in other cost savings equal to or greater than the energy cost savings. To put these benefits into perspective, the estimated energy savings alone (in 2000) are almost enough to provide all the energy that the State of New Hampshire uses in one year (1995 data, New Hampshire used .285 quads).

I. C. Performance Measures

<u>ENABLING MATERIALS - ENGINEERED CERAMICS/CFCCS</u>

<u>MEASURE</u>

Two new industrial applications by 2001.

Key challenges to new industrial applications are long-term product life, cost and demonstrated reliability to industrial end-users.

As Continuous Fiber Ceramic Composite (CFCC) research progresses toward increased application survival and strength, CFCC Program participants will begin to introduce industrial applications. Figure 1 shows the roadmap for resolving key challenges for CFCC materials for

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

several application opportunities and includes estimates of timing for industry to be confident enough to pursue initial CFCC applications in significant levels of field testing. Continued efforts also involve demonstrating that the CFCC materials can meet industry life targets in selected application environments. Reliability and long term stability are being addressed by iterations between CFCC material development and testing in simulated and real application environments. Cost and quality/reproducibility are being addressed by CFCC fabrication process development plus discussions with industry to negotiate realistic life cycle cost targets. Arrows in Figure 1 indicate anticipated introduction of CFCC Technologies.

Although many ceramics perform well at considerably higher temperatures than conventional metal alloys, they are generally brittle and as a result can exhibit catastrophic failure in service. CFCCs offer all the advantages of ceramics - resistance to heat, corrosion, erosion, and chemical activity - while adding toughness (strength) and thermal shock resistance. The strength of CFCCs as a function of temperature is shown in the Figure 2 graph. The graph shows that CFCC materials maintain a strength advantage over high alloy steels at elevated temperatures. Superalloys are limited to temperatures under 1800^0F, while CFCCs are useful to at least 2200^0F.

Figure 1. Simplified CFCC Roadmap

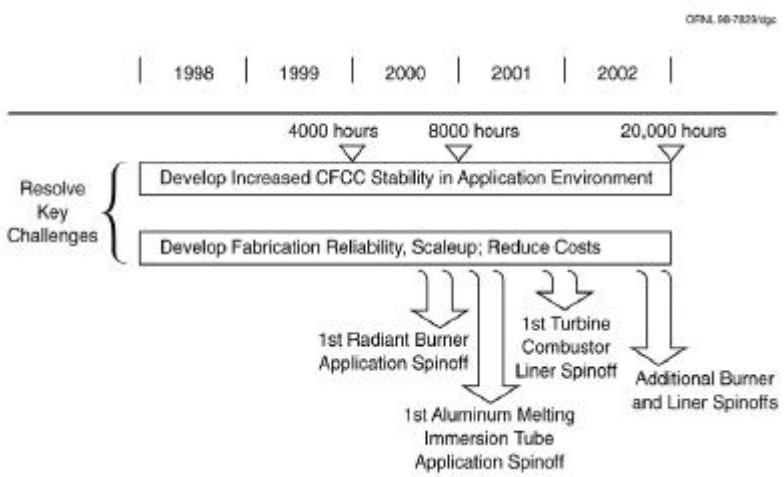
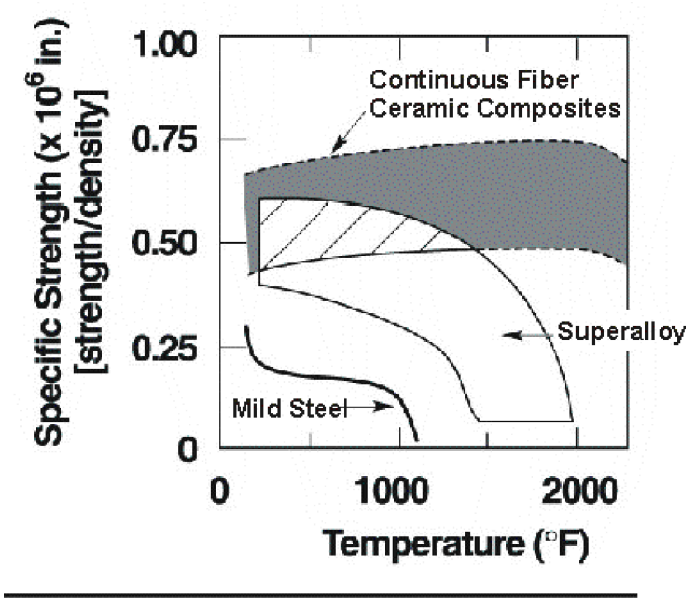


Figure 2. CFCC Strength



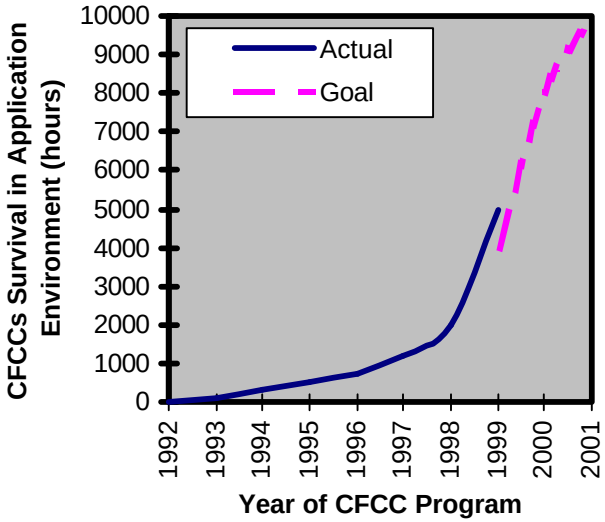
I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

Application survival / hours of testing.

CFCCs are a complex material system consisting of a carefully designed architecture of ceramic fibers in a ceramic matrix with an interface layer between the fibers and matrix. Extensive development iterations have been required to achieve combinations of fibers, matrix, and interface that provide acceptable strength, toughness, and other properties and that are stable under the application conditions (temperature, atmosphere, stress, cycles).

As shown in Figure 3, major progress has been accomplished. Application survival has increased from less than 10 hours under laboratory conditions at the beginning of the Program (1992) to approximately 5,000 hours more recently (1999) in a realistic industrial application environment. The 5,000 hours is 1,000 hours more than the projected goal for 1999. Although CFCC life has now been increased to several thousand hours, many of the industrial applications require a minimum of 10,000 - 20,000 hours. Mechanisms of property degradation are being identified and promising routes to solutions are being pursued.

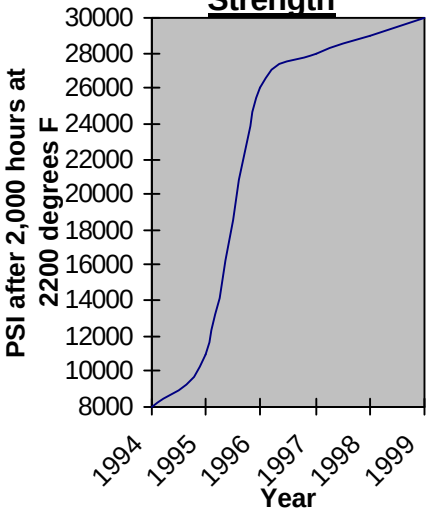
Figure 3: Survival Goal: 20,000 hours



CFCC material strength.

CFCC material strength has increased since the beginning of the CFCC Program as shown in Figure 4. Over the period 1994 to 1999 CFCC retention strength has increased from 8,000 psi to over 30,000 psi after exposure to 2200^0F for 2,000 hours. Prior to 1995, ceramic grade Nicalon™ fiber was used to produce CFCCs. A significant jump in material strength occurred in 1995 due to the introduction of Hi-Nicalon™ fiber.

Figure 4: CFCC Material Strength



I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

FY 1999 Accomplishments

- Demonstrated commercial application of CFCC combustor liners in retro-fitted commercial industrial gas turbines at Malden Mills.
- Developed and published codes and standards for CFCC for use in design and testing in cooperation with industry partners, American Society for Testing and Materials (ASTM), American Society for Mechanical Engineers (ASME), International Organization (Comite' Europe'en de Normalisation), and DoD.
- Fabricated and tested representative CFCC components, including turbine tip shroud in gas turbine engine test rig and immersion tubes for use in the metalcasting industry.

FY 2000 Planned Accomplishments

- Demonstrated CFCC immersion tubes at a metalcasting production facility.
- Demonstrated CFCC shrouds for 1,000 hours in gas turbine engine.
- Demonstrated CFCC radiant burner screen for use in glass industry.

FY 2001 Planned Accomplishments

- Demonstrate CFCC furnace fan in metal heat treating furnace for 2,000 hours.
- Demonstrate 25% cost reduction in CFCC manufacturing for immersion tubes.

FY 2002 - 2005 Planned Accomplishments

- Develop and demonstrate CFCC infrared burner for use in paper drying facility.
- Develop life prediction design codes for CFCC industrial components.

I. Mission Supporting Goals and Objectives: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

ENABLING MATERIALS - ADVANCED INDUSTRIAL MATERIALS

MEASURE

Increased Deployment of New Advanced Industrial Materials

Measure	Baseline (2000)	Projected
Deployment of Intermetallic Alloy to Industry	Four	Three more by 2001 Three more by 2002 Three more by 2003
Transfer Membrane Technologies to IOF Teams for Demonstration	Two	One more by 2001 Two more by 2002
Deploy Infrared and Plasma Heat Treating Process to Industry	None	One by 2001 Three by 2002

By the year 2002, in collaboration with the DOE National Laboratories, their industrial partners, and universities, the Advanced Industrial Materials (AIM) Program will develop high performance materials for the Industries of the Future to reduce energy consumption, improve productivity and product quality, and reduce greenhouse gases. The emphases will be on high temperature, corrosion and wear resistant materials with superior fatigue resistance and on improved materials for separations in the process industries. The long term objectives are to increase the service lives and reduce repair and maintenance interruptions, thereby saving a significant portion of the energy now wasted in these industries, and to replace much of the energy and capital intensive distillation and recrystallization processing now used in liquid and gas separations. In addition, opportunities for more energy efficient and cost effective methods for production of materials will be identified, followed by research to demonstrate these technologies. These long term objectives are to be realized by nurturing promising technologies through the interval between basic research to the stage at which they will be funded for demonstration by the IOF teams. The Metals Processing Laboratory at Oak Ridge is supported as a user center to work with the IOF industries. To date, more than 80 short term projects have been completed or are in progress.

Application of high temperature materials is in response to clear opportunities for large savings in energy and productivity costs. The cost of metallic corrosion alone was estimated to be between $70 and $300 billion per year and the cost of corrosion in the IOF industries is undoubtedly very high and saving even a few percent of that will save enormous amounts of energy. Combustion processes alone are estimated to use about one half of the industrial energy use, about 15 Quads.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

The focus on new materials for separations is also in response to opportunities for large savings in energy and productivity costs. For distillation alone, U.S. industry uses 0.75 Quads per year. Replacing distillation by a membrane separations system or catalytic membrane reactors, in general, will save approximately 75% of the energy required for separation of liquids or gases in industrial processes. Cryogenic recrystallization uses about 0.1 - 0.2 Quads and similar savings can be realized. The Vision 2020 Separations Roadmap for separations states, "Adsorbents, membranes, and separative reactors are alike in that (a) they are all relatively new or underutilized technologies and (b) they are all dependent on one or more new materials." If, by development of these materials, only two percent of all distillation and recrystallization systems could be replaced per year, about 16 trillion BTUs could be saved each year and the cumulative effect over the next two decades would be very large. Though the AIM Program alone cannot make all this come about, the potential is the basis for performance measures.

<u>FY 1999 Accomplishments</u>

- Determined the optimum process cycles for making intermetallic composites by reactive metal penetration (RMP) and measured properties as a function of temperature.

  - Will reduce the cost of fabrication of intermetallic composites; study of the wetting of solid particles by molten aluminum has led to the potential of developing improved refractories for aluminum processing.

- Developed new iron aluminide materials for die casting and boiler applications.

  - Will increase the life times of die materials, saving significant cost and energy; tubes for boilers will virtually eliminate coking in ethylene crackers in the chemical and petroleum industries.

<u>FY 2000 Planned Accomplishments</u>

- Complete development of the process for uniform metal droplet manufacturing and deploy to industry.

  - Will enable development of greatly improved hot gas filters for industrial operations and power generation and will reduce the cleanup time in these processes.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

<u>FY 2001 Planned Accomplishments</u>

- Complete development of the infrared and plasma heating process for heat treating alloys and formation of hard surface coatings.
  - Will reduce energy consumption in steel heat treating by preheating the material prior to entry into the furnace; will provide an inexpensive method for surface hardening of metals by heat treating only the surface and by development of new hard coatings.
- Complete project on making intermetallic composites by reactive metal infiltration.
  - Will reduce cost and energy consumption in composite fabrication and provide a unique microstructure with improved toughness.
- Initiate integration of advanced industrial materials and continuous fiber ceramic composites programs into Industrial Materials for the Future Program.
-
  - Integrated program will greatly improve effectiveness and more closely align the materials development efforts with Industries of the Future.

