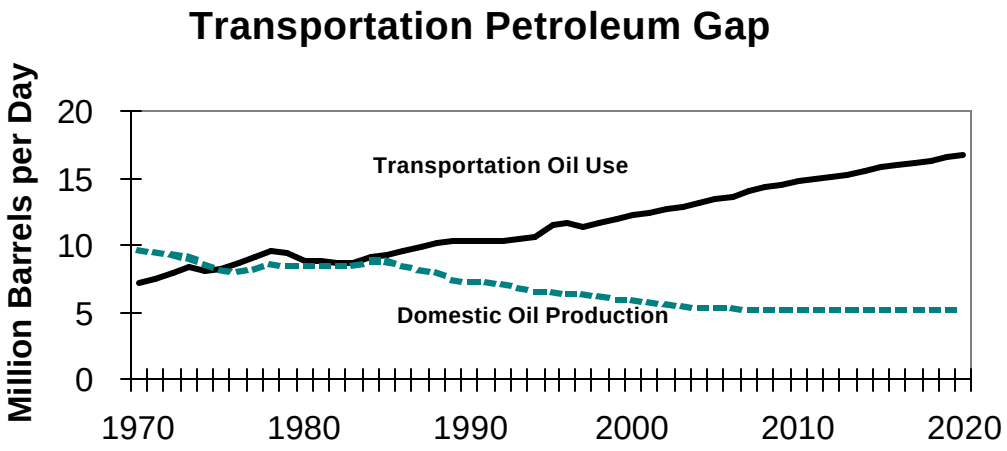
DEPARTMENT OF ENERGY
FY 2003 CONGRESSIONAL BUDGET REQUEST
ENERGY EFFICIENCY AND RENEWABLE ENERGY
ENERGY CONSERVATION
(Tabular Dollars in Thousands, Narrative in Whole Dollars)

TRANSPORTATION SECTOR
PROGRAM MISSION

Mission: The Transportation Program partners with industry, research organizations, State governments, and other Federal agencies to support development and use of advanced vehicle technologies and fuels which reduce demand for petroleum, decrease emissions of criteria air pollutants and greenhouse gases, and enable the U.S. transportation industry to sustain a strong, competitive position in domestic and world markets.

Strategic Context: The transportation sector consumed 27 percent of the nation's energy in 2001. Petroleum is the primary fuel source in this sector, accounting for 95 percent of the fuel consumed. While there have been many improvements in vehicle/engine fuel efficiency, transportation fuel consumption continues to increase due to the rise in the number of drivers and miles traveled, as well as the demand for larger vehicles and lower fuel-economy vans, pickup trucks, and sport utility vehicles. The transportation of persons and goods demands 67 percent of this nation's oil consumption. Our increasing transportation requirements have helped create a daily imported oil demand of 10 million barrels, or 52 percent of the country's petroleum consumption. The Department's Energy Information Administration (EIA) is projecting 1.9 percent annual growth in transportation energy use through 2020. At the present time, the United States consumes 26 percent of the world's oil while producing 12 percent of the total global supply. Considering the distribution of known world conventional oil reserves, the U.S. has only 2 percent while the Organization of Petroleum Exporting Countries (OPEC) currently account for 79 percent.



Some of the major market barriers which new transportation technology and fuels must overcome are: low consumer priority on fuel economy; significant business investment required for advanced vehicle technologies and alternative fuels; lack of alternative fuel infrastructure; and strong competition among fuel alternatives for a relatively small market.

Strategic Approach: The Administration's National Energy Policy (May 2001) describes the need for a Federal role to promote renewable energy and energy efficiency. The Office of Transportation Technologies supports the National Energy Policy and the Office of Energy Efficiency and Renewable Energy's (EERE) strategic goals by conducting long-term research, development, and deployment programs which will enable reduced oil consumption. This reduction will be accomplished by achieving: 1) significant improvements in vehicle fuel economy; and 2) displacement of oil by other fuels which are domestic, clean, and cost-competitive. This investment focuses on areas that would not be pursued by industry alone due to high risk and uncertain outcomes. Transportation technologies work is primarily focused on research and development of advanced technologies, with priorities established in conjunction with cost-sharing partners, primarily industry. The work is accomplished by numerous organizations, including industry, government and university laboratories, and strong public/private partnerships with the automotive and truck industries. Initiatives in such areas as incentives, information, and education are also essential if advanced transportation technologies are to achieve market share sufficient to provide significant oil reduction benefits during the next 15 to 20 years.

Indicative of the long-range vision behind our research and development activities is the recently announced new cooperative public/private research partnership, entitled FreedomCAR, with the U.S. Council for Automotive Research (USCAR). The new partnership supercedes and builds upon the successes of the Partnership for a New Generation of Vehicles (PNGV) that began in 1993. It is, however, different in scope and breadth. FreedomCAR shifts government research to more fundamental, higher risk activities, with applicability to multiple passenger vehicle models and special emphasis on development of fuel cells and hydrogen fuel infrastructure.

By sharing R&D costs and risks, the Transportation program is successfully stimulating both evolutionary and breakthrough technologies and processes. The transportation program assists industry through a variety of high-risk research and development activities, and provides a neutral, third-party platform to help competitors, suppliers, and government organizations reach consensus on program directions and plans.

GPRA: The projected annual benefits of the Transportation program, without any policy changes (and excluding biofuels benefits), are summarized in the table below.

	2005	**2010**	**2020**
Petroleum Displaced (Million Barrels per Day)	0.13	0.40	2.09
Total Primary Energy Displaced (Trillion Btu)	27	515	3,705
Energy Costs or Savings (Millions of $)	890	8,070	45,060
Carbon Equivalent Emissions Displaced (MMTCe)	2.0	11.2	73.8

Note: Program benefit projections are developed through an impact analysis process undertaken annually by EERE, based on assumptions for future energy markets derived from EIA's annual energy outlook. EERE's sectors analyze the impacts their programs will have on energy savings, energy cost savings, and carbon reductions if all program goals are met, and future energy markets develop as expected. A sample of program benefit estimates are externally reviewed by Arthur D. Little. An integrated analysis model run by an external contractor controls for interaction effects across programs and sectors.

At the sector level, we report a range of estimates that correspond to two modeling cases: with and without program interactions. For example, reductions in new electricity generation requirements due to energy efficiency improvements would reduce the potential market for a range of electricity supply options. When integrated and non-integrated estimates are virtually the same, no estimate range is shown.

Program Strategic Performance Goals

The following Program Strategic Performance Goals (PSPG) have been established for the Transportation Program:

ER1-10: Hybrid Systems R&D
Hybrid Systems R&D activities will reduce the production cost of a high power 25kW battery from $3,000 in 1998 to $500 in 2010, with an intermediate goal of $750 in 2006.

ER1-11: Fuel Cells R&D
Fuel Cell R&D activities will reduce the production cost of the 50 kW vehicle fuel cell power system from $275/kW in 2002 to $125/kW in 2005 and $45/kW in 2010.

ER1-12: Advanced Combustion Engine R&D
Advanced Combustion Engine R&D activities will reduce NOx emissions in light-duty diesel vehicles from 0.10 grams per mile (g/m) in 1998 to 0.05 g/m in 2006 and 0.03 g/m in 2010 and in heavy duty diesel engines from 4.0 grams per brake horsepower hour (g/bhp-hr) in 1998 to 2.4 g/bhp-hr in 2002 and 0.2 g/bhp-hr in 2005.

ER1-13: Electric Vehicles R&D
Electric Vehicles R&D activities will reduce the production cost of a 40kWh lithium ion battery from $365/kWh in 2001 to $295/kWh in 2004 and to $150/kWh in 2010.

ER1-14: Heavy Vehicle Systems R&D
Heavy Vehicle Systems R&D activities will reduce the parasitic losses, including aerodynamic drag from 39 percent in 1998 to 24 percent in 2006.