<u>FY 2002 - 2005 Planned Accomplishments</u>

- Develop new nickel silicide alloys for acid resistance in the chemical, petroleum, and agriculture industries.
  - Will prolong useful life times for industrial components, saving energy through reduced down time for maintenance and repair and money for replacement materials.
- Develop new membranes, based on molten salt transfer phenomena, for separation of hydrogen and carbon dioxide.
  - Will reduce energy consumption and cost of separating these components in the petroleum refining and chemical industries and result in a less expensive method for recovery of hydrogen.
- Develop a new class of membrane separation materials, based on phosphate chemistry.
  - Will provide more efficient separation of liquids and gases at very high temperature, reducing reliance on energy intensive distillation processes; will provide better selectivity and throughput.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

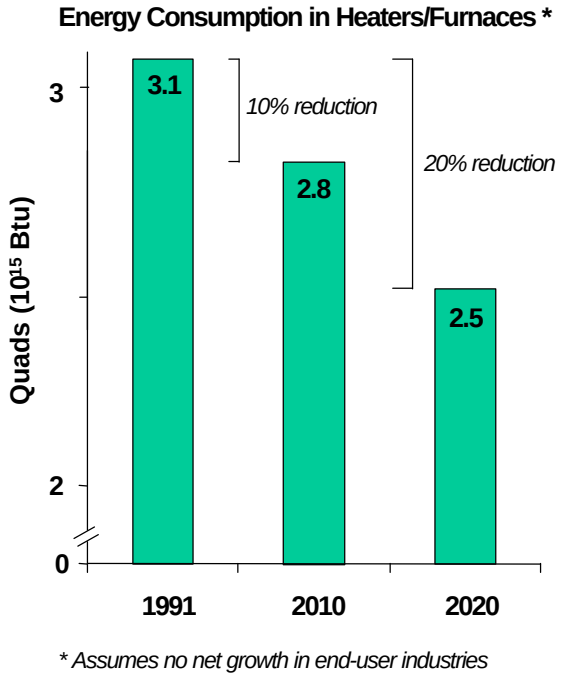
- Complete integration of advanced industrial materials and continuous fiber ceramic composites into a single OIT materials program.
  - Will improve effectiveness of materials development for the Industries of the Future.

ENABLING MATERIALS - COMBUSTION SYSTEMS

MEASURE

Reduce heater/furnace specific fuel consumption by 10% by 2010 and 20% by 2020 relative to 1991.

The energy efficiency of industrial combustion systems is critical to U.S. industry. These systems supply over 80% of the necessary steam and heat to the petroleum refining, forest products, steel, chemicals, and glass industries, and significant percentages in other industries. Therefore, advanced combustion systems have the potential to contribute greatly to overall U.S. industrial energy efficiency. Specific fuel consumption is defined as energy use per constant dollar of product, using 1990 as a base year. Due to the variety of industrial combustion systems and industries that use them, all targets are meant to be averages. Some industries may be able to exceed fuel consumption reduction targets while others do not attain them.



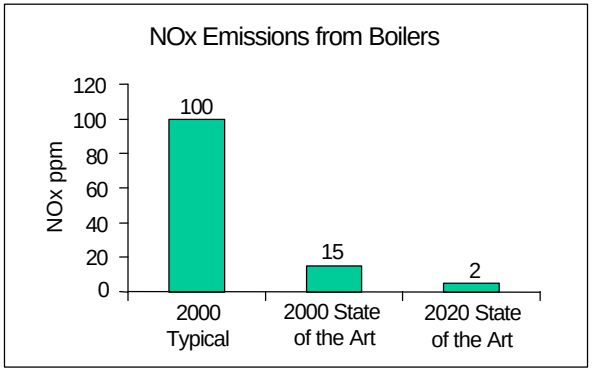
Reduce criteria pollutant emissions from heaters/furnaces by 90% by 2020 relative to 1990.

The most critical issue facing industrial combustion systems and their users in the future is more stringent emission standards. The industrial combustion community must develop combustion systems that can continue to deliver process heat and steam to meet customer needs while also meeting these strict standards.

Due to the variety of industrial combustion systems and industries that use them, all targets are meant to be averages. Some industries may be able to exceed the emissions reductions while others do not attain them.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

Reduce NOx emissions from gas-fired boilers to 2ppm by 2020.



Assumes that the goal of 2ppm must be technically attainable on a practical basis (economically). Nitrogen oxides, or NO_x, will have the greatest impact on industry for the foreseeable future. The development of state-of-the-art low NO_x burners under OIT funding has shown clearly that improved heat transfer can simultaneously reduce NO_x emissions and increase overall system efficiency. Thus, OIT's new generation of combustion projects is integrating the burner and boiler (or furnace) to maximize heat transfer and minimize emissions as a route to achieving ambitious NO_x targets at the lowest possible cost.

<u>FY 1999 Accomplishments</u>

- Extended oscillating combustion to rotary hearth furnace, continuous steel plate reheat furnace and to glass furnace.
- Completed combustion technology roadmap by combustion system users and manufacturers to guide industry-wide combustion activities, including those of OIT.
- Initiated new generation of combustion projects to meet industry-generated vision and roadmap targets in advanced boiler and process heater markets.

<u>FY 2000 Accomplishments</u>

- Demonstrated an advance which increases efficiency and lowers the cost of oxy-fuel dilute/oxygen combustion systems.
- These projects are to produce combustion systems which, relative to today's equipment, reduce NO_x by over 85% to single digit levels and increase thermal efficiency to over 90%.
- Solicitations for black liquor gasification for pulp and paper mills was completed with one award and several pending.

<u>FY 2001 Planned Accomplishments</u>

- Complete initial site analyses for black liquor gasification for multiple sites and initiate R&D critical components.
- Redesign steel furnace to obtain maximum efficiency and minimum emissions with oxy-fuel/dilute oxygen combustion system.

I. Mission Supporting Goals and Objectives: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

FY 2002 - 2005 Planned Accomplishments

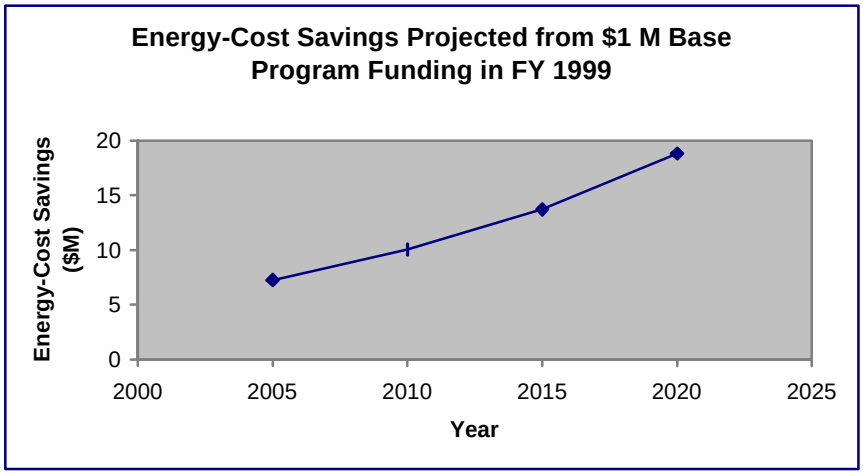
- New generation projects begun in FY 1999 are expected to reach the host site demonstration phase and appropriate evaluations at industrial facilities will occur.

- Bio-gasification technologies will be demonstrated in the mill environment, leading to their initial commercialization by 2008.

ENABLING MATERIALS - SENSOR & CONTROLS (S&C) TECHNOLOGIES

The worldwide markets for sensing technologies and for process controls are $15 billion and $26 billion a year, respectively, with the United States being the largest provider and single national market. The major share of both the sensor and the process control markets is in the manufacturing sectors targeted by the Industries of the Future (IOF) Program. The high-volume use of sensor and control technologies in IOF sectors is based on the realization that significant resource/process efficiency and waste reduction can be achieved through intelligent process control using real-time measurement information. Critical to achieving the set targets of reduction in energy use and carbon emissions by the IOF vision industries is the development and delivery of sensor and control solutions for the 205 unmet needs as documented in the IOF technology roadmaps. The S&C Program aims at delivering these needed solutions with broad applicability across multiple industry sectors, with a particular focus on high-risk and high-payoff technology research, development, and demonstration activities.

Based on the S&C Program FY99 funding of $1M, the projected energy cost savings, energy reduction, and carbon emissions reduction are shown in the respective charts provided.



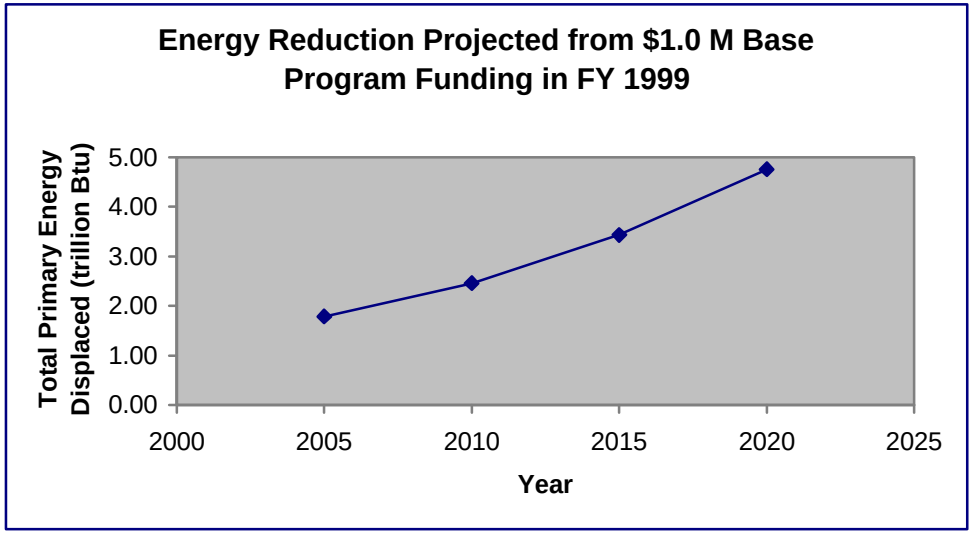
MEASURE

Commercialize two integrated sensor and control systems in 2003 and each year thereafter. Introduce intelligent control systems for harsh environment applications by 2005. Introduce wireless sensors for industrial applications by 2010.
The Program will serve as the lead to commercialize two emerging on-line measurement systems by 2003 and to commercialize two integrated sensor and control systems each year thereafter. A return on federal investment of a minimum of 5:1 will be realized from the implementation of each emerging, commercialized technology at IOF industry sectors.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

Technology development continues to succeed in overcoming technical risks and in achieving technical progress as anticipated by technology developers and subject-area experts; the desired capital and operating costs of the emerging sensor and control systems by IOF users remain unchanged during the technology development, demonstration, and commercialization phases.

Sensors for Harsh Environment Processes – introduce a new family of sensors for applications in high-temperature, reactive, corrosive, and sometimes toxic environments by 2005. This will lead to an increase in process efficiency by 15 percent and a reduction in emissions by 10 percent by 2005, based on the 1997 data of individual industrial processes.



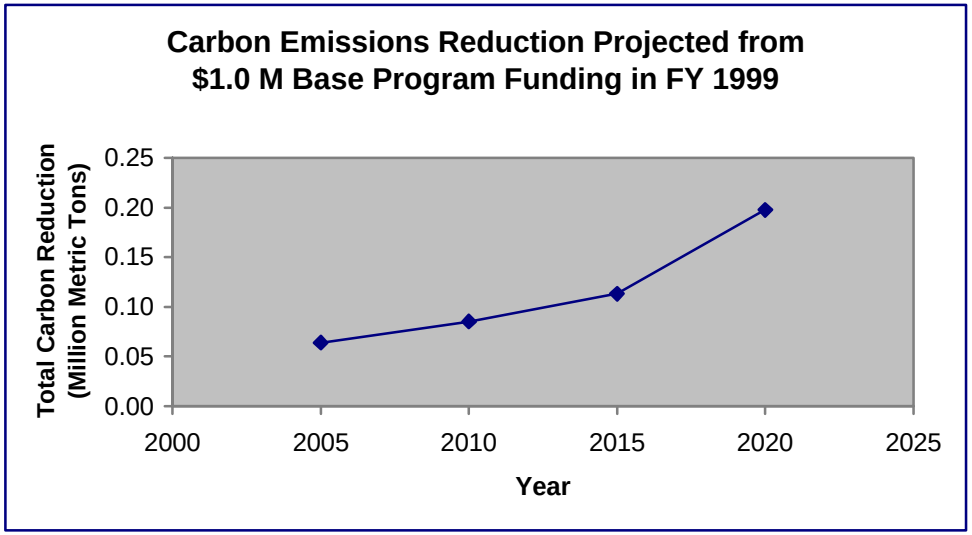
This goal is based on the recommendation of the President's Committee of Advisors on Science and Technology (PCAST), as cited in its November 1997 report entitled "Federal Energy Research and Development for the Challenges of the Twenty-First Century." Benefit projections for the domestic steel industry by the American Iron and Steel Institute (AISI): a reduction of $146 million in annual production costs including an annual energy savings potential of 6 trillion BTUs, from the successful development of sensor and control system technologies.

Durable and robust technologies for on-line, real-time measurements in harsh environments are generally lacking. Baseline applications often involve shutting down the process, waiting for the temperature to cool off, and then sampling for analysis. The practice of such process interruptions hampers the ability to control the process in real-time to assure quality products and also results in higher energy use with fewer cycle times of furnaces and equipment. Assumes that the current collaborations with other federal programs such as Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) grants in jointly developing harsh environment sensor and control systems will continue; the Advanced Industrial Materials Program will continue to focus on new materials R&D for improved lifetime of use in harsh environments.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

Wireless Sensors – The Program will introduce wireless sensors for industrial applications by 2010. This will lead to an increase in process efficiency by 10 percent and a reduction in emissions by 25 percent by 2010, based on the 1997 data of individual industrial processes.

This goal is based on the recommendation of the President's Committee of Advisors on Science and Technology (PCAST) (November 1997, "Federal Energy Research and Development for the Challenges of the Twenty-First Century"). It assumes continued projected development of microsystem sensor technologies funded by other federal programs (especially at the Defense Advanced Research Projects Agency, or DARPA) and biomedical industries; the continued growth projection at a 20 to 30 percent annual rate for microsystem devices will be sustained to achieve a critical mass enabling the reduction of production costs to a level acceptable to industrial users.