ER1-15: Fuels Utilization
Fuel Utilization R&D activities will decrease light truck and passenger vehicle engine-out emissions of particulate matter from 0.1 grams per brake horsepower hour (g/bhp-hr) in 2001 to 0.06 g/bhp-hr by 2008.

ER1-16: Transportation Materials Technologies
Transportation Materials Technologies R&D activities will reduce the production cost of carbon fiber from $12 per pound in 1998, to $3 per pound in 2006.

ER1-17: Transportation Technology Assistance

The Clean Cities program will increase the number of alternative fuel vehicles in the Clean Cities from 110,000 in 2001, to 250,000 in 2007 and to 400,000 in 2010; helping to create successful niche markets that will yield nationwide 1,000,000 alternative fuel vehicles, consuming 1 billion gallons of alternative fuel in 2010.

Significant Accomplishments and Program Shifts

The following were significant accomplishments in the Transportation program during FY 2001:

- Demonstrated the Digital Functional Vehicle analytical tool, which will be used to quantify the benefits of optimizing the designs of various components.
- Completed component selection and system design definitions for natural gas heavy hybrid vehicles.
- Fabricated two 276-volt lithium ion mini-battery packs with thermal and electrical controls.
- Completed test and evaluation of a fuel-flexible 50 kW integrated fuel cell power system that was 32 percent efficient at 1/4 peak power. This 50kW power system, developed by UTC Fuel Cells, was the world's first fully functional, automotive fuel cell system which operated on gasoline with extremely low emissions. It also indicated the development areas needed for creating a more compact/lightweight, fully integrated, and cost-competitive system.
- Completed planning of Focal Project 3, focused on a predominantly carbon-fiber-reinforced polymer-matrix composite, hybrid-material (i.e., some additional materials like steel and aluminum are used sparingly when necessary) vehicle "body-in-white."
- Completed explorations of four approaches to lower-cost precursors for carbon fibers; downselected and initiated further work on two most promising approaches.
- Demonstrated ceramic particulate filter system for engines that removes 90 percent of particulates with 90 percent filter regeneration efficiency.
- Achieved 50 percent reduction of friction in a variable displacement compressor/expander utilizing carbon/carbon composite and anodized aluminum contact pairs.
- Supported the annual acquisition of 10,000 alternative fuel vehicles in the Federal Fleet.
- Funded 54 projects in 25 States with $3.8 million, through the State Energy Program, leveraging over $20 million of non-Federal funds.
- Developed data collection protocols and initiated testing program for light-duty hybrid electric vehicles and neighborhood electric vehicles.
- The winning university in the FutureTruck competition achieved 40 percent improvement in fuel economy for a large sport utility vehicle (SUV).

The following are proposed significant program shifts in the Transportation program for FY 2003:

- The new cooperative public/private research partnership, entitled FreedomCAR, supercedes and builds upon the successes of the Partnership for a New Generation of Vehicles (PNGV).
- Accelerate research and development of vehicle fuel cell technologies.
- Reduce funding for diesel emission control technologies.
- Reduce support for battery research and development accomplished in conjunction with the U.S. Advanced Battery Consortium.
- Current heavy vehicle efforts are now emphasizing vehicle systems technologies alongside the more mature engine and fuels activities.
- The Light Truck Engine program will be coming to completion in 2004. The emphasis is shifting to improving the efficiency and reducing the emissions from the Heavy Truck Engine.
- Increase Heavy Vehicle Systems R&D to accelerate aerodynamic improvements.
- Close out activities relevant to heavy-duty natural gas vehicles and infrastructure.
- Reduce funding for lightweight materials development.
- Reduce Special Project State Grants.

DEPARTMENT OF ENERGY
FY 2003 CONGRESSIONAL BUDGET REQUEST
ENERGY CONSERVATION
(Dollars in Thousands)

TRANSPORTATION SECTOR

PROGRAM FUNDING PROFILE

Program Activity	FY 2001 Enacted	FY 2002 Enacted	FY 2003 Request	$ Change	% Change
Vehicle Technologies R&D	$157,061	$155,122	$149,280	$-5,842	-3.77%
Fuels Utilization R&D	$23,134	$25,908	$18,483	$-7,425	-28.66%
Materials Technologies	$41,547	$40,293	$29,800	$-10,493	-26.04%
Technology Deployment	$14,776	$15,160	$15,000	$-160	-1.06%
Cooperative Programs with States	$1,964	$2,000	$0	$-2,000	-100.00%
Energy Efficiency Science Initiative	$3,828	$4,000	$0	$-4,000	-100.00%
Management and Planning	$9,152	$10,232	$10,101	$-131	-1.28%
TOTAL	$251,462	$252,715	$222,664	$-30,051	-11.19%

Program Activity	FY 2001 Enacted	FY 2002 Enacted	FY 2003 Request	$ Change	% Change
Summary					
Operating Expenses	$251,462	$252,715	$222,664	$-30,051	-11.19%
Capital Equipment	$0	$0	$0		
Total Program	$251,462[a]	$252,715	$222,664	$-30,051	-11.19%

Staffing (FTEs)	Actual	Budgeted	Budgeted
HQ FTEs	66	62	61
Field FTEs	1	1	1
Total FTEs	67	63	62

Actual Full-Time Equivalent (FTE) usage is cited for FY 2001 while budgeted staffing numbers are displayed in the FY 2002 and FY 2003 columns. For comparability purposes, budgeted FY 2001 FTE were HQ 62, Field 1 and total 63.

Authorizations:
P.L.93-275, "Federal Energy Administration Act of 1974"
P.L. 93-577, "Federal Nonnuclear Energy Research and Development Act of 1974"
P.L. 94-163, "Energy Policy and Conservation Act" (EPCA) (1975)
P.L. 94-413, "Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976"
P.L. 95-91, "Department of Energy Organization Act" (1977)
P.L. 95-238, Title III - "Automotive Propulsion Research and Development Act of 1978"
P.L. 96-512, "Methane Transportation Research, Development and Demonstration Act of 1980"
P.L. 100-494, "Alternative Motor Fuels Act of 1988"
P.L. 102-486, "Energy Policy Act of 1992"

[a] Reflects adjustments of $-562,000 for Omnibus Rescission, P.L. 106-554; and $-3,936,000 for SBIR/STTR.

DEPARTMENT OF ENERGY
FY 2003 CONGRESSIONAL BUDGET REQUEST
ENERGY CONSERVATION
(Dollars in Thousands)

TRANSPORTATION SECTOR

SUMMARY OF CHANGES

	FY 2003 Request
FY 2002 Enacted	$ 252,715
Non-Discretionary	
- Increase for Federal Pay Raise and Locality Pay	$ 128
FY 2003 Base	$ 252,855
Vehicle Technologies R&D:	
- Hybrid Systems R&D - Reduce effort on development of Digital Functional Vehicle, battery thermal management, and predicting emissions from advanced simulation models; one automotive integrated power module (AIPM) supplier will complete work in FY 2002, reducing need for funds in FY 2003; extend schedule for development of heavy hybrid electric vehicles and postpone completion of analytical modeling	-4,006
- Fuel Cell R&D - Investigate non-precious metal catalysts to reduce membrane electrode assembly cost. Accelerate manufacturing technology development to reduce costs. Accelerate research of low pressure hydrogen storage for vehicle applications. Initiate government/industry cooperative program to test and evaluate fuel cell research vehicles	8,075
- Advanced Combustion Engine R&D - Defer expansion of homogeneous charge compression ignition (HCCI) technologies to reduce engine-out emissions. Extend schedule for emission control technology R&D, delaying expected attainment of Tier 2 emissions standards	-8,412
- Cooperative Automotive Research for Advanced Technologies - Initiate 3 Phase I projects with small businesses/universities to address key vehicle technology barriers; renew Graduate Automotive Technology Education (GATE) program activities.	500

- Electric Vehicles R&D - Reduce level of support to the USABC and national laboratories to develop solid polymer electrolyte battery technology . . . . . -3,519