<u>FY 1999 Accomplishments</u>

- Initiated seven sensor and control projects affecting the accomplishment of five IOF industry vision plans.
- Collaborated with SBIR/STTR Program to engage small businesses in innovative research and development and transfer of advanced sensor and control technologies.
- Convened Steering Committee to lead the sensor and control coordination across the IOF industries, NSF, and NIST.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

FY 2000 Accomplishments

- Demonstrate robust, transition-metal-oxide sensors for online monitoring of NO_x and hydrocarbon emissions from industrial processes.
- Validate the performance of an in-line Raman analyzer for real-time monitoring of impurity information in caustic processes.
- Coordinate development of microfabricated sensors and diagnostic tools with DoD.
- Develop engineering site analysis for integrating black liquor gasification into pulp and paper mills.

FY 2001 Planned Accomplishments

- Demonstrate use of an integrated ultrasonic measurement system for in-process monitoring of a steel manufacturing process.
- Demonstrate an inferential control system in an extrusion process.
- Introduce a non-proprietary, wireless-network architecture with a generic sensor interface and a simple deployment methodology ready for a beta-site demonstration.

FY 2002 - 2005 Planned Accomplishments

- Demonstrate sensing and control technologies for high-temperature-furnace applications.
- Demonstrate data fusion of critical parameters for intelligent process control.
- Demonstrate capabilities of an improved sensor technology for real-time diagnosis of material chemical properties in a manufacturing process.
- Demonstrate use of an open-architecture control system for efficient integration of off-the shelf measurement devices for displaying an industrial manufacturing process.
- Demonstrate use of an improved sensor technology for real-time data collection in high temperature and harsh environment applications.
- Demonstrate use of a micro sensor device based on MEMS technology for industrial process measurement and control.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

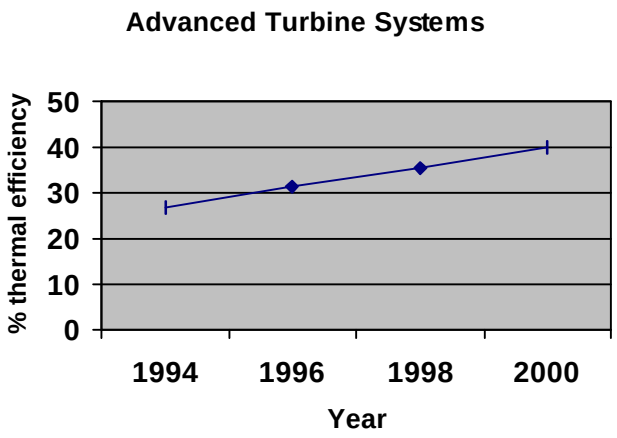
- Demonstrate capabilities of an integrated measurement system for harsh environment process industry to achieve an increase in process efficiency of up to 15 percent and a reduction in emissions of as much as 10 percent.

DISTRIBUTED GENERATION - INDUSTRIAL POWER GENERATION

MEASURE

Advanced turbine systems will be demonstrated at approximately 40-percent efficiency by the year 2000 from 27 percent in 1994.

Thermal efficiency measures the system efficiency of electric power generated from thermal or heat-producing energy sources. This metric is measured by thermal efficiency of the system (%). The goal is to help Industry will realize a 15 percent improvement in efficiency of power generation/cogeneration systems by 2010.

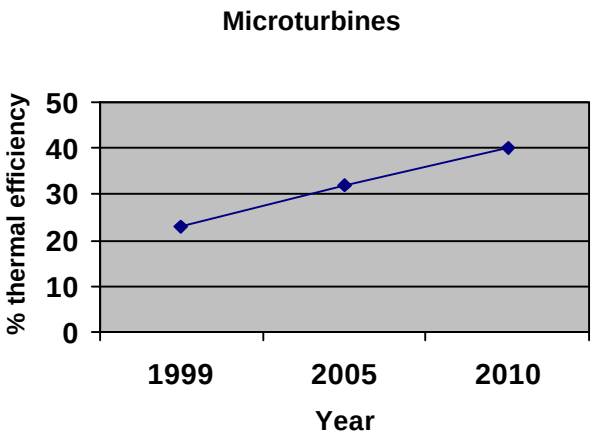


With the advent of utility restructuring, new opportunities are opening for U.S. manufacturers to use electricity even more effectively to boost productivity, cut costs, and gain additional competitive advantages. The Distributed Generation (DG) Program assists in research and development (R&D) of advanced power generation and cogeneration technologies including gas turbines, microturbines, and reciprocating engines.

The DG Program is building partnerships among the power generation community, industrial power users, gas and electric utilities, universities, Federal and state agencies, and the National Laboratories to find methods to develop and implement DG technologies quickly and cost-effectively. There is also extensive coordination among other Federal and state R&D programs, particularly those sponsored by DOE.

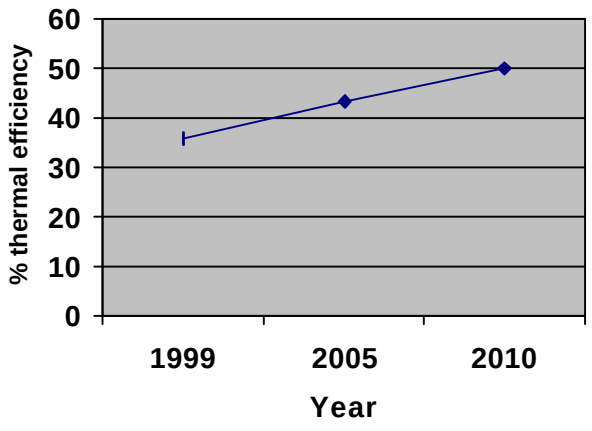
I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

Microturbines will be demonstrated at approximately 40-percent efficiency by the year 2010 from levels of 23-27% in 1999.



Thermal efficiency measures the system efficiency of electric power generated from thermal or heat-producing energy sources. This metric is measured by thermal efficiency of the system (%). Advanced microturbines can provide the opportunity for on-site generation and cogeneration, reduce the emissions to single digit, and provide quality power with high reliability and low cost maintenance. The program will be in partnership with microturbine manufactures, utilities/energy service companies, national laboratories, universities and end-users to demonstrate and successfully commercialize a product that meets or exceeds technical and economic requirements.

Reciprocating engines will be demonstrated at approximately 50-percent efficiency by the year 2010 from a baseline of 36-42% in 1999.



Thermal efficiency measures the system efficiency of electric power generated from thermal or heat-producing energy sources. This metric is measured by thermal efficiency of the system (%). Reciprocating engines have been the workhorse of the U.S. economy for backup generation and onsite generation. With the restructured utility industry, these units will generate power as consumer needs increase and capacity is constrained. The program seeks to increase the efficiency, reduce the emissions, and improve the maintenance/operation cost of these engines. The program will be in partnership with natural gas engine manufacturers, utilities/energy service companies, national laboratories, universities, and end-user to demonstrate and commercialize a product meeting user requirements.

<u>FY 1999 Accomplishments</u>

- Initiated field test evaluation of advanced thermal barrier coating systems in Advanced Turbine System (ATS) to test life and performance improvements.

- Completed ATS full scale engine test in test cell (50 hours).

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

- Completed studies on state-of-the-art micro turbines and reciprocating engines to identify opportunities for industrial power generation and back-up power.

<u>FY 2000 Planned Accomplishments</u>

- Delivered and initiated first commercial Solar ATS engine demonstration at customer site.
- Completed demonstration of the durability of next generation thermal barrier coating systems in an industrial gas turbine engine.
- Completed Phase I feasibility studies for 50% efficient reciprocating engines and 40% efficient microturbines and identified R&D opportunities.
- Initiated a utility/industrial partnership program to address industrial power research and development issues with the manufacturing sector.

<u>FY 2001 Planned Accomplishments</u>

- Complete 5,000 hour durability, performance and emissions testing of the Mercury 50 ATS engine.
- Complete 8,000 hour durability demonstration of CFCC combustor liners in a commercial industrial gas turbine for emissions reduction.
- Complete 8,000 hour demonstration of an advanced thermal barrier coating to improve gas turbine performance.

<u>FY 2002 - 2005 Planned Accomplishments</u>

- Continue low emissions work for industrial power generation technologies to demonstrate less than 5 ppm NO_x guaranteeing siting ability.
- Continue development of advanced materials to improve the durability and efficiency of power generation.
- Initiate Phase II effort for developing and rig testing advanced microturbines and reciprocating engines to achieve high efficiency and low emissions goals.

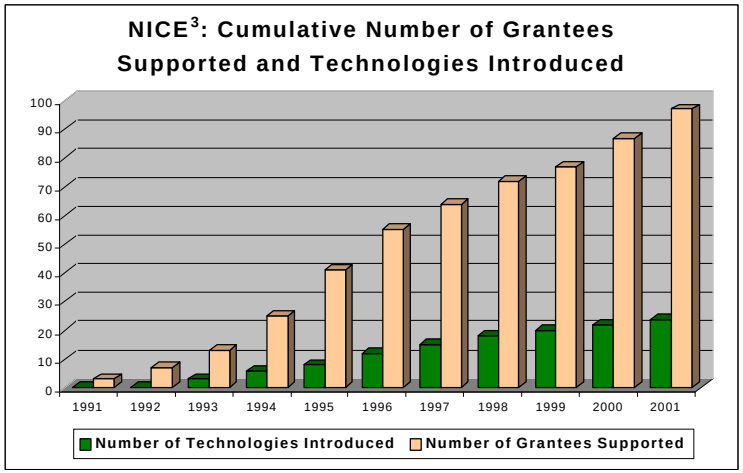
I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

FINANCIAL ASSISTANCE - NICE^3

MEASURE

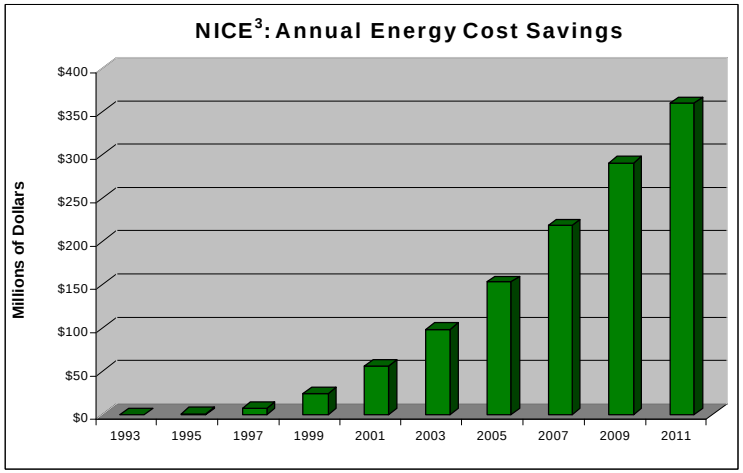
By 2001, increase the cumulative number of grantees supported since 1991 to 97 and increase the cumulative number of technologies introduced into the market place since 1991 to 24.

The number of Nationally Competitiveness through the Energy, Environment, and Economics (NICE^3) grants awarded per year has varied from 3 in 1991, the first year of the program, to 16 in 1995. The program now concentrates on energy-intensive industries to achieve its most cost-effective impact. Historically, around 25% of the technologies funded have achieved commercial introduction within two years of funding. Commercial introduction is defined as a technology having at least one unit beyond the original demonstration unit having been deployed. Because of the magnitude of the financial investment required to adopt most NICE^3 technologies, prospective buyers generally need to see one year of documented energy and waste savings, and may need another year to effectively introduce the idea within their companies and budget for the purchase of the new equipment. Commercialization is also influenced by the state of the economy, which affects the ability of industry to purchase the technologies.



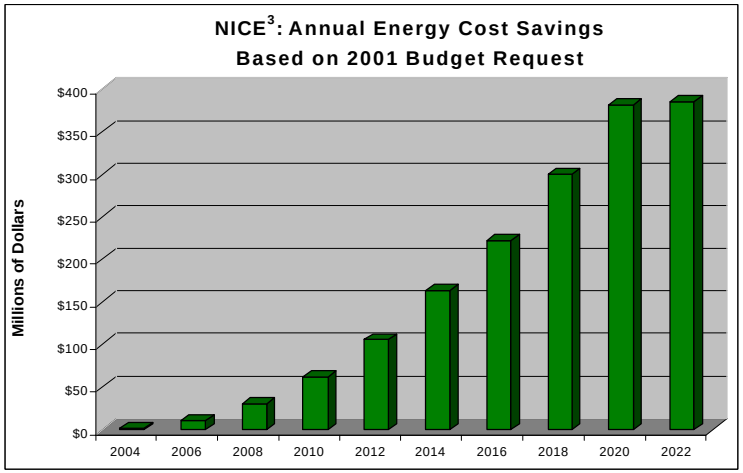
By 2010, increase annual energy cost savings from NICE^3 technologies to $331 million from $14 million in 1998.

Annual energy cost savings in 2001 are estimated to be $56 million. NICE^3 impacts represent the annual savings that accrue from all NICE^3 technologies that entered the market since the beginning of the program in 1991. Because of the magnitude of the financial investment required to adopt most NICE^3 technologies, potential users generally need to see one year of documented energy and environmental emissions savings. Achievement of the energy cost savings goal will be influenced by the amount of NICE^3 technologies that are commercialized and by energy prices.



I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

The following chart shows the effect of the FY 2001 budget request and assumes future funding at the 2001 level.



<u>FY 1999 Accomplishments</u>

- NICE^3 issued a competitive solicitation on schedule. An additional 5 new projects were funded.

<u>FY 2000 Accomplishments</u>

- OIT continued to provide integrated delivery of financial assistance services by issuing financial assistance through a competitive solicitation process. A regional network of service providers will work with state and local programs to better leverage DOE funds and promote the successful commercialization of technologies funded through financial assistance. The NICE^3 program is expected to or has issued 10 to 12 new grants designed to address pressing energy and environmental issues.

- The NICE^3 Program continued to focus on the IOF sectors. More states and territories will be added to the portfolio of participants.

<u>FY 2001 Planned Accomplishments</u>

- OIT will continue to provide integrated delivery of financial assistance services by issuing financial assistance through a competitive solicitation process. A regional network of service providers will work with state and local programs to better leverage DOE funds and promote the successful commercialization of technologies funded through financial assistance. The NICE^3 program is expected to issue 10 new grants designed to address pressing energy and environmental issues.