- Heavy Vehicle Systems R&D - Perform dynamic stability tests of the air circulation control system on full-scale tractor-trailer systems, conduct wind tunnel tests on yaw angle amelioration for tractor-trailer rigs, accelerate development of new brake materials. 1,520

Fuels Utilization R&D:

- Advanced Petroleum Based Fuels - Accelerate the development and evaluation of fuel formulations that use petroleum as the base fuel in a complete engine emission control and fuel system. Advanced fuel formulations will be necessary to enable high-efficiency diesel engines to meet new stringent emission standards. 1,730

- Alternative Fuels - Terminate activities relevant to heavy duty natural gas vehicles and infrastructure R&D by completing existing contract obligations . . . . . -9,155

Materials Technologies:

- Propulsion Materials Technology - Terminate activities relevant to power electronics; fuel injection holes; electronic ceramics; inorganic PEM electrode support; and frictionless coatings for compressors, carbon foam, and heat exchangers. . . . . -1,962

- Lightweight Materials Technology - Extend schedule for work on materials such as carbon fibers, magnesium, and titanium, in order to bring work on aluminum and advanced high-strength steels to scheduled conclusions; delay funding of carbon composite component awards resulting from second solicitation. . . . . -6,931

- High Temperature Materials Laboratory - Decrease staffing from 16 to 12 FTEs. . . . . -1,600

Technology Deployment:

- Clean Cities Program - Reduce Special Project State Grants and other key niche market projects; reduce technical assistance to coalitions . . . . . -2,560

- Testing and Evaluation - Expand assistance to Federal agencies; test two additional hybrid vehicles; test several additional electric vehicles. 1,200

- EPACT Replacement Fuels - Expand program activities with States and covered fleets to increase alternative fuel use; strengthen fleet monitoring and fuels analysis 1,000

- Advanced Vehicle Competitions - Add fuel cells to Future Truck and initiate planning for next competition	200
Management and Planning:	
- Technology Assessment and Analysis - Increase analytical activities	300
- Program Direction - Reduce support for FTEs.	-571
Cooperative Program With States:	
- No activities.	-2,000
Energy Efficiency Science Initiative:	
- No activities.	-4,000
FY 2003 Congressional Budget Request .	$ 222,664

TRANSPORTATION TECHNOLOGIES
TRANSPORTATION SECTOR
(Dollars in Thousands)

VEHICLE TECHNOLOGIES R&D

I. Mission Supporting Goals and Objectives

Mission: The Vehicle Technologies Research and Development (R&D) sub-program supports work on advanced vehicle technologies that will produce dramatic improvements in fuel economy for automobiles, sport utility vehicles (SUVs), and light and heavy trucks, without sacrificing safety, environmental performance, and affordability.

Summary: The Vehicle Technologies R&D sub-program comprises six areas that are focused on enabling high-fuel-efficiency and low-emissions advanced vehicles. The areas of research include Hybrid Systems R&D, Fuel Cell R&D, Advanced Combustion Engine R&D, Electric Vehicle R&D (high-energy batteries), Heavy Vehicle Systems R&D, and programs for small businesses and universities called CARAT (Cooperative Automotive Research for Advanced Technologies) and GATE (Graduate Automotive Technology Education), respectively. All six activities are focused on advancing enabling technologies and eliminating the barriers to commercialization.

The Hybrid Systems R&D activity includes research in high power energy storage, advanced power electronics, ancillaries, and propulsion technology. Hybrid Systems R&D is overarching in that it sets performance targets for all vehicle technology areas and validates achievement of those targets in a systems context.

The key research and development areas for the automotive Fuel Cell R&D activity are the fuel cell stack subsystem, the on-board fuel processing and storage subsystem, the balance-of-plant components (compressors, humidifiers, heat exchangers, sensors, controls), and the fuel infrastructure (off-board fuel processing, purification and dispensing). Performance improvements in the stack are necessary to achieve the size, weight, and cost targets required for commercialization. To provide fuel for the stack, advanced fuel-flexible fuel processors with rapid start-up and full load-following capability are being developed. Balance-of-plant components R&D is needed for the unique fuel cell requirements of flow rate, pressure, efficiency, turn-down characteristics, automotive durability, and cost. In addition, the activity is evaluating the use of petroleum, natural gas, and alternative fuels to produce hydrogen on-board and off-board the vehicle, while economical renewable sources for hydrogen are being developed. These activities are closely coordinated with DOE/EERE's Hydrogen Program.

The Advanced Combustion Engine R&D activity encompasses research on improved engine and related technologies in these primary areas: combustion and emissions controls R&D, light-truck engine R&D, heavy-truck engine R&D, and off-highway heavy vehicles. These activities are focused on improving engine efficiencies and on reducing regulated emissions through better engine performance, in combination with technologies such as emission controls (e.g., catalysts and particulate traps). The potential health impacts of exhaust emissions will be evaluated.

The Electric Vehicle R&D activity is focused on developing lithium-based technologies to enable 200 mile range electric vehicles. Current vehicle range is still limited by battery performance and life, and battery cost remains high. The United States Advanced Battery Consortium (USABC), under a cost-shared Cooperative Agreement with DOE, continues to work on lithium-based batteries, with goals that will extend the range of electric vehicles by a factor of four when compared to lead-acid. The USABC has selected two types of lithium-based batteries for further research and development: lithium ion and lithium-polymer. This work is supported by national laboratories and universities funded directly by DOE. Exploratory work on new low-cost electrodes and electrolytes is conducted by the national laboratories and university researchers under Exploratory Technology Research.

The Heavy Vehicle Systems R&D activity seeks to develop, in collaboration with truck manufacturers and their suppliers, technologies that will reduce non-engine parasitic energy losses from aerodynamic drag, rolling resistance, friction and wear, underhood thermal conditions, and accessory loads, as well as ensure powertrain and truck system integration to increase overall vehicle system energy utilization and efficiency. Performance of the truck as an integrated system can be optimized and substantial overall energy efficiency improvement can be achieved through systematic reduction of these parasitic energy losses. The focus is on improving the fuel economy of Class 7 and 8 long-haul tractor-trailers from 6.6 mpg to 10.3 mpg.

Context: The Vehicle Technologies R&D sub-program achieves its mission through a balanced portfolio of research and development aimed at efficiency improvements for vehicle technologies. Projects focus on research and development program successes that can be translated by industry into vehicles rolling off the assembly lines. The sub-program organization also facilitates supplier-customer relationships to ensure that R&D results from federally sponsored laboratories are transferred to industry suppliers, and that industry supplier developments are made available to the domestic automakers. DOE=s initiatives have helped accelerate the introduction of hybrid vehicles and enabling technologies. The sub-program was instrumental in stimulating the auto industry, worldwide, to initiate in-house efforts to develop and demonstrate hybrid vehicles. The Japanese auto companies were first to market small numbers of these vehicles in the U.S. in 2000, notably the Toyota Prius and Honda Insight. Other announcements to market hybrid vehicles in 2003 and 2004 in high-volume segments came from the U.S. automotive industry recently pertaining to the DaimlerChrysler hybrid Durango SUV, Ford Escape hybrid SUV, and General Motors Silverado and GMC Sierra. In addition, the program=s partnership with industry has demonstrated concept vehicles with improvements in fuel efficiency of up to three times over conventional vehicles. Prior to this program, hybrid vehicles were thought to be too expensive and not feasible. The program continues to push the technology envelope to help realize the potential benefits in improved fuel economy and reduced emissions, as well as

to develop a U.S. supplier base. Examples of the impact on industry and moving these technologies closer to commercialization follow:

As a result of the groundwork laid through the DOE transportation fuel cell activity, a U.S. industry base for fuel cells has been built. Companies such as Plug Power and NUVERA exist primarily because of early DOE support. Other, larger U.S. companies such as 3M, International Fuel Cells (now UTC Fuel Cells), and Honeywell have instituted polymer electrolyte membrane fuel cell (PEMFC) programs primarily because of DOE support. A number of mergers, and the formation of several spin-off companies that plan to commercialize fuel cell technology, have also occurred. In 1992, DOE funded Arthur D. Little (ADL) to perform a fuel chain analysis and identify appropriate reforming technologies for fuel cells. This work led to a fuel processing research effort at ADL funded by DOE, an area where previously there was no work. This work was successful and grew (almost exclusively funded by DOE) until ADL spun off a separate company, Epyx, to continue work. DOE continued to fund Epyx and urged it to form a partnership that involved a fuel cell stack technology company, which it did in 2000 with the formation of NUVERA, a joint venture among Amerada Hess, A.D. Little, and DeNora Fuel Cells. The role of DOE in automotive fuel cell technology R&D was cited by Harry Pearce, former Vice-Chairman of General Motors, at the Detroit Auto Show in January 2000: "With the assistance that we've received from the Department of Energy, who I believe is the entity primarily responsible for bringing this technology out of the aerospace industry into the automotive industry, and with the very able assistance of the national labs, I am satisfied we'll get there.@

The Advanced Combustion Engine activity has shown that barriers to achievement of Tier 2 emissions levels by advanced direct injection engines can be overcome. Tests at both the Oak Ridge National Laboratory and at Cummins Engine Company have shown that the current research path for NOx and PM reduction is viable and has demonstrated Tier 2 levels, though not for a period long enough to be viable for use on vehicles. Pacific Northwest National Laboratory (PNNL) is also developing an integrated nonthermal plasma (NTP) assisted catalyst and particulate filter system for reducing PM and NOx from compression ignition direct injection (CIDI) engines by an average of 90 percent for PM and 80 percent for NOx. Detroit Diesel Corporation (DDC) has developed a Urea Selective Catalytic Reduction (SCR) NOx control system that is combined with a continuously regenerating PM filter. SCR is being explored because it has shown the best conversion efficiencies to date over the widest temperature range, and is relatively sulfur tolerant. Industrial Ceramic Solutions continued its successful development of a microwave regenerated PM trap. Its researchers were able to increase PM removal to the range of 80 to 95 percent which will enable CIDI vehicles to meet the most stringent Tier 2 PM standards.

The Electric Vehicle R&D goals of the mid-term technology development phase of the Department's program with USABC were generally met. Successful completion of the nickel metal hydride mid-term battery development has resulted in the use of these batteries in commercially produced electric and hybrid electric vehicles. About 1,000 electric vehicles with nickel metal hydride batteries were put into operation in the late 1990s; thus, the technology was subjected to extensive in-use evaluation. It is expected that the transition from the use of nickel metal hydride batteries to lithium-based batteries for electric vehicles will occur in the next seven to ten years as the new technology is developed. At that point, the overall goals of the Department's program will have been met. Currently, more than 100 electric vehicles

(manufactured by Nissan) with Shin Kobe lithium ion batteries are in operation. USABC-developed, lithium-based batteries have been integrated into prototype electric vehicles.

The Heavy Vehicle Systems R&D activity works closely with key stakeholders, including truck and trailer manufacturers, engine companies, suppliers, and other industry stakeholders. For the relatively short time that the Heavy Vehicles activity has been in existence, there are several notable accomplishments that resulted from efforts on innovative ideas to improve the overall fuel efficiency of the heavy vehicle when optimized as an integrated system. Energy systems analysis identified aerodynamic drag as the dominant parasitic energy loss for heavy-duty long-haul trucks. Analysis of energy loss from truck idling and state-of-the-art assessment on heating and cooling auxiliary power units that have the potential to reduce idling of heavy-duty trucks were completed, with opportunities identified to increase effectiveness of truck engine cooling systems (radiator), enabling safety and design enhancements to the truck cab.

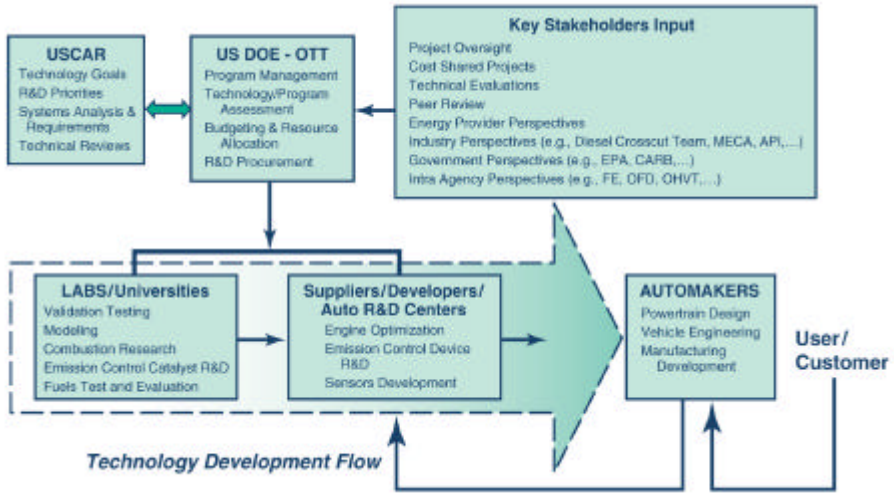
The Vehicle Technologies R&D sub-program provides technology options that span the sub-sectors of the light and heavy vehicle markets. These technology options, when sufficiently developed, can be commercialized by industry when fuel prices and environmental imperatives warrant. The sub-program is pursuing a technology portfolio that is responsive to consumer and commercial needs for vehicles that offer enhanced functionality while also respecting the environment. The program has been very successful at partnering with stakeholders who identify opportunities for targeted technology development that can have significant impact on reducing petroleum consumption while also being cost effective.

Because almost half of the 17 million passenger vehicles sold each year are light trucks, the program has shifted to focus more resources on this market segment. Also, as powerful computers and innovative software have become available, the program has increasingly invested in modeling and analysis tools to improve its capabilities to speed up evaluating new concepts and determining fuel efficiency potential before committing to expensive hardware. When small companies have devised innovative concepts, the program has provided support as well as formed strategic partnerships to accelerate those technologies to market. The program has also provided engineering data and important research findings to sister agencies that proved to be vital in fuel, emissions, and fuel-economy related regulatory activity. The program will continue to be in tune with changes in the light and heavy vehicle markets and to take advantage of opportunities for leveraging government resources.

Management Strategy: The Vehicle Technologies' activities, except for the CARAT and Heavy Hybrid Vehicles R&D activities, are organized in cooperation with the U.S. Council for Automotive Research (USCAR), to provide a mechanism for developing requirements, industry consensus, and recommendations for program direction through the implementation of technical teams. These teams are composed of government and industry experts that meet on a periodic basis to review and provide guidance on projects. DOE anticipates that some technical teams may change as the research shifts focus during the transition from PNGV to FreedomCAR. Cost-shared cooperative agreements with industry are implemented through competitive solicitations by the Department of Energy. Laboratories are directly funded,

based on their capabilities and performance. An advisory panel comprised of automotive industry experts reviews each laboratory project at the annual Merit Review and Peer Evaluation of National Laboratory R&D. Projects are evaluated based on the following criteria: 1) technical approach; 2) technical accomplishments and progress toward DOE goals; 3) technology transfer and collaborations with industry, universities, and other national laboratories; and 4) proposed future research. The panel also evaluates the strengths and weaknesses of each project, as well as recommending additions to or deletions from the scope of work. The program organization facilitates supplier-customer relationships to ensure that R&D results from federally sponsored laboratories are transferred to industry suppliers and that industry supplier developments are made available to the domestic automakers. All activities conducted under the FreedomCAR partnership – including vehicle technologies activities – will be reviewed biennially by the National Research Council.

The figure below illustrates the management structure and responsibilities of the major groups participating in the FreedomCAR programs.



The different management structures used in CARAT, Electric Vehicle R&D, and Heavy Vehicle Systems R&D are explained below.