- The NICE^3 program will continue to focus on the IOF sectors and add to the portfolio technologies identified through the IOF strategy. More states and territories will be added to the portfolio of participants.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

FY 2002 - 2005 Planned Accomplishments

- OIT will continue to provide integrated delivery of financial assistance services by issuing financial assistance through a competitive solicitation process. A regional network of service providers will work with state and local programs to better leverage DOE funds and promote the successful commercialization of technologies funded through financial assistance. The NICE^3 program is expected to issue 10 new grants designed to address pressing energy and environmental issues.

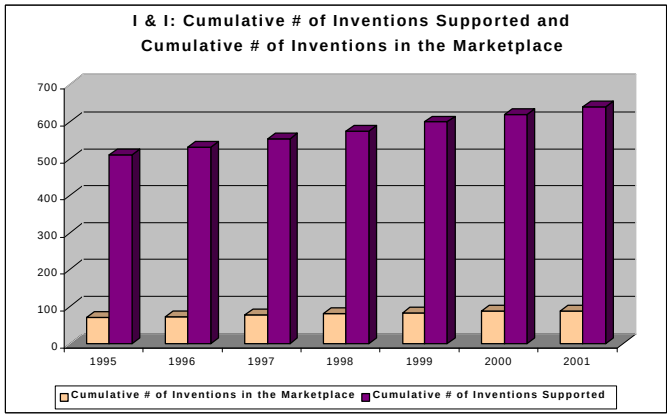
- The NICE^3 program will continue to focus on the IOF sectors and add to the portfolio technologies identified through the IOF strategy. More states and territories will be added to the portfolio of participants.

FINANCIAL ASSISTANCE - INVENTIONS & INNOVATION (I&I)

MEASURE

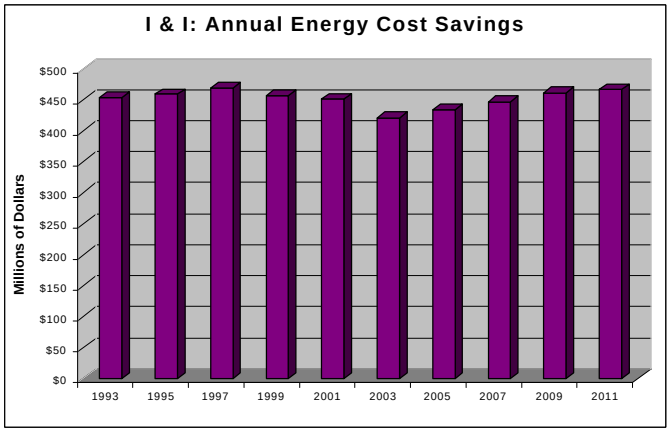
By 2001, increase the cumulative number of inventions supported since 1974 to 640, with 89 inventions in the marketplace.

Since 1974, the I&I program has provided financial support for over 600 inventions. Historically, 25% of those receiving funding ultimately achieve commercial introduction. Because some inventions that had been in the market have themselves been overtaken by improved technology, or because the 12 years of program "attribution effect" has run its course, the graph shows that about 15% of all those inventions ever funded are still in the marketplace today. The portfolio of successful inventions support includes inventions in all four major end-use market segments represented by EE's Industrial, Transportation, Buildings and Power Sectors. The number of inventions entering the market place is influenced by factors outside the control of the program, such as the state of the economy.



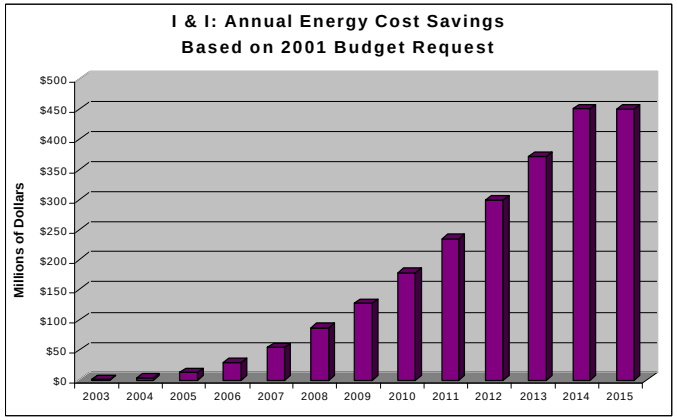
I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

By 2010, increase the annual energy cost savings from the I&I program to $468 million from $449 million in 1998.



Annual energy cost savings in 2001 are estimated to be $451 million. Annual energy cost savings are calculated using engineering estimates or actual measured savings per unit per year for every unit of every invention in use during that year, regardless of year of grantee funding. Thus, the roughly one half billion dollars saved per year is the result of the approximately 84 inventions still in the market place. Savings from any one invention are eliminated from the portfolio total after 12 years. Future estimates assume twice the average impact since the program is now more closely targeted to the industrial sector where past energy impacts have been larger.

This chart shows the energy cost savings at the FY 2001 budget request assuming constant level funding in future budgets.



<u>FY 1999 Accomplishments</u>

- For the first time, financial assistance was provided by the I&I Program through a competitive solicitation process. This process reduced the time from initial contact to award from over two years to under one year, and allowed the program to support the most worthy applicants.

- I&I issued competitive solicitations on schedule.

- The number of proposals has decreased, but the focus and quality of the proposals has been substantially improved.

- I&I issued competitive solicitations on schedule, and 27 new projects were funded.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

FY 2000 Accomplishments

- OIT continued to provide integrated delivery of financial assistance services by issuing financial assistance through a competitive solicitation process. A regional network of service providers will work with state and local programs to better leverage DOE funds and promote the successful commercialization of technologies funded through financial assistance. The I&I program issued 20 to 25 new grants designed to address pressing energy and environmental issues.

- The I&I programs continued to focus on the IOF sectors and add to the portfolio of small businesses and independent inventors supporting new technology development.

FY 2001 Planned Accomplishments

- OIT will continue to provide integrated delivery of financial assistance services by issuing financial assistance through a competitive solicitation process. A regional network of service providers will work with state and local programs to better leverage DOE funds and promote the successful commercialization of technologies funded through financial assistance. The I&I program is expected to issue 20 to 25 new grants designed to address pressing energy and environmental issues.

- The I&I programs will continue to focus on the IOF sectors and add to the portfolio of small businesses and independent inventors supporting new technology development.

- OIT will continue to provide integrated delivery of financial assistance services by issuing I&I solicitation schedules. Regional network of service providers works with state and local programs to better leverage DOE funds. The I&I program is expected to issue 20 to 25 new grants designed to address pressing energy and environmental issues.

- The I&I program will continue to focus on IOF sectors. More states and territories will be added to the portfolio of participants.

FY 2002 - 2005 Planned Accomplishments

- OIT will continue to provide integrated delivery of financial assistance services by issuing financial assistance through a competitive solicitation process. A regional network of service providers will work with state and local programs to better leverage DOE funds and promote the successful commercialization of technologies funded through financial assistance. The I&I program is expected to issue 20 to 25 new grants designed to address pressing energy and environmental issues.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

- The I&I programs will continue to focus on the IOF sectors and add to the portfolio of small businesses and independent inventors supporting new technology development.

- OIT will continue to provide integrated delivery of financial assistance services by issuing I&I solicitation schedules. Regional network of service providers works with state and local programs to better leverage DOE funds. The I&I program is expected to issue 20 to 25 new grants designed to address pressing energy and environmental issues.

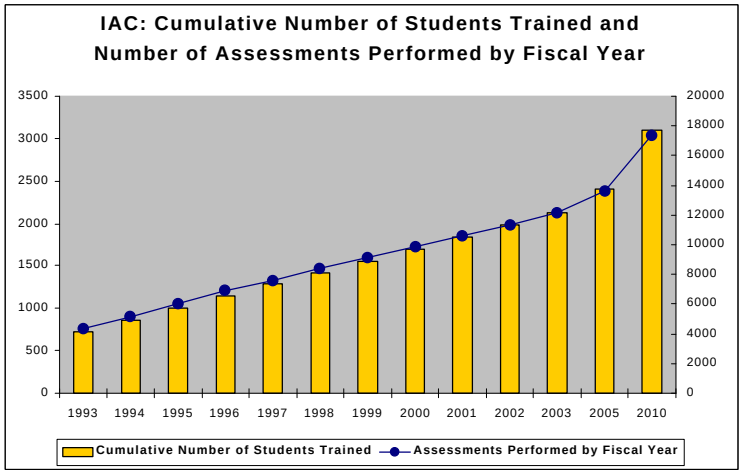
- The I&I program will continue to focus on IOF sectors. More states and territories will be added to the portfolio of participants.

<u>TECHNICAL ASSISTANCE - INDUSTRIAL ASSESSMENT CENTERS (IAC)</u>

<u>MEASURE</u>

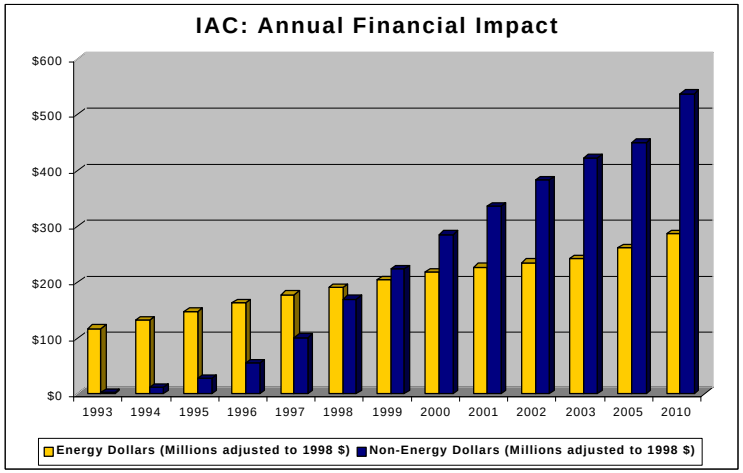
By 2010, increase the cumulative number of students trained to 3,100, and increase the cumulative number of assessments to 17,350.

The cumulative number of students trained by 2001 will be 1,840 and the cumulative number of assessments will be 10,600. Training engineering students at the 30 participating universities has been an important element in this program. Through June 1999, over 1,500 engineering students have received training through the program by conducting over 9,100 assessments. Program impacts are felt not only through the implementation of assessment recommendations, but also through replication of those energy saving technologies and practices within the companies audited. ORNL's evaluation of the program's impact has highlighted the longer term impacts coming from program alumni as they have applied the practical knowledge they have gained.



I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

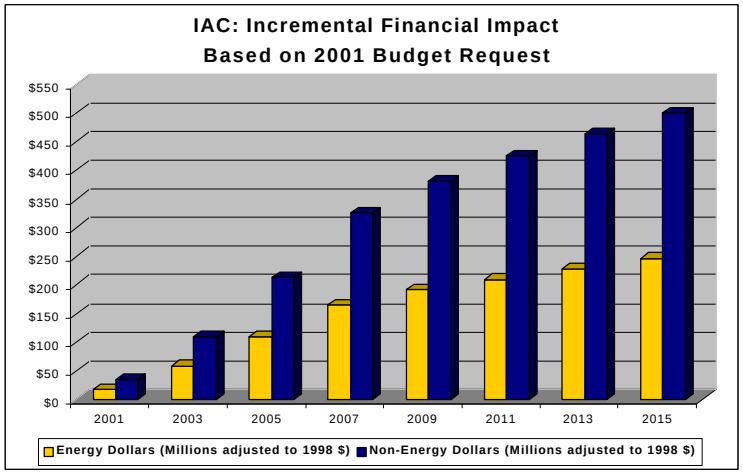
By 2010, increase the annual energy cost savings from the IAC program to $287 million and annual non-energy savings to $538 million.



Annual energy cost savings in 2001 are estimated to be $227 million and annual non-energy cost savings are estimated to be $336 million. Energy cost savings at small- and medium-sized industrial plants may be due to energy efficiency measures, fuel switching, and better pricing from utilities resulting from switching to more advantageous rate schedules. Non-energy savings include both waste savings and productivity savings. The waste and productivity savings assessments were added to the program on a pilot basis in 1993 and became a full part of the IAC program in FY 1996. Non-energy cost savings resulting from these assessments were about twice as large as the energy cost savings.

This chart shows the financial impact of the FY 2001 budget request and assumes constant level funding in future budgets.

<u>FY 1999 Accomplishments</u>



- Industrial Assessment Centers provided support to IOF integrated delivery showcase initiative. For example, the program conducted an assessment of the Lester Precision Die Casting Plant in Twinsburg, OH. This plant is working with OIT to be a showcase of efficiency. Implement recommendations of Program Critical Review. An additional 175 engineering students were trained and an additional 750 industrial assessments were initiated. IACs continued coordinating efforts with the National Institute of Standards and Technologies (NIST) Manufacturing Extension Program centers.

<u>FY 2000 Accomplishments</u>

- Six IOF plant sites participated with OIT in integrated delivery effort designed to produce plants that are showcases for energy efficiency and clean production.

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

FY 2001 Planned Accomplishments

- Industrial Assessment Centers will continue to provide support to IOF integrated delivery showcase initiative. IACs will provide critical, sector specific information on near term technical solutions that are based on actual program assessment data. IACs will continue to work with regional resources including the NIST Manufacturing Extension Program and community colleges. IACs will help replication of IOF technology through the assessment process. Program will complete implementation of recommendations from Strategic Review completed in FY 1999. Recommendations from the Revised Strategic Program Review of FY 1999 will be implemented.

- IOF plant sites will participate with OIT in integrated delivery effort designed to produce plants that are showcases for energy efficiency and clean production.

FY 2002 - 2005 Planned Accomplishments

- IACs will continue to provide support to IOF showcase plants.