Cooperative Automotive Research for Advanced Technology (CARAT): This activity has two elements: CARAT and Graduate Automotive Technology Education (GATE). Under CARAT, the objective is to include the innovative ideas and technologies of small businesses and institutions of higher learning in DOE's advanced automotive technologies programs. This is accomplished through regular competitive solicitations of proposals to conduct cost-shared research and development. The topic areas cover the spectrum of automotive technologies that

have potential for improving efficiency. Industry partners provide input on priorities for topic selection. The evaluations of applications are completed by outside expert reviewers, and a consensus meeting is held among the Office of Advanced Automotive Technologies (OAAT) technology managers to determine which projects will be awarded. The types of projects selected must complement the existing research and often fill gaps in the existing programs. Once the projects are underway or near completion, the results are presented at an industry review meeting (for example, Government/Industry Partnership Fuel Cell Technical Team monthly meeting, USABC program review, Automotive Composites Consortium meeting, annual Vehicle Systems Merit Review and Peer Evaluation of National Laboratory R&D, etc.), during which participants provide feedback on the merit of the work, and whether further support is recommended.

The objective of the GATE program is to train a future workforce of automotive engineers who are knowledgeable about advanced technologies, and also to utilize the brightest university graduate students to help solve current technical challenges. This is accomplished by setting up GATE Centers of Excellence, establishing focused curriculum, and providing funds for research fellowships. The original ten GATE schools were selected through a competitive solicitation. An annual GATE Forum is held with representatives from industry, universities, and government agencies to increase partnering opportunities and present the research on enabling technologies being developed at the GATE centers. These research projects are evaluated for merit by the participants with formal feedback provided to the presenters.

Electric Vehicles R&D: The Electric Vehicles R&D activity has two elements: Advanced Battery Development and Exploratory Technology Research. Under Advanced Battery Development, the United States Advanced Battery Consortium (USABC) conducts R&D on advanced proprietary battery technologies by contracting with industrial developers, with support from the DOE national laboratories. Exploratory Technology Research, focused on developing new electrode and electrolyte materials for advanced batteries, is conducted at the national laboratories. All of the USABC subcontracts to develop advanced batteries for electric vehicles have been awarded under a competitive process established by the USABC.

All program participants regularly make measurements or estimate critical parameters of program progress in accordance with standardized procedures and processes. Deliverables by the industrial contractors to the USABC are independently evaluated by the DOE national laboratories. The Electric Vehicles R&D activity is reviewed by Transportation technologies and OAAT every four months, during which progress toward the battery technical targets and fiscal year milestones is evaluated. Similarly, all industrial and laboratory R&D activities are reviewed every three months by DOE and the USABC, with progress being assessed against the established metrics and milestones. Merit Reviews are conducted annually by DOE. Interagency coordination on advanced battery development is conducted through the government-sponsored Interagency Advanced Power Group.

Heavy Vehicle Systems R&D: DOE's goals and planning for the Heavy Vehicle Systems activity have been substantially augmented by workshops involving representatives from government, industry, and academia, which have resulted in the formulation of peer-group reviewed Multi-Year Program Plans (MYPPs). The MYPPs have identified the key technical thrust areas, technical barriers, potential market barriers,

time frames for development, and estimated resources required to achieve the identified goals. Truck original equipment manufacturers (OEMs), engine manufacturers, material suppliers, and key component manufacturers have been actively involved in the review, approval, and acceptance of the MYPPs, the subsequent research activities, and the evaluation and commercial implementation of the technical developments of the program. The national laboratories, particularly LLNL, ANL, and ORNL, provide key technical support for the R&D project activities with industry, many of which are selected through competitive solicitations. The DOE program manager retains the sole responsibility for making the final decisions in the selection of the projects within the programmatic portfolio.

A. Hybrid Systems R&D

Long Term Goals and Benefits

The goals of the Hybrid Systems R&D activity are to develop advanced propulsion and ancillary subsystem components (e.g., high-power energy storage, power electronics, electric machines), consistent with established performance targets. The activity also sets performance targets for component development programs and validates the achievement of vehicle-level objectives through a combination of component and vehicle testing and computer simulation. All activities are system-driven and barrier-focused, to ensure maximum benefit from the R&D investment and development of hybrid systems technologies that are practical for automobile, light trucks and heavy vehicle applications. All technological targets for hybrid system technologies are derived from a common vehicle-level perspective, and the resultant technologies are validated in the context of a vehicle operating environment. Additionally, resources are being refocused on longer term R&D applicable to a broader range of clean and efficient vehicles to give the industry greater flexibility in harvesting the benefits from these new technologies.

GPRA: The projected benefits of the Hybrid Systems R&D activity are shown in the table below.

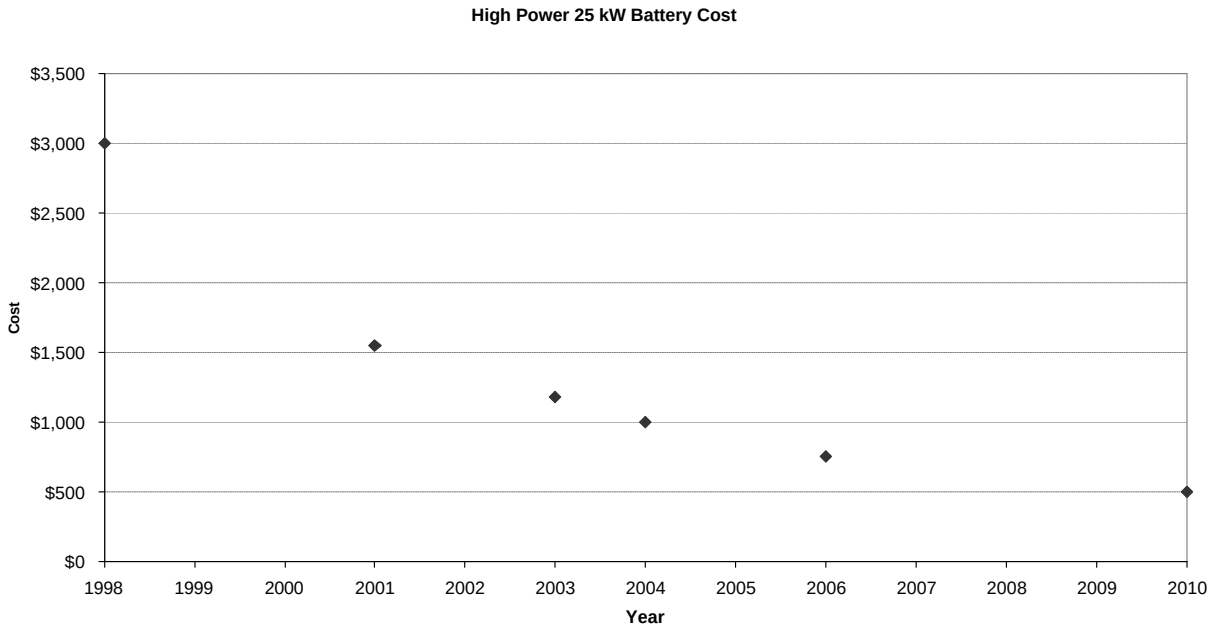
Hybrid Systems R&D	2005	2010	2020
Petroleum Displaced (Millions Barrels per Day)	0.01	0.09	0.71
Total Primary Energy Displaced (Trillion Btu)	10	182	1,499
Energy Costs or Savings (Millions of $)	105	1,991	16,005
Carbon Equivalent Emissions Displaced (MMTCE)	0.19	3.53	29.02

Note: Program benefit projections are developed through an impact analysis process undertaken annually by EERE, based on assumptions for future energy markets derived from EIA's annual energy outlook. EERE's sectors analyze the impacts their programs will have on energy savings, energy cost savings, and carbon reductions if all program goals are met, and future energy markets develop as expected. A sample of program benefit estimates are externally reviewed by Arthur D. Little.