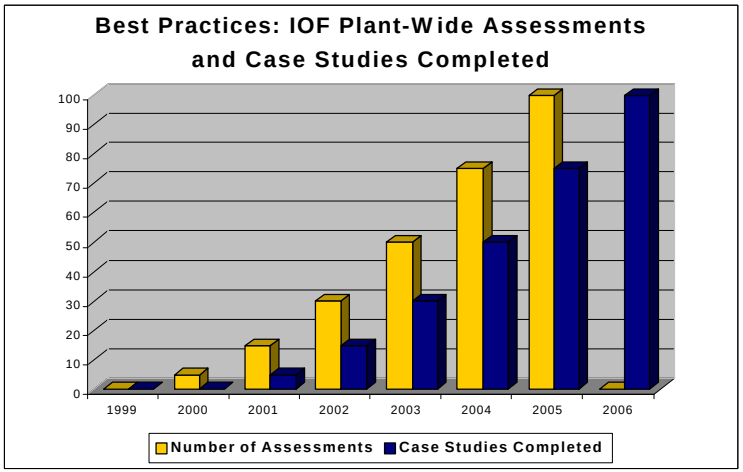
- The program will continue to be an important component of OIT's integrated delivery efforts.

- An additional 175 engineering students will be trained each year.

TECHNICAL ASSISTANCE - BEST PRACTICES

MEASURE

By 2005, increase the cumulative number of IOF plant-wide energy efficiency assessments and case studies completed to 100 and 75, respectively.



By 2001, 15 assessments and 5 case studies will be completed. All 100 plants will receive plant-wide assessments, technical assistance and develop case studies with OIT that document the results for a variety of system-focused, implemented actions. These will influence replication of similar energy savings for other plants.

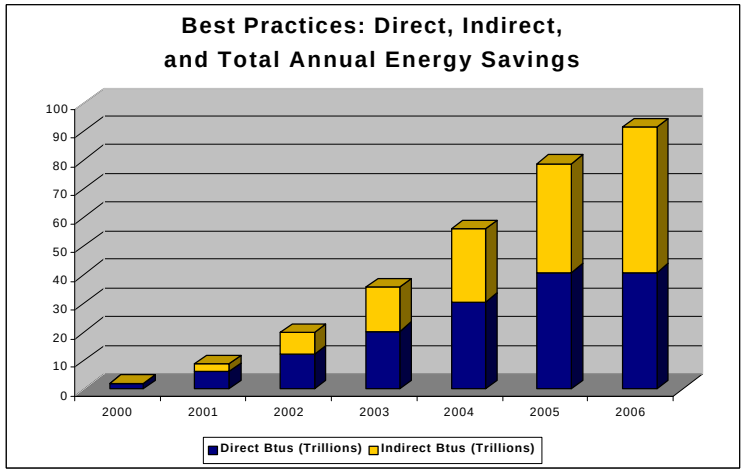
Assessments will be modeled on the IAC program where a team of engineers examines how a plant is set up and operated. Best Practice assessments will be done by qualified professionals who will take a more in-depth look over a longer period of time. Case Studies will document before and after

I. <u>Mission Supporting Goals and Objectives</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

energy usage per unit of throughput based on careful measurement and monitoring over at least one full year of operation. Plants will consider opportunities to improve energy efficiency through advanced motor, steam, compressed air and combined heat and power technologies.

Accelerate industry adoption of best-available and emerging technology, and best practices that OIT has to offer, directly saving 40.7 trillion Btu per year, and indirectly saving 38.2 trillion Btu per year by 2005.

The direct energy savings will be a result of a 10% energy efficiency gain at the 100 major industrial plants. These IOF leaders will serve as catalysts for their respective industries to influence the replication of similar energy savings for another 1,000 plants. Total energy savings by 2005 will amount to 80 trillion btus per year valued at about $280 million.



<u>FY 1999 Accomplishments</u>

- Reached over 30,000 industrial people to provide tools, information and training 6,000 end-users using Motor Master Software.

- Two hundred fifty industry partners (including suppliers, distributers, consultants, and utilities) providing energy efficiency information and tools to their customers.

<u>FY 2000 Accomplishments</u>

- Worked with six IOF plants to perform plant-wide assessments in order to identify technology opportunities for application across IOF partners.

- New integrated tool and training resource portfolio developed that will assist in promoting a plant-wide, system approach in energy efficiency opportunities.

<u>FY 2001 Planned Accomplishments</u>

- Fifteen assessments and five case studies will be completed.

I. Mission Supporting Goals and Objectives: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

FY 2002 - 2005 Planned Accomplishments

- One hundred assessments and seventy five case studies will be completed.
- Achieve replication of results of case studies at 1,000 energy-intensive IOF plant sites to save $280 million annually.

TECHNICAL ASSISTANCE - INTERNATIONAL BEST PRACTICES

MEASURE

FY 2001 will be the first year of funding. Performance measures will be developed.

FY 1999 and 2000 Accomplishments

- Not applicable

FY 2001 Planned Accomplishments

- In the international area, best practice programs will be established in at least three key developing countries. Partnerships between US industry and U.S. government non-government organizations will be established with host country entities to implement the programs and to promote the development of joint ventures, licensing and sale of U.S. technologies, tools and equipment for existing industry infrastructures.
- Engage U.S. industry in a partnership through the development of technology roadmaps to reduce the energy intensity of major energy-using industrial processes in a key developing country over the next two decades by 40 percent compared to its current performance.

FY 2002 - 2005 Planned Accomplishments

- Best practice programs will be established in at least three additional developing countries bringing the total established to six.
- As a result of the establishment and implementation of the best practice programs, at least five joint ventures will be established. Licensing and sale of US technologies, tools and equipment will be in excess of 5 million dollars per year. Environmental benefits of the program will be assessed.

II. A. Funding Table: INDUSTRIES OF THE FUTURE (CROSSCUTTING)

Program Activity	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request	$ Change	% Change
Enabling Technologies	$ 18,881	$ 36,000	$ 35,726	$ -274	-0.8%
Distributed Generation	50,103	27,300	17,300	-10,000	-36.6%
Financial Assistance	10,512	11,350	12,000	650	5.7%
Technical Assistance	18,645	19,750	25,800	6,050	30.6%
Total, Industries of the Future (Crosscutting)	$ 98,141	$ 94,400	$ 90,826	$ -3,574	-3.8%

Note: Industries of the Future (Crosscutting) includes $1,460 for the State Energy Program Special Projects State Grants, in FY 2001, $1,600 in FY 2000, and $1,200 in FY 1999.

II. B. Laboratory and Facility Funding Table: INDUSTRIES OF THE FUTURE (CROSSCUTTING)

	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request	$ Change	% Change
Argonne National Laboratory (East)	$ 341	$ 328	$ 316	$ -12.0	-3.7%
Idaho National Engineering Laboratory	303	291	280	-11	-3.8%
Lawrence Berkeley National Laboratory	1,090	1,048	1,009	-39	-3.7%
Los Alamos National Laboratory	1,100	1,058	1,018	-40	-3.8%
National Renewable Energy Laboratory	1,985	1,909	1,837	-72	-3.8%
Oak Ridge National Laboratory	19,559	18,813	18,101	-712	-3.8%
Pacific Northwest National Laboratory	2,538	2,441	2,349	-92	-3.8%
Sandia National Laboratories	1,025	986	949	-37	-3.8%
All Other	70,200	67,526	64,967	-2,559	-3.8%
Total, Industries of the Future (Crosscutting)	$ 98,141	$ 94,400	$ 90,826	$ -3,574	-3.8%

III. <u>Performance Summary</u>: (New BA in thousands of dollars)

Program Activity	FY 1999	FY 2000	FY 2001
Industries of the Future (Crosscutting)			
Enabling Technologies	**Engineered Ceramics/CFCCs**: Continued long-term field demonstration and testing of components, environmental exposure of Continuous Fiber Ceramic Composite (CFCC) components, material analysis, data collection, and database establishment. Continued sub-scale engine testing of CFCC liners for long-term durability. Initiated sub-scale component testing, including burners, immersion tubes and filters, for IOF participants. Focused work on CFCC processing technologies that would allow for tight tolerances as required by industrial applications. Continued to coordinate CFCC research with OIT's Vision Industries, DOE, DoD, NASA, and others. Assessed relevance of ceramic technology projects initiated under prior projects from the Transportation programs for development of the next-generation	**Engineered Ceramics/CFCCs**: The collaborative team among the program, industry, national laboratories, and universities will develop long term testing of CFCCs with superior high temperature strength and fatigue resistance, corrosion resistance, and wear resistance for various applications in the Vision Industries. Develop and demonstrate processing methods for reliable and cost-effective ceramic composite scaled-up to sizes and shapes consistent with industry needs for key near-term and intermediate term applications. Applications include gas turbine components, immersion tubes for molten metals, hot gas filters, radiant burners, heat exchangers, and refinery pipe hangers. Long term testing and exposure of representative CFCC components such as hot gas filters, gas turbine combustor liners, and radiant burners will be performed under application conditions for hundreds to thousands of hours.	**Engineered Ceramics/CFCCs:** With industry, national laboratories, and universities collaborative teams develop, test and demonstrate CFCCs with superior high temperature strength and fatigue resistance, corrosion resistance, and wear resistance for various applications in the Vision Industries. Industries that adopt CFCCs will realize substantial energy, economic and environmental benefits, including higher efficiency, lower maintenance and decreased operating costs. The team will demonstrate processing methods and feasibility of process scale-up for reliable and cost-effective ceramic composite in actual sizes and shapes consistent with industry needs for key near-term and intermediate term applications. In addition, initiate new applications for CFCCs and new materials to benefit process industry and distributed generation. Existing applications include gas turbine components, immersion tubes for molten metals, hot gas filters for

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Enabling Technologies (Cont'd)	microturbines. Concluded efforts which do not have relevance, redirect and/or continue funding projects which can enable microturbines to meet low emission levels (less than 9 parts per million NOx) and have long life (greater than 40,000 hours) while meeting high efficiency targets (up to 40%). ($10,881)	Develop and test advanced ceramics and coatings for industrial manufacturing processes, the next-generation microturbines and industrial gas turbines, building upon ceramic technologies developed under prior U. S. government funded programs.	particle separation, radiant burners for glass bending, and drying applications. Long term testing and exposure of representative CFCC components will be performed under application conditions for hundreds to thousands of hours. These long term exposures will allow for the collection of data to support the benefits of using CFCCs and support industrial adoption and commercialization.
		The supporting technology infrastructure is an integrated effort which addresses the design methodologies for advanced ceramics (including CFCCs), the role of material characteristics on mechanical performance, testing techniques for accurately evaluating their performance, and the development of a data base which includes life and long-term reliability in appropriate environments. These efforts help build the scientific foundation for the successful design, fabrication, characterization, and utilization of advanced ceramics for industrial and distributed power applications. ($12,000)	The supporting technology effort for advanced ceramics (including CFCCs) will continue to support the needs of industry. These efforts will build on results obtained from field testing and the supporting technology team will evaluate components that have been tested in operating conditions for a better understanding of material properties and failure methods. Databases that include life and long-term reliability in appropriate environments will be expanded. These efforts help build the scientific foundation for the successful design, fabrication, characterization, and utilization of advanced ceramics for industrial and

Program Activity	FY 1999	FY 2000	FY 2001
Enabling Technologies (Cont'd)			distributed power applications. ($12,000)
		Participants include: Allied Signal Ceramics, Engineered Composites, Inc., Dupont Lanxide, General Electric, McDermott Technologies, Textron Systems, Oak Ridge National Laboratory, Argonne National Laboratory.	Participants include: Allied Signal Ceramics, Engineered Composites, Inc., General Electric, McDermott Technologies, Textron Systems, Oak Ridge National Laboratory, Argonne National Laboratory.
	Advanced Industrial Materials: Following on successful identification of new industrial applications for, and demonstration of, nickel and iron aluminides in FY 1997, the effort continued at an accelerated pace to deploy these materials in a wider range of applications over all the Vision Industries. Additional work included titanium aluminides, which have superior specific strengths at high temperatures, in order to ready them for industrial trials. Developed chromium silicides, iron-chromium alloys, and iron-chromium-silicon alloys for molten glass contact applications and uses in corrosive atmospheres in the chemical and refinery industries continues, and	**Advanced Industrial Materials**: The Advanced Industrial Materials (AIM) Program will continue development and deployment of advanced intermetallic alloys, other high temperature alloys, polymers, membrane materials, and metal matrix composites for the IOF. These materials are designed to meet specific needs to improve productivity, product quality and energy efficiency in the Vision Industries. The focus of intermetallic alloy research and development will shift from nickel aluminide, which is a mature material being demonstrated by industry, to more rapid development of iron aluminides, molybdenum and other silicides, and titanium aluminides.	**Advanced Industrial Materials:** The Advanced Industrial Materials (AIM) Program will continue development and deployment of advanced intermetallic alloys, polymers, membrane materials, and metal matrix composites for the IOF. These materials are designed to meet identified needs to improve productivity, product quality, and energy efficiency in the Vision Industries. The focus of the intermetallic alloy research, following on the results of FY 2000, will be on demonstration of iron aluminide/stainless steel composite tubes for corrosive environments in the chemical, refining, and forest products industry and on further development of nickel silicide, which

Program Activity	FY 1999	FY 2000	FY 2001
Enabling Technologies (Cont'd)	new applications were identified. Cooperative research and development agreements (CRADAs) with Dow Chemical and Amoco, to develop superior organic and inorganic membranes for gas and liquid separations and an electrochemical reaction cell for improvement of energy efficiency in the chloralkali process, were completed. Development of metal matrix composites by reactive metal infiltration under terms of a CRADA with Reynolds Metals and A.P. Green Industries continued with completion scheduled for FY 2000. Work also continued on uniform metal droplets and spray coatings, with emphasis on high temperature alloys, steel, and aluminum, for the primary, secondary, and powder metallurgy industries. Work on inorganic membranes for para-xylene separation was turned over to the IOF Chemical Industry Team in FY 1999 for demonstration. ($6,000)	Standardized test methods and physical process data bases are being developed to enable qualification of these materials in industrial applications. The process for production of uniform spherical metal powders over a wide range of steels and intermetallic alloys was scaled up, in cooperation with industry partners. Work on development of inorganic membranes and electrochemical reactors for harsh chemical environments was turned over to the IOF Chemical Industry Team for industrial demonstration. Work on metal matrix composites, with superior strength and wear resistance was completed. Activities of the Metals Processing Laboratory (MPlus) at Oak Ridge National Laboratory was enhanced for the benefit of the industries and universities engaged in development of new and improved high temperature alloys for use in corrosive environments in the vision industries. In addition, efforts will be placed on precision forging activities. ($6,500)	has been shown to be very resistant to acid environments. The process for production of uniform spherical metal powders will be completed and transferred to the industrial partner for commercialization. AIM will fund further work in the chemical separations area. Activities at the Metals Processing Laboratory User Center (MPlus) at Oak Ridge National Laboratory will likely receive additional funding in FY 1999 from the Aluminum, Chemical, and Metal Casting teams, as was done in the past, but AIM will continue to provide base funding for work with IOF industries. ($6,000)

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Enabling Technologies (Cont'd)		Participants include: Oak Ridge National Laboratory, Sandia National Laboratory, Argonne National Laboratory, Weyerhaeuser, PPG Industries, Dow Chemical, Amoco, and other industry partners in CRADAs and other cooperative agreements.	Participants include: Oak Ridge National Laboratory, Sandia National Laboratories, and Los Alamos National Laboratory, Dow Chemical, Amoco, PPG Industries, Alloy Engineering and Casting, Sandusky International, and other industry partners by CRADA or other cooperative agreements.
	Combustion Systems: Completed whirl burner scoping with transfer of technology to industry. Continued pre-competitive fuel injection recirculation research to determine why this procedure is more effective than flue gas recirculation. In conjunction with glass, steel, and metal casting activities, demonstrated oscillating combustion in additional equipment types and continue development of efficient low cost heat exchanger system for power generation. For FY99, the combustion program solicited projects in industrial boilers, process heaters, and furnaces in the seven industries for cross-cutting impacts. ($1,000)	**Combustion Systems**: The combustion program will continue and initiate projects to meet combustion vision and roadmap targets. These include goals of environmental quality (2 parts per million NOx is a long term goal for boilers), fuel flexibility (maximize the use of multiple fuels, including waste and renewable fuels), energy efficiency (or 20 to 50% specific fuel consumption reduction is a long term goal for furnaces), cost effectiveness (lower life cycle costs), and improved system reliability (double the time between scheduled boiler outages). Specific projects for boilers may include an increased reliability air-fuel ratio control system which could cut boiler energy use by more than 5% or 200 billion	**Combustion Systems:** The combustion program will continue boiler and process heater projects to meet combustion vision and roadmap targets. These include goals of environmental quality (2 boilers), fuel flexibility (maximize the use of multiple fuels, including waste and renewable fuels), energy efficiency (or 20 to 50% specific fuel consumption reduction is a long term goal for furnaces), cost effectiveness (lower life cycle costs), and improved system reliability (double the time between scheduled boiler outages). The projects build on advances made in very low emission burner projects. Continued advances toward energy consumption and environmental targets are being realized through improved systems

Program Activity	FY 1999	FY 2000	FY 2001
Enabling Technologies (Cont'd)		Btu/year. In the furnace area, an improved furnace design could lower specific fuel consumption by 20% or over one quad in extensive use. ($2,000)	design and better heat transfer. ($2,000)
		Industrial Gasification: (Presented here for required comparability, the following efforts are funded in FY 2000 through the Fossil Energy R&D Program) Initiated preliminary design studies, including R&D, engineering design, and cost projections. A competitive solicitation will identify technology development and demonstrations of advanced biomass and black liquor gasification systems. Technology development may include improved refractory performance, systems integration with combined cycle systems and gas clean-up. Projects funded will have a clear path to demonstration and commercialization of systems in the forest products industry. ($13,500) ($15,500)	Industrial Gasification: Gasification in industrial processes is a critical link to improve efficiency of processes in Forest Products, Chemicals and Petroleum. Utilization of the low and medium BTU fuels, such as black liquor in the pulp and paper process, produced by Gasification opens new process opportunities for these industries. Preliminary design studies will be completed in 2001 for biomass gasification systems. This includes engineering design, cost projections, and identification of critical R&D needs for systems in industrial plants. ($10,726) With oversight by OIT, the program will be implemented through National Energy Technology Laboratory (NETL). Included in this activity will be a technology support program guided by industry and utilizing the expertise of NETL, ORNL and NREL. Supporting technical areas include sulfur

Program Activity	FY 1999	FY 2000	FY 2001
Enabling Technologies (Cont'd)			management, gas clean-up, materials, systems integration and other combustion related studies ($3,000). This activity will be coordinated with Fossil Energy and the EERE Bioenergy/Bioproducts Initiative. ($15,726)
		Participants include: industrial boiler manufacturers, burner manufacturers, process heater and furnace manufacturers.	Participants include: Industrial burner, boiler and process heater manufacturers and users. Babcock & Wilcox, Bechtel, MTCI.
	Sensors and Control Technologies: Emphasized low emissions, high efficiency, and remote sensing for high temperature, corrosive systems. Synergies between the vision industries were utilized through a competitive solicitation to increase leveraging of projects. ($1,000)	**Sensors and Control Technologies**: The Sensors and Controls Program will continue to develop and deploy integrated measurement systems for operator-independent control of manufacturing processes with broad applicability across multiple industry sectors. In collaboration with major industrial associations and instrumentation manufacturer societies, the Sensors and Controls Program will implement a comprehensive technology development strategy to meet the needs identified in the individual industry technology roadmaps. Particularly needed is improved technology both in sensors including	**Sensors and Control Technologies**: The Sensors and Controls Program will continue implementing its Program Plan to achieve leap-frog advancement of sensor and control technologies that have high impact on two or more IOF industries. Focus will be on bringing projects into the field demonstration phase and continuing the bench-scale research and development of projects awarded in FY 2000. Notable demonstrations will include 1) an online, laser-based ultrasonic system to measure wall thickness and eccentricity of steel seamless mechanical tubing during piercing, elongation, and rotary sizing operations, 2) an intelligent

Program Activity	FY 1999	FY 2000	FY 2001
Enabling Technologies (Cont'd)		embedded, high temperature, and harsh environment applications and in information processing from different sensory modalities to detect and remedy malfunctions. ($2,000)	extruder which incorporates low-cost, readily available sensors into inferential control to produce quality resin products in polymer compounding, and 3) a non-proprietary, dynamically reconfigurable, wireless-network architecture that provides standardized communication protocols and data structures for robust performance in industrial environments. Bench-scale research and development will focus on achieving major improvements of sensor attributes such as self-diagnostics and self-calibration, high-speed measurements with accuracy and reliability, as well as those for harsh-environment (high temperature or corrosive) sensing. Also, some seed activities will be launched in the areas of microfabrication and integration of sensors and controls for wireless and harsh-environment applications. ($2,000)
		Participants include: Institute of Gas Technology/U. Of Illinois/Combustion Tec/Owens Brockway Glass Containers/Acme;	Major participants include the Timken Company, Institute of Gas Technology, GE Research & Development Center, Visteon Glass

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Enabling Technologies (Cont'd)		GE Research & Development Center/Krupp Werner-Pfleiderer; Visteon Automotive Systems/Sandia National Laboratory/U. of Utah; Energy Research Company/Mississippi State University/Oak Ridge National Laboratory; Tennessee Technological University/Utah State U./Idaho National Engineering Laboratory/Albany Research Center/American Foundrymen's Society/General Motors.	Systems, Energy Research Company, Tennessee Technological University, Oak Ridge National Laboratory, T/J Technologies Inc., Detection Limit Inc., and Concurrent Technologies Corporation. Also participating in the collaboration are National Research Council Canada; University of Illinois, Combustion Tec, Owens Brockway Glass Containers, and Gas Research Institute; Krupp Werner-Pfleiderer; Sandia National Laboratory, and University of Utah; Mississsippi State University; and Utah State University, Idaho National Engineering Laboratory, Albany Research Center, American Foundrymen's Society, and General Motors.
	$18,881	$36,000	$35,726
Distributed Generation	**Industrial Power Generation**: Continued the industrial Advance Turbine System (ATS) program activities including manufacture and field testing of full-scale components. Commenced first industrial scale engine builds and initiate full-scale testing. Continued ceramic insertion	**Industrial Power Generation**: Complete the industrial ATS program activities including manufacture, demonstration, and deployment of full-scale engines. Complete first industrial scale engine build and ATS deliver to customer site for full-scale demonstration of technology. Begin to validate program goals of increased engine	**Industrial Power Generation**: Industrial Power Generation Program will continue durable, cost effective low emissions technology development to demonstrate emissions levels of less than 7 ppm NO_X for advanced gas turbines. Continue R&D to demonstrate innovative high temperature

Program Activity	FY 1999	FY 2000	FY 2001
Distributed Generation (Cont'd)	program for industrial turbines, including microturbines. Completed post-testing component evaluation and characterization. Continued enabling materials support program including scale-up of single crystal turbine casting and improved Thermal Barrier Coatings. Initiated Phase IV of thermal barriers coatings. Continued to identify defect tolerance limits and alternative casting technologies. Continued to support the development of catalytic combustion systems and initiate pilot demonstrations for catalyst stability, fuel poisoning, and long-term durability. ($49,903)	efficiency (15%) with less than 10 parts per million NOx and less than 20 parts per million carbon monoxide emissions, and reduction in the cost of electricity by 10%. Continue enabling materials and manufacturing support program including demonstration of the durability of next generation thermal barrier coating systems in an industrial gas turbine engine. Distributed generation in the form of microturbines and advanced gas engines (less than 1,000 KW) have the potential to alleviate high-peak load demands. Complete Phase I feasibility studies for microturbines and reciprocating engines and identify key barriers and enabling technologies required for development. ($24,300) Participants include: Solar Turbines Inc., Allison Engines, Oak Ridge National Laboratory, Argonne National Laboratory, Battelle Columbus Laboratories, Pratt & Whitney, Westinghouse, Southwest Research Institute, University	materials such as coatings and ceramics in gas turbines for 8,000 hours. Investigate the oxidation/water vapor degradation of ceramic components for gas turbines. Continue industrial power generation technology roadmap assessments and the R&D program for advanced microturbines with goals of over 40% efficiency, single digit emissions, fuel flexibility and 10% reduction in costs and the advanced reciprocating engines systems (ARES) to develop an over 50% efficient reciprocating engine with single digit emissions and 10% reduction in costs. ($16,300) Participants include: State Energy Offices, Solar Turbines Inc., Allison Engines, Oak Ridge National Laboratory, Argonne National Laboratory, Battelle Columbus Laboratories, Pratt & Whitney, Westinghouse, Southwest Research

Program Activity	FY 1999	FY 2000	FY 2001
Distributed Generation (Cont'd)		consortium, Allied Signal Ceramics Inc., Kyocera, Catalytica, PCI, microturbine and engine suppliers.	Institute, University consortium, Allied Signal Ceramics Inc., Kyocera, Catalytica, PCI, microturbine and engine suppliers.
	Industrial Distributed Generation: Assessed the potential for ATS technology for industrial Combined Heat and Power applications including refrigeration, cooling, and industrial process systems. Initiated visioning efforts in the industrial power community for distributed power generation focusing on grid reliability and stability such as grid control of flickering in the steel industry. Initiated technology roadmaps and R&D priority activities for combined heat and power technologies having a system efficiency of greater than 65%. ($200)	**Industrial Distributed Generation**: Complete industrial visioning activities for power and industrial process applications. Continue the development of technology roadmaps and R&D priorities. Support industrial power technologies R&D through the industrial visions and roadmaps on power quality, power reliability and stability such as grid control of flickering in the steel industry; combustion and power in the glass industry; gasification in the paper industry; alternative fuels combined heat and power for the mining/agricultural industries; and cooling/refrigeration needs that crosscut all industries. ($3,000)	**Industrial Distributed Generation:** Continue supporting R&D solicited for direct support to utility/industrial teams for addressing power generation/cogeneration issues identified by the industry through the visions and roadmaps. Initiate a real time load control monitoring system in cooperation with the steel vision and industry. ($1,000)
		Participants include: steel companies, utilities, Edison Technology Solutions, Oak Ridge National Laboratory, universities.	Participants include: industrial manufacturing companies, utilities, national laboratories, universities.
	$50,103	$27,300	$17,300

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Financial Assistance	**Financial Assistance:** The programs are designed to encourage State, industrial, and independent inventors to develop and implement new energy efficient technologies.	**Financial Assistance:** OIT introduces an integrated delivery system of financial assistance services in the form of grants. The Program addresses industry requests for a simpler, more flexible package of services that is easier for industry to access. By reducing overhead activities, additional worthy projects are supported. The programs work with regional centers to more effectively leverage local resources and to better tailor assistance to specific needs and situations. The NICE^3 and Inventions Programs issue a total of 30 to 35 new grants.	**Financial Assistance:** OIT will continue the integrated delivery system of financial assistance service. The Program will continue to provide industry with a simpler, more flexible package of services that is easier for industry to access. By continuing to reduce overhead activities, additional worthy projects will be supported. The programs will continue to work with regional centers to more effectively leverage local resources and to better tailor assistance to specific local needs and situations. The NICE^3 and Inventions Programs will issue a total of 30 to 35 new grants.
	NICE^3: The National Industrial Competitiveness through Energy, Environment and Economics (NICE$^{3)}$ was in its ninth year. The Program, which is designed to improve competitiveness, foster energy efficiency, and reduce waste, provided funding to State and industry partnerships through its competitive solicitation process.	**NICE^3**: NICE^3 is continuing to provide a voluntary, non-regulatory approach to improve competitiveness, foster energy efficiency, and reduce waste. The program is working closely with the Inventions and Innovations (I&I) program to support an integrated delivery of OIT's financial assistance services. Competitive solicitations for both programs will continue to be issued on concurrent schedules.	**NICE^3**: NICE^3 will continue to provide a voluntary, non-regulatory approach to improve competitiveness, foster energy efficiency, and reduce waste. The program will continue to work closely with the I&I program to support an integrated delivery of OIT's financial assistance services. Competitive solicitations for both programs will continue to be issued on concurrent schedules.