– By 2004, demonstrate the automotive integrated power module (AIPM) and automotive electric motor drive (AEMD) enabling technologies that meet all performance criteria and less than $7/kW and less than $4/kW, respectively with mean time between failures (MTBF) approaching 150,000 miles. (A 1994 baseline example was the DOE fuel cell bus, for which the power system cost $900,000; these targets would allow the same system to be built for $3,000.)

– By 2006, develop hybrid technologies that enable commercial (competitive in terms of cost and performance) high-efficiency urban heavy vehicles, light trucks and SUVs.

– By 2010, reduce hybrid electric high power battery cost to $500 per 25 kW battery and increase battery life to 15 years.



The program target for FY 2003, which is an important milestone to achieving the overall goal, is projected to be achieved with funding at the FY 2003 level.

Estimated cost per battery based on production of 100,000 batteries per year.

– By 2015, complete development and validation (through hardware test and modeling known as “hardware in the loop”) of enabling vehicle technologies applicable across the fleet that:

i. enable dramatic improvements in fuel economy across vehicle segments
ii. have near-zero harmful emissions
iii. operate on domestic renewable fuels

Program Strategic Performance Goal

ER1-10: Hybrid Systems R&D
Hybrid Systems R&D activities will reduce the production cost of a high power 25kW battery from $3,000 in 1998 to $500 in 2010, with an intermediate goal of $750 in 2006.

Performance Indicator:
The estimated cost of high power 25 kW batteries will be the indicator of performance for the hybrid systems R&D activity. This will be measured as the cost per 25kW battery system, at a production level of 100,000 battery systems per year.

Annual Performance Results and Targets

FY 2001 Results	FY 2002 Target	FY 2003 Proposed Target
Completed testing of the 276-volt battery aimed at demonstrating an integrated system having thermal and electrical controls. (ER3-1)	Complete development of second generation lithium ion electrochemistry for hybrid vehicle power. (ER3-1)	Reduce high power 25 kW estimated battery cost to $1,180 per battery system.

Significant Accomplishments

The Hybrid Systems R&D activity develops the propulsion system components that are vital to the widespread commercialization of hybrid vehicles in light and heavy vehicles. The program has been very successful in creating the analytical tools and instruments that enable advanced vehicles to be simulated and evaluated without having to build hardware. This capability will be a valuable asset as the program moves forward. In addition, progress has been made in development of high-power battery and electric drive technologies for use in hybrid electric vehicles.

FY 2001. Demonstrated the Digital Functional Vehicle analytical tool, which will be used to quantify the benefits of optimizing the designs of various components. Completed component selection and system design definitions, and equipped two heavy vehicles with parallel hybrid propulsion systems. Results of testing are as good or better than conventional vehicles for performance, and as good or better than natural gas vehicles for emissions. Fabricated and completed testing of two 276-volt lithium ion mini-battery packs, demonstrating an integrated system with thermal and electrical controls.

FY 2002. Complete the development of the Advanced Powertrain Test Facility. This facility will have the capability of measuring the performance of all components being developed under the Hybrid Systems R&D activity and simulating their actual contribution to improved fuel economy in advanced vehicles. Integrate the latest energy storage and power control technologies for heavy hybrid vehicles. Complete sport utility vehicle fuel economy improvement projects focused on emissions, aerodynamics, and mass reduction. Complete characterization and cycle life capability of the two 276-volt lithium ion battery packs. Complete development of second generation lithium ion electrochemistry.

FY 2003. Complete development of the advanced thermal manikin and integrate with psychological, physiological, and vehicle cabin models. This manikin will be used to optimize the design of climate control systems for reduced power demand. Complete Phase II nickel metal hydride battery module development efforts and assess performance against performance targets. Complete battery thermal management and packaging development efforts and transfer knowledge to battery system producers. Reduce high power 25 kW estimated battery cost to $1,180 per battery system. Complete testing of final Automotive Integrated Power Module prototypes and electric drive motors. Share results with vehicle developers.

B. Fuel Cell R&D

The use of fuel cell vehicles has the potential to significantly reduce harmful emissions and consumption of non-renewable energy sources. The fuel cell is a revolutionary technology that can power automobiles with little or no tailpipe emissions, provide energy to homes and factories with virtually no smokestack pollution, and utilize renewable, domestic energy while creating thousands of jobs.

Long Term Goals and Benefits

The Fuel Cell R&D activity develops technologies for highly-efficient, low- or zero-emission, cost-competitive vehicle fuel cell power systems that can operate on either conventional or alternative fuels. The long-term goal is to develop fuel cell vehicles that operate on renewable-based hydrogen. The program integrates efforts of the automotive industry, fuel cell and fuel processor developers, national laboratories, universities, and fuel suppliers in a customer-focused program to develop fuel-efficient vehicle power systems that meet the most stringent emission standards while retaining the same performance as today's vehicles.

The goals of the program are to develop and validate fuel cell power system technologies (including fuel cell stack subsystem, fuel processor subsystem, and balance of plant components) by the year 2010 that are:

- 45 percent energy efficient at 1/4 peak power; 35 percent energy efficient at peak power

- capable of being manufactured with a projected high-volume cost of $45 per kilowatt (kW) in 2010
- compliant with EPA Tier 2, Bin 2, emissions regulations
- capable of operating on hydrogen, or on hydrogen-rich fuel produced from on-board reforming of Tier 2 gasoline, methanol, ethanol, and natural gas
- comparable in performance, safety, and reliability to the gasoline internal combustion engine.

GPRA

Fuel Cell R&D	2005	2010	2020
Petroleum Displaced (Millions Barrels per Day)	0	0	0.18
Total Primary Energy Displaced (Trillion Btu)	0	2	368
Energy Costs or Savings (Millions of $)	0	25	3,779
Carbon Equivalent Emissions Displaced (MMTCe)	0	0.04	7.16

Note: Program benefit projections are developed through an impact analysis process undertaken annually by EERE, based on assumptions for future energy markets derived from EIA's annual energy outlook. EERE's sectors analyze the impacts their programs will have on energy savings, energy cost savings, and carbon reductions if all program goals are met, and future energy markets develop as expected. A sample of program benefit estimates are externally reviewed by Arthur D. Little.

S By 2005, demonstrate a 50kW fuel-flexible fuel processing subsystem with power density greater than 700 W/L and specific power greater than 700 W/kg. (Year 2000 baseline performance was 500W/L and 450 W/kg.)

S By 2005, demonstrate an integrated 50kW fuel cell system with 40 percent efficiency at 1/4 peak power running on gasoline. (Year 2000 baseline performance was a 10kW system that achieved 30 percent efficiency at 1/4 peak power.)

S By 2005, reduce the cost of a 50kW fuel cell stack subsystem to $125/kW. (Year 2000 baseline performance was $325/kW.)

S By 2005, reduce fuel cell stack platinum loading to 0.6g/peak kW. (Year 2000 baseline performance was 2.0g/kW.)