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Financial Assistance (Cont'd)	Increased emphasis continued to be placed in the solicitation on commercialization and deployment of projects to assure replication of successful technologies. ($5,850)	Administrative streamlining, and the use of regional centers continues to allow for more effective leveraging of local resources and enhances the ability of both programs to better meet specific regional industry needs. See the Financial Assistance description above. ($6,450) Participants: The OIT focus industries, the dominant energy users and waste generators in the U.S. manufacturing and industrial sectors, are the primary recipients of the approximately 10 grants awarded each year.	Administrative streamlining, and the use of regional centers will continue to allow for more effective leveraging of local resources and enhance the ability of both programs to better meet specific regional industry needs. See the Financial Assistance description above. ($6,000) Participants: The OIT focus industries, the dominant energy users and waste generators in the U.S. manufacturing and industrial sectors, are the primary recipients of the approximately 10 grants awarded each year.
	Inventions and Innovations: Inventions and Innovations continued to assist in the development of new technology by private sector individuals, particularly independent inventors and start-up businesses. The recommendations from the strategic program review conducted in FY 1997 were fully implemented. For the first time, the programs issued funding by using a competitive solicitation. ($4,662)	**Inventions and Innovations**: The I&I Program is continuing to provide financial assistance to support the development of new energy efficient technologies. The program is working closely with the NICE^3 Program to support an integrated delivery of OIT's financial assistance services to IOF partners. The I&I Program reaches typically underserved population of independent inventors and small start-up businesses. The program has	**Inventions and Innovations**: The I&I Program will continue to provide financial assistance to energy efficient technologies. The program will continue to work closely with the NICE^3 Program to support an integrated delivery of OIT's financial assistance services to IOF partners. Participants: Each year the I&I program awards 20 to 25 new grants to independent inventors and small technology-based businesses through competitive processes. On average,

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Financial Assistance (Cont'd)		received over 35,000 applications for financial assistance since its inception in 1974. Nearly 25% of the technologies funded have reached commercial success. The successful technologies supported by this program have saved enough energy to light 6 million homes for one year. ($4,900)	the program receives nearly three times as many worthy proposals as it can fund. This means 25 - 30 good proposals go unfunded each year. These recipients change from year to year. ($6,000)
	$10,512	$11,350	$12,000
Technical Assistance	**Technical Assistance Activities**: Initial evaluation of Burns Harbor Pilot is completed. Work with American Foundrymen's Society and metal casting plants continued to showcase lost-foam and other clean energy efficient technologies. Groundwork and plans were developed to select other IOF showcase plant sites. ($0)	**Technical Assistance Activities**: In order to respond to its industry partners, OIT introduces an integrated system for delivery of technologies, tools, and technical assistance to thousands of plants. At the core of the integrated delivery strategy is the development of one-on-one ongoing partnerships between OIT and its IOF industry partners at the plant level. OIT's efforts model the success achieved since 1998 at Bethlehem Steel's Burns Harbor plant and other showcase plant sites. In 2000, each of the IOF industries has at least one major showcase initiative in partnership with OIT. ($300)	**Technical Assistance Activities**: OIT will have completed the strategy and fully implemented the integrated system for delivery of technologies, tools, and technical assistance to thousands of plants. ($0)

Program Activity	FY 1999	FY 2000	FY 2001
Technical Assistance (Cont'd)		Participants are selected from the 9 IOF target industries.	
	Industrial Assessment Centers: Support for IACs continued. Approximately 750 combined energy, waste, and productivity assessments were conducted. Top performing schools were given incentives to look at and evaluate innovative program approaches. Collaborative work with State agencies continued. Work to strengthen university and local industry cooperation continued. Collaboration with the NIST Manufacturing Extension Program centers began. A Strategic Program Review to enhance program efficiency was completed. ($8,222)	**Industrial Assessment Centers**: Support for IACs continues. Approximately 750 combined energy, waste, and productivity assessments are being conducted. Top performing schools are given new incentives to look at and evaluate innovative program approaches. Collaborative work with State agencies continues. Work that strengthens university and local industry cooperation continues. Collaboration with the NIST Manufacturing Extension Program centers continues. The students continue to transfer best practices learned through the program to U.S. manufacturers all across the nation. To date, 2,300 students have been trained by the IAC program. Work continues at the national level to share results of successful IACs/NIST Manufacturing Extension Program Centers collaboration. Recommendations from the Strategic Program Review are being implemented. ($8,100)	**Industrial Assessment Centers**: OIT will continue to support IACs efforts to provide hands-on training at 30 participating universities in energy and waste management to an additional 240 engineering students and to conduct approximately 750 new combined energy, waste, and productivity assessments. The program will work closely with the other OIT Technical Assistance programs to fully support an integrated delivery of services and will provide industrial assessment expertise to identify and capitalize on technology applications at participating showcase plants. The IAC database, with data on over 8,300 industrial assessments, will help these plants target specific opportunities for efficiency. Engineering students who have worked with the 30 IAC's nationwide will continue to graduate with the experience and skills necessary to implement energy efficiency, waste reduction, and

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Technical Assistance (Cont'd)			productivity improvements. Recommendations from the Strategic Program Review will be implemented. ($8,300)
		Funding recipients are Rutgers University, the University City Science Center, University of Dayton, University of Florida, Georgia Institute of Technology, Hofstra University, University of Louisville, University of Maine, University of Massachusetts, University of Michigan, Mississippi State University, North Carolina State University, University of Notre Dame, Old Dominion University, University of Tennessee, West Virginia University, University of Wisconsin, Arizona State University, University of Arkansas-Little Rock, Bradley University, Colorado State University, Iowa State University, University of Kansas, University of Missouri-Rolla, University of Nevada-Reno, Oklahoma State University, Oregon State University, Prairie View A&M University, San Diego State University, San Francisco State University, South	Under the Fellowship program, selected universities would establish graduate-levels programs on advanced manufacturing technologies relating to OIT Industries of the Future. The universities would develop courses and lab work to support a graduate degree with a focus on specific Industries of the Future. Fellowships at these universities would help direct research towards the most critical technology barriers identified in industry visions and technology roadmaps. Universities would be required to partner with associated industry members who can offer internships, shared research facilities and equipment, and funding, etc. These industries will assist in the selection of research projects for the students. ($500) Funding Recipients: TBD

Program Activity	FY 1999	FY 2000	FY 2001
Technical Assistance (Cont'd)		Dakota State University, Texas A&M University.	
	Best Practices Program: Previously funded under Technology Transfer, Combined Heat and Power (CHP), Motor, Compressed Air, and Steam.	**Best Practices Program:** Previously funded under Technology Transfer, Combined Heat and Power (CHP), Motor, Compressed Air, and Steam.	**Best Practices Program:** In FY 2001, in order to provide better customer service and to reduce costs, OIT will initiate the Best Practices Program which will integrate the activities of the following programs: (Combined Heat and Power, Motors and Compressed Air, and Steam). The program will help U.S. manufacturers by providing credible technical information and assistance to help them lower their energy bills, often with little or no capital investment. ($12,000)
	Technology Transfer: The Technology Transfer Program continued to work closely with industry to develop outreach products to convey the benefits of advanced energy efficient, pollution prevention technology. ($396)	**Technology Transfer**: No activities. ($0)	**Technology Transfer**: No activities. ($0)
	Combined Heat and Power (CHP) Challenge: Initiated CHP challenge program for improved deployment of CHP systems. Benchmarked combined heat and power activities	**Combined Heat and Power (CHP)**: CHP technical assistance activities are focused on addressing the barriers and providing the technical tools and expertise necessary to	**Combined Heat and Power (CHP)**: Recent technological advances have made CHP systems more efficient and less expensive. The energy efficiency of CHP systems can

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Technical Assistance (Cont'd)	in the U. S. and abroad. Held four workshops at the Federal and State level to address combined heat and power technology barriers and successes. ($991)	demonstrate to industry how successful CHP technologies are, and to increase awareness of and confidence in these technologies. The program continues to work with the other OIT Technical Assistance programs to fully support an integrated delivery of services making CHP an important technology option for IOF industries. ($1,000)	exceed 80%. Additionally, CHP has been identified as one of the most near term cost-effective sections to reduce global carbon emissions. The effort will support the joint DOE-Industry goal to double the amount of CHP capacity in the U.S. by 2010, equal to 46 gigawatts of electricity and reduce air pollution by 40 million metric tons of carbon. The program will continue to work with the other OIT Best Practices programs to fully support an integrated delivery of services making CHP an important technology option for IOF industries. CHP technical assistance activities will continue to focus on addressing the barriers conducting CHP technology assessments and providing the technical tools and expertise necessary to demonstrate to industry how successful CHP technologies are, and to increase awareness of and confidence in these technologies. Industry will complete technology and barrier elimination roadmaps. (Funding requested under Best Practices Program above)

Program Activity	FY 1999	FY 2000	FY 2001
Technical Assistance (Cont'd)		Participants include: State Energy Offices, Onsite Energy, Washington State University, Oak Ridge National Laboratory, Allison Engines.	Participants include: State Energy Offices, Onsite Energy, Washington State University, Oak Ridge National Laboratory, Allison Engines.
	Motors and Compressed Air: All Vision industries were targeted and supported by Motor Challenge. These industries comprise over half of the U.S. manufacturing sectors motor system electricity consumption. Motor Challenge products were tailored to each industry's application-specific needs and were delivered to plant sites in partnership with the industry end-user trade associations and Motor Challenge end-user Partner corporate offices. Activities to catalyze the efforts of suppliers, distributors, utilities, states and trade associations to develop and deliver the tools and technical assistance manufacturers need to make informed decisions about motors and motor-driven systems continued. Starting in FY 1999, and building on the success of Motor Challenge as a model, work was started to provide	**Motors and Compressed Air:** Motors and compressed air are both motor driven systems. Technical assistance support and expertise in these areas is being provided as critical components of OIT's integrated delivery of technical assistance services. The programs continue to work with manufacturers to identify and target new energy efficiency and productivity opportunities and to help them develop and refine the credible, unbiased tools that assist industry in making the most informed energy decisions. ($8,600)	**Motors and Compressed Air:** Motors and compressed air technical assistance support and expertise will be provided as critical components of OIT's integrated delivery of technical assistance services under the Best Practices Program. The programs will continue to work with manufacturers to identify and target new energy efficiency and productivity opportunities and to help them develop and refine the credible, unbiased tools that assist industry in making the most informed energy decisions. (Funding requested under Best Practices Program above)

Program Activity	FY 1999	FY 2000	FY 2001
Technical Assistance (Cont'd)	enhanced technical assistance on steam and compressed air systems. ($7,536)		
		Participants include: Oak Ridge National Laboratory, National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory, Macro International, Washington State University Extension Office.	Participants include: Oak Ridge National Laboratory, National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory, Macro International, Washington State University Extension Office.
	Steam: The Steam Challenge was launched under the Motor Challenge budget to provide tools, information, and technical assistance to help industry improve the energy efficiency of its steam systems. ($1,500)	**Steam:** The Steam Challenge, which was run under the Motor Challenge budget in FY99, is now a full fledged initiative jointly partnered by DOE and the Alliance to Save Energy. Technical assistance, information and tools are being provided to plants interested in improving the energy efficiency of their steam systems and industrial heating equipment. The Steam program is working with suppliers, equipment manufacturers and end-users to garner the greatest impact. At the same time integrated delivery of technical assistance provides the right level of assistance to each plant. ($1,750)	**Steam:** The Steam Program will continue to be a full fledged initiative jointly partnered by DOE and the Alliance to Save Energy under OIT's integrated delivery effort under the Best Practice Program. Technical assistance, information and tools will be provided to plants interested in improving the energy efficiency of their steam systems and industrial heating equipment. This program provides valuable unbiased information on system design, equipment, purchase, and operation from experts with practical experience addressing steam system challenges. As with motors and compressed air, this program aims to increase U.S. industrial energy efficiency by helping industry adopt

Program Activity	FY 1999	FY 2000	FY 2001
Technical Assistance (Cont'd)			the systems approach with boilers, steam distribution systems, steam applications, furnaces and other equipment. The Steam program will work with suppliers, equipment manufacturers and end-users to garner the greatest impact. At the same time integrated delivery of technical assistance will provide the right level of assistance to each plant as part of the Best Practices Program. (Funding requested under Best Practices Program above)
		Participants include: Oak Ridge National Laboratory, National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory, Macro International, Washington State University Extension Office, Alliance to Save Energy.	Participants include: Oak Ridge National Laboratory, National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory, Macro International,
	International Best Practices: International Clean Energy Initiative - No activities.	**International Best Practices: International Clean Energy Initiative -** No activities.	**International Best Practices: International Clean Energy Initiative -** Partner with U.S. private industry, U.S. non-government organizations and with host country entities to implement an integrated best practice programs approach in energy intensive industries in both

Program Activity	FY 1999	FY 2000	FY 2001
Technical Assistance (Cont'd)			developing and developed countries. Work with both U.S. manufacturers and energy service companies (ESCO's) to facilitate trade and market development. Best practice includes adoption of process specific technologies in energy intensive industries, crosscutting technologies in such areas as materials, combustion and sensors and controls, and information, tools, software and experience from the U.S. motors, compressed air, steam, and combined heat and power programs and from the Industrial Assessment Center program. Through the best practice approach, industry can have access to both near term and long-term solutions to energy efficiency and enhanced environmental performance. Facilitate the development of joint ventures, licensing and the sale of U.S. technologies, tools and equipment to international entities that will lead to profitable and economic and environmental benefits to both the U.S. and the host country. Partner with U.S. private industry and international entities to facilitate the development of technology roadmaps