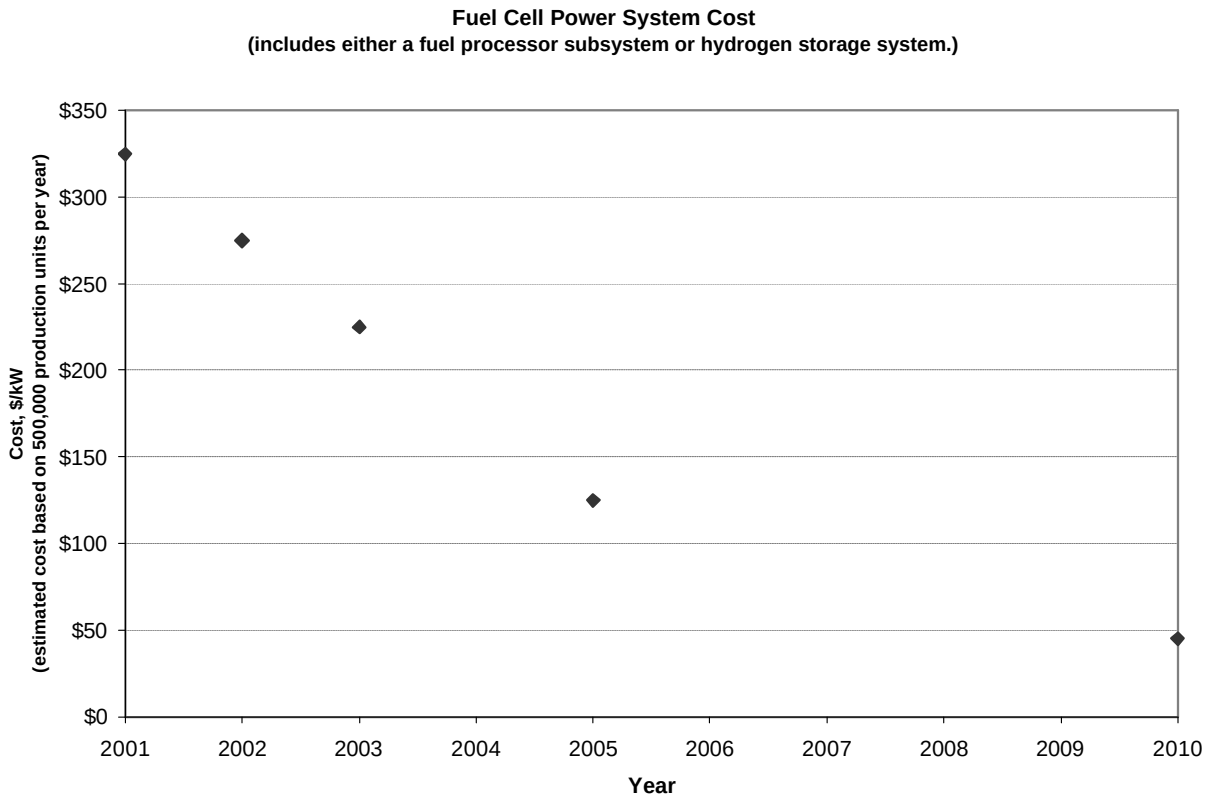
Program Strategic Performance Goal

ER1-11: Fuel Cells R&D

Fuel Cell R&D activities will reduce the production cost of the 50 kW vehicle fuel cell power system from $275/kW in 2002 to $125/kW in 2005 and $45/kW in 2010.

Performance Indicator:

The performance measure for this activity is the cost of the 50 kW vehicle fuel cell power system.



The program target for FY 2003, which is an important milestone to achieving the overall goal, is projected to be achieved with funding at the FY 2003 level.

Annual Performance Results and Targets

FY 2001 Results	FY 2002 Target	FY 2003 Proposed Target
Achieved $325/kW for a 50 kW fuel cell power system.	Achieve $275/kW for a 50 kW fuel cell power system.	Achieve $225/kW for a 50 kW fuel cell power system.

Significant Accomplishments

The Fuel Cells for Transportation Program funds multiple component development efforts in support of the ultimate objective of industry production of automotive fuel cell power systems that are highly efficient, low or zero emission, and cost competitive. Projects have included the development of complete systems, fuel processing and stack systems, individual components, and fuel infrastructure subsystems. Specific technical targets for the complete system, subsystems and components guide these activities.

FY 2001. Completed test and evaluation of a fuel-flexible 50 kW integrated fuel cell power system that was 32 percent efficient at 1/4 peak power. This 50kW power system, developed by International Fuel Cells (now UTC Fuel Cells), was the world's first fully functional, automotive fuel cell system which operated on gasoline with extremely low emissions. It also indicated the development areas needed for creating a more compact/lightweight, fully integrated, and cost-competitive system. This is a major program accomplishment toward DOE's 2010 goal of creating a high efficiency propulsion system comparable in performance to the internal combustion engine.

FY 2002. Demonstration and delivery of an advanced 50 kW fuel-flexible fuel processor subsystem for automotive fuel cell systems achieving a power density of 800W/L and a specific power of 550 W/kg. Since a hydrogen infrastructure is currently unavailable, a fuel processor on-board the vehicle that can derive hydrogen from fuels such as gasoline, alcohols, or natural gas will allow fuel cell vehicles to enter the market more quickly. This could provide the fuel efficiency benefits of fuel cells sooner, thus accelerating fuel cell vehicle commercialization and hydrogen fueling infrastructure development. A major challenge is to make the on-board fuel processor compact and lightweight.

FY 2003. Demonstrate feasibility of low-cost fabrication processes for membrane electrode assemblies (MEAs) in pilot plant operation to meet an overall fuel cell stack subsystem cost target of $100/kW. Initiate development of advanced catalyst deposition techniques that will meet the 2005 precious metal loading target of 0.6g/kW. Accelerate research of hydrogen storage for vehicle applications. Cost is one of the main barriers to commercialization. New materials and high-volume manufacturing processes can significantly reduce costs. Support field evaluations of fuel cell research vehicles, which are necessary to determine future R&D needs and the feasibility of hydrogen refueling operations.

C. Advanced Combustion Engine R&D

Long Term Goals and Benefits

The Advanced Combustion Engine R&D activity focuses research and development efforts on removing critical technical barriers to commercialization of higher efficiency, advanced internal combustion engines. These efforts will enable dramatic improvements to

automobile, light truck, and heavy truck fuel economy (ranging from 10 percent to 35 percent, depending on vehicle size and weight) while cost-effectively meeting projected emissions regulations.

This activity encompasses research on improved engine and related technologies in three primary areas: Combustion and Emission Control, Light Truck Engine, and Heavy Truck Engine. Work supported is focused on improving engine efficiency and on reducing regulated emissions through better engine performance in combination with supporting technologies such as emission controls (e.g. NOx catalysts and particulate traps). Complementing the three primary efforts are evaluations of the potential health impacts of exhaust emissions and the development of technologies to reduce emissions from off-highway heavy vehicles. These efforts are performed in conjunction with research supported by the Advanced Petroleum Based Fuels activity.

GPRA

Advanced Combustion Engine R&D	2005	2010	2020
Petroleum Displaced (Millions Barrels per Day)	0	0.10	0.39
Total Primary Energy Displaced (Trillion Btu)	1	208	828
Energy Costs or Savings (Millions of $)	23	3,391	12,572
Carbon Equivalent Emissions Displaced (MMTCe)	0.03	3.70	14.74

Note: Program benefit projections are developed through an impact analysis process undertaken annually by EERE, based on assumptions for future energy markets derived from EIA's annual energy outlook. EERE's sectors analyze the impacts their programs will have on energy savings, energy cost savings, and carbon reductions if all program goals are met, and future energy markets develop as expected. A sample of program benefit estimates are externally reviewed by Arthur D. Little.

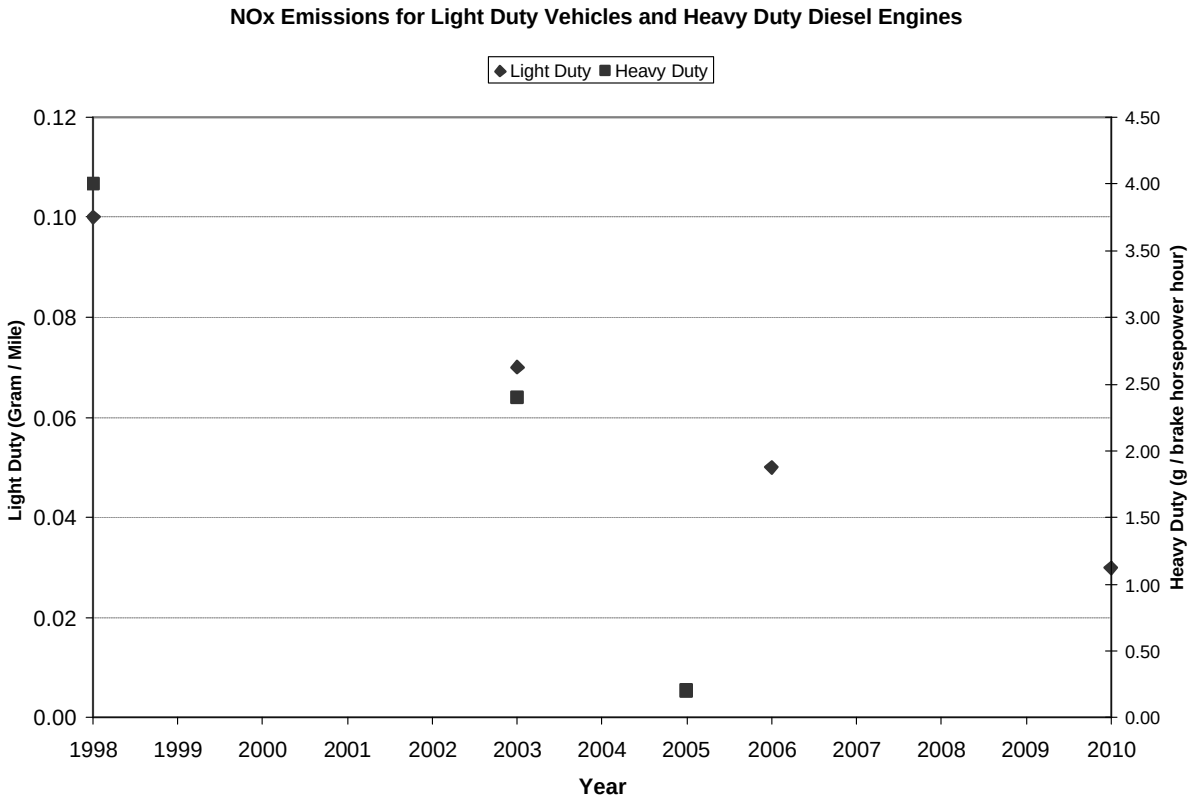
- **S** By 2004, complete development of advanced clean diesel engine technologies that enable commercial production of pickup trucks, vans, and SUVs that achieve at least a 35 percent fuel efficiency improvement relative to current gasoline-fueled trucks while demonstrating the ability to achieve Tier 2 emission standards.
- **S** By 2006, increase the efficiency of heavy duty diesel engines from 45 percent to 50 percent, while reducing emissions to EPA 2007 levels.
- **S** By 2010, reduce emissions of light duty compression ignition, direct injection vehicles from 0.08 to 0.01 grams/mile PM and from 1.0 to 0.03 grams/mile NOx with 120,000 mile durability.
- **S** Provide the engine technology community with toxicological assessments of health impacts for various technologies.
- **S** By 2010, increase the thermal efficiency of heavy truck engines from 45 to 55 percent.

Program Strategic Performance Goal

ER1-12: Advanced Combustion Engine R&D

Advanced Combustion Engine R&D activities will reduce NOx emissions in light-duty diesel vehicles from 0.10 grams per mile (g/m) in 1998 to 0.05 g/m in 2006 and 0.03 g/m in 2010 and in heavy duty diesel engines from 4.0 grams per brake horsepower hour (g/bhp-hr) in 1998 to 2.4 g/bhp-hr in 2002 and 0.2 g/bhp-hr in 2005.

Performance Indicator:
The NOx emissions is the indicator of performance for the advanced combustion activity.



The program target for FY 2003, which is an important milestone to achieving the overall goal, is projected to be achieved with funding at the FY 2003 level.

Annual Performance Results and Targets

FY 2001 Results	FY 2002 Target	FY 2003 Proposed Target
Light truck demonstration resulting in a 35 percent increase in fuel efficiency in a sport utility vehicle.	Complete initial testing of light trucks with prototype diesel engines to demonstrate a 35 percent increase in fuel efficiency and Tier 2 emissions. Demonstrate 45 percent thermal efficiency for heavy duty diesel engine while meeting EPA 2004 emission standards.	Demonstrate optimized emission control system that achieves 0.07 g/mile NOx and 0.01 g/mile PM short-term performance in light duty vehicles.

Significant Accomplishments

FY 2001

- Combustion and Emission Control R&D: Demonstrated NOx reduction of 90 percent in bench-scale non-thermal plasma catalyst tests
- Heavy Truck Engine: Demonstrated EPA 2004 emission standards.
- Light truck demonstration resulting in a 35 percent increase in fuel efficiency in a sport utility vehicle.

FY 2002

- Combustion and Emission Control R&D: Demonstrate CIDI emissions levels of 0.2 grams/mile NOx and 0.02 grams/mile PM with prototype NOx adsorber, urea selective catalytic reduction and regenerative particulate filter devices.
- Light Truck Engine: Conduct initial testing of prototype diesel engines to demonstrate a 35 percent increase in fuel efficiency and feasibility of meeting Tier 2 emissions when integrated into a sport utility vehicle using low sulfur fuel.
- Heavy Truck Engine: Demonstrate 45 percent thermal efficiency while meeting EPA 2004 emission standards.

FY 2003

- Combustion and Emission Control R&D: Demonstrate an integrated CIDI emission control subsystem with the potential to achieve 0.07 g/mile NOx and 0.01 g/mile PM short-term performance.
- Light Truck Engine: Complete testing of prototype diesel engines to demonstrate a 35 percent increase in fuel efficiency and feasibility of meeting Tier 2 emissions when integrated into a sport utility vehicle using low sulfur fuel.
- Heavy Truck Engine: Demonstrate 50 percent thermal efficiency in a laboratory engine while meeting EPA 2004 standards.

D. Cooperative Automotive Research for Advanced Technology (CARAT)

The Cooperative Automotive Research for Advanced Technology activity consists of CARAT and Graduate Automotive Technology Education (GATE). CARAT represents an aggressive and focused effort to ensure that small businesses and universities can fully participate in advanced automotive R&D activities. GATE provides graduate-level engineering training focused on crosscutting advanced automotive technologies by providing research fellowships and support to develop technology-based curricula.

Long Term Goals and Benefits

The goal of CARAT is to develop the most promising ideas for energy-efficient automotive technologies from small businesses and universities. The goals for GATE are (1) to train a future workforce of engineering professionals who are knowledgeable about and experienced in developing automotive technologies critical to the design and production of future automobiles; and (2) to marshal the resources of the brightest university graduate students to help solve the technology challenges identified by government and industry.

CARAT: By FY 2005, design, test and evaluate approximately 40 advanced components for potential applications in high-efficiency vehicles.

GATE: By FY 2005, award fellowships to over 100 graduate students to study and conduct research on the most critical automotive technologies related to high fuel economy vehicles.

The technical objectives that the specific CARAT and GATE projects support are within each of the other Vehicle Technologies activities. (For example, one CARAT project on development of lithium ion anodes addresses the Electric Vehicle activity's objective of a 200 mile range battery by 2008).

Significant Accomplishments

FY 2001. For CARAT, the five Phase 1 projects initiated in FY 2000 were completed; the results are being evaluated by industry to determine if further development support is warranted. Seven Phase 2 projects initiated in FY 2000 are midway through completion. A solicitation for new Phase 1 projects was initiated. For GATE, curriculum development was completed at all ten schools, and fellowship support was provided to 47 graduate students. During this year, new courses were introduced, new faculty were hired, GATE students graduated and took jobs in the automotive industry, and one hybrid technology project at the University of Maryland resulted in a patent pending. At the GATE Forum held in Dearborn, Michigan in March 2001, 116 participants from industry, government and academia learned about the enabling technologies being developed at the GATE Centers. A cost/benefit evaluation of the GATE program was initiated.

FY 2002. For CARAT, the seven Phase 2 projects initiated in FY 2000 will be completed and evaluated by industry. Conduct about three new Phase 1 projects. There was no FY 2002 appropriation for GATE program.

FY 2003. For CARAT, evaluate existing Phase 1 projects