Program Activity	FY 1999	FY 2000	FY 2001
Technical Assistance (Cont'd)			for energy intensive industries in both developing and developed countries. The goal of this activity would be to transfer knowledge based on U.S. experience so that industries in other countries could promote an Industry of the Future (IOF) process, including visions, roadmaps and implementation plans tailored to the situation and needs of their energy intensive industries. U.S. industry personnel familiar with the process would be an essential part of the dialogue, which would include discussions of development of the vision, stretch goals in such areas as energy efficiency, environment and human resources, lessons learned, barriers, issues, results, benefits, etc. Key developing countries include Brazil, China, India (when sanctions are lifted), Mexico and South Africa. Significant opportunities also exist in other African, Asian, Latin and Central American countries, and in Europe and Australia. (PCAST International $2,500) ($5,000).
	$18,645	$19,750	$25,800

III. <u>Performance Summary</u>: INDUSTRIES OF THE FUTURE (CROSSCUTTING) (Cont'd)

Program Activity	FY 1999	FY 2000	FY 2001
Technical/Prog. Management Support	INTRODUCTION: Consistent with other DOE programs under the jurisdiction of the Interior and Related Agencies Appropriations Committees, the Energy Conservation programs provide funding for: (a) Technical/Program Management Support; (b) and Management Support Services. Technical/Program Management Support includes activities such as R&D feasibility studies; R&D option development and trade-off analysis; and technical, economic, market evaluations of R&D, and contract audit costs. These activities provide important benefits directly to the R&D program described above and are therefore an integral part of the R&D program. As directed by Congress, the FY 2001 Congressional Budget Request identifies the funding requirements for Technical/Program Management Support as shown below.		
	Funding of $ 4,911,135 from within the Industries of the Future (Crosscutting) Program described above was used to provide Technical/Program Management Support.	An estimated $4,322,077 from within the Industries of the Future (Crosscutting) Program described above provides for the continuation of critical Technical/ Program Management Support.	A total of $4,319,077 from within the Industries of the Future (Crosscutting) Program described above provides for the continuation of critical Technical/ Program Management Support.
Industries of the Future (Crosscutting) Total	**$98,141**	**$94,400**	**$90,826**

INDUSTRIAL TECHNOLOGIES
INDUSTRY SECTOR
(Dollars in Thousands)

COOPERATIVE PROGRAMS WITH STATES

I. Mission Supporting Goals and Objectives

I. A. Program Strategy

The Office of Energy Efficiency and Renewable Energy is pursuing collaborative applied research, development, and field testing with the States, specifically aimed at achieving common goals. This collaboration provides opportunities to leverage funding for important R&D that might not receive adequate support at either the federal or the state level. In the industry sector, EERE and the States will pursue the following areas of work: distributed generation/combined heat and power, fuel cells and microturbines, school-related R&D, and clean alternative power.

I. B. Performance Goals

FY 2000 Planned Accomplishments

- Increase collaborative applied research which will increase market penetration of fuel cells and microturbines, alternative fuels, and energy-efficient vehicles.

II. A. Funding Table: COOPERATIVE PROGRAMS WITH STATES

Program Activity	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request	$ Change	% Change
Cooperative Program with States	$ 0	$ 2,000	$ 0	$ -2,000	-100.0%
Other	0	0	0	0	0.0%
Total, Cooperative Program with States	$ 0	$ 2,000	$ 0	$ -2,000	-100.0%

II. B. Laboratory and Facility Funding Table: COOPERATIVE PROGRAMS WITH STATES

	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request	$ Change	% Change
Argonne National Lab	$ 0	$ 0	$ 0	$ 0	0.0%
National Renewable Energy Lab	0	0	0	0	0.0%
Oak Ridge National Lab	0	0	0	0	0.0%
All Other	0	2,000	0	-2,000	-100.0%
Total, Cooperative Programs with States	$ 0	$ 2,000	$ 0	$ -2,000	-100.0%

III. Performance Summary: (New BA in thousands of dollars)

Program Activity	FY 1999	FY 2000	FY 2001
Cooperative Programs with States		Provide cooperative agreements to approximately 6 to 10 States for collaborative applied research, development, and field testing. Partnerships will be encouraged with industry, national laboratories, and other entities. Areas of effort are expected to include bioenergy, fuel cells and microturbines, and clean alternative power and increased energy efficiency in vehicles.	
	$0	$2,000	$0
Other			
	$0	$0	$0
Cooperative Programs with States, Total	**$0**	**$2,000**	**$0**

INDUSTRIAL TECHNOLOGIES
INDUSTRY SECTOR
(Dollars in Thousands)

ENERGY EFFICIENCY SCIENCE INITIATIVE

I. Mission Supporting Goals and Objective

I. A. Program Strategy

The goal of the Energy Efficiency Science Initiative is to focus funding and effort on "bridge" research and development (R&D) that falls between fundamental exploratory science and pre-commercial applied R&D. EERE's goal is to stimulate R&D in ways that maximize synergies among different research fields, technologies, investigator communities, and end-use applications. This cross-cutting approach seeks to expand EERE's R&D activities among energy efficiency technologies, with particular focus on distributed power generation applications, to industrial and buildings systems; and its work on technologies with applications to both transportation and stationary power. This approach also seeks to expand existing cooperation with the Office of Fossil Energy in such areas as natural gas-fueled turbine and fuel cell technologies, combined heat, power, and cooling applications, hydrogen production and carbon emission sequestration. It also aims at more extensive coordination with the Office of Science in pursuing fundamental research in areas that are critical to energy efficiency and clean energy development, such as basic biosciences, plant genetics, photo emission, heat transfer, new materials, catalysts, and computational science.

I. B. Performance Goals

FY 2000 Planned Accomplishments

- Increased fundamental strategic research, which advances the use of energy-efficient technologies.

II. A. Funding Table: ENERGY EFFICIENCY SCIENCE INITIATIVE

Program Activity	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request	$ Change	% Change
Energy Efficiency Science Initiative	$ 0	$ 3,900	$ 0	$ -3,900	-100.0%
Other	0	0	0	0	0.0%
Total, Energy Efficiency Science Initiative	$ 0	$ 3,900	$ 0	$ -3,900	-100.0%

II. B. Laboratory and Facility Funding Table: ENERGY EFFICIENCY SCIENCE INITIATIVE

	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request	$ Change	% Change
Argonne National Lab	$ 0	$ 0	$ 0	$ 0	0.0%
National Renewable Energy Lab	0	0	0	0	0.0%
Oak Ridge National Lab	0	0	0	0	0.0%
All Other	0	3,900	0	-3,900	-100.0%
Total, Energy Efficiency Science Initiative	$ 0	$ 3,900	$ 0	$ -3,900	-100.0%

III. Performance Summary: (New BA in thousands of dollars)

Program Activity	FY 1999	FY 2000	FY 2001
Energy Efficiency Science Initiative		Fund approximately 10 to 20 cooperative agreements with research and development teams, which are expected to be led by universities and to include industrial, national laboratory and other partners. The cooperative agreements will focus on fundamental strategic R&D, such as advanced materials, bio-based fuels, combustion-related research, sensors and controls, computational sciences, and microsystems science and engineering.	
	$0	$3,900	$0
Other			
	$0	$0	$0
Energy Efficiency Science Initiative, Total	**$0**	**$3,900**	**$0**

INDUSTRIAL TECHNOLOGIES
INDUSTRY SECTOR
(Dollars in Thousands)

MANAGEMENT AND PLANNING

I. Mission Supporting Goals and Objectives:

The request supports 73 full-time equivalent (FTE) positions to maintain adequate program management and support for the Industrial Sector Program (Interior and Related Agencies). This program also includes Technical Evaluation, Analysis and Planning.

II. A. Funding Table: MANAGEMENT AND PLANNING

Program Activity	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request	$ Change	% Change
Evaluation and Planning	$ 628	$ 1,090	$ 700	$ -390	-35.8%
Program Direction	7,559	7,810	8,600	790	10.1%
Total, Management and Planning	$ 8,187	$ 8,900	$ 9,300	$ 400	4.5%

II. B. Laboratory and Facility Funding Table: MANAGEMENT AND PLANNING

All Other	$ 8,187	$ 8,900	$ 9,300	$ 400	4.5%
Total, Management and Planning	$ 8,187	$ 8,900	$ 9,300	$ 400	4.5%

III. Performance Summary: (New BA in thousands of dollars)

Activity	FY 1999	FY 2000	FY 2001
Management and Planning			
Evaluation and Planning	Provide increased technical evaluation, analysis, and planning, including development of quality metrics for the energy intensive industries.	Provide increased technical evaluation, analysis, and planning, including development of quality metrics for the energy intensive industries. Continue some technology transfer activities transferred from Industries of the Future (Crosscutting).	Provide increased technical evaluation, analysis, and planning, including development of quality metrics for the energy intensive industries. Continue some technology transfer activities transferred from Industries of the Future (Crosscutting).
Technical/Prog. Management Support and Management Support Services	INTRODUCTION: Consistent with other DOE programs under the jurisdiction of the Interior and Related Agencies Appropriations Committees, the Energy Conservation programs provide funding for: (a) Technical/Program Management Support; (b) and Management Support Services. Technical/Program Management Support includes activities such as R&D feasibility studies; R&D option development and trade-off analysis; and technical, economic, market evaluations of R&D, and contract audit costs. These activities provide important benefits directly to the R&D program described above and are therefore an integral part of the R&D program. Management Support Services include activities such as improving the effectiveness, efficiency and economy of management and general administrative services. These activities are critical to the planning, formulation, and execution of the Energy Conservation programs. As directed by Congress, the FY 2001 Congressional Budget Request identifies the funding requirements for Management Support Services as shown below. Funding for Technical/Program Management Support continues to be funded in the R&D programs described above.		

III. <u>Performance Summary</u>: MANAGEMENT AND PLANNING (Cont'd)

Activity	FY 1999	FY 2000	FY 2001
Technical/Prog. Management Support and Management Support Services (Cont'd)	Funding of $252,000 from within the Management and Planning Program described above was used to provide Technical/Program Management Support.	An estimated $252,000 from within the Management and Planning Program described above provides for the continuation of critical Technical/ Program Management Support.	A total of $252,000 from within the Management and Planning Program described above provides for the continuation of critical Technical/ Program Management Support.
	$628	$1,090	$700
Program Direction	The following is a breakdown of the funding by Object Class: 11.9 Personnel compensation $ 5,177 12.1 Civilian personnel benefits $ 1,179 21.0 Travel and transportation of persons $ 611 25.2 Other services $ 592 Funds supported the salaries, benefits, and travel (including normal increases in both salaries and benefits) for 66 FTEs needed to conduct and monitor research, development of the various Industry technologies, at Headquarters and in the field. The funding for other services supported such activities as training and permanent change of station moves.	The following is a breakdown of the funding by Object Class: 11.9 Personnel compensation $ 6,036 12.1 Civilian personnel benefits $ 1,416 21.0 Travel and transportation of persons $ 675 25.2 Other services $ 300 Funds support the salaries, benefits, and travel (including normal increases in both salaries and benefits) for 73 FTEs needed to conduct and monitor research, development of the various Industry technologies, at Headquarters and in the field. Included in the program direction are staffing adjustments resulting from Workforce 21 plans. Funding under other services supports such activities as training, permanent change of station moves, and a small contingency. Total obligational authority of $8,427,000	The following is a breakdown of the funding by Object Class: 11.9 Personnel compensation $ 6,400 12.1 Civilian personnel benefits $ 1,500 21.0 Travel and transportation of persons $ 685 25.2 Other services $ 15 Funds are requested to support the salaries, benefits, and travel (including normal increases in both salaries and benefits) for 73 FTEs needed to conduct and monitor research, development of the various Industry technologies, at Headquarters and in the field. The FY 2001 Congressional Request for program direction provides for continued implementation of Workforce 21 plans. The request for other services supports such activities as training and a small contingency. Overall Program Direction funding

Activity	FY 1999	FY 2000	FY 2001
Program Direction (Cont'd)		for Program Direction includes an estimated $617,000 from FY 1999 unobligated carryover in Program Direction to cover FY 2000 requirements.	of $8,600,000 increases only 2% over the FY 2000 estimated total obligational authority to cover payraise. The Department of Energy has conducted detailed workforce analyses that have identified current and projected staffing disciplines. During 1999, DOE conducted a systematic analysis of critical staffing needs within the context of current and projected R&D program missions. The Department will develop a comprehensive plan that will focus on building and sustaining a talented and diverse workforce of R&D Technical Managers. The plan will include innovative recruitment strategies, retention incentives, comprehensive training and development programs for new and current employees, and succession planning. The FY 2001 program direction request includes $333,000 for the Scientific Retention and Recruitment Initiative. This will enable the recruitment of experienced scientists and related support staff (full-time equivalents) in areas of emerging interest to the

III. Performance Summary: MANAGEMENT AND PLANNING (Cont'd)

Activity	FY 1999	FY 2000	FY 2001
Program Direction (Cont'd)			Department's science mission. Funds will also be used to motivate and retain highly skilled, top-performing technical managers with, for example, retention allowances and performance awards. Additionally, training in areas crucial for effective job performance will be a key element of the initiative.
	Funding of $1,905,048 from within the Industrial Technologies R&D described above was used to provide Management Support Services and LAN operations.	An estimated $2,127,105 from within the Industrial Technologies R&D programs described above provides for the continuation of critical Management Support Services and LAN operations.	A total of $ 2,135,013 from within the Industrial Technologies R&D programs described above provides for the continuation of critical Management Support Services and LAN operations.
	$7,559	$7,810	$8,600
Management and Planning Total	$8,187	$8,900	$9,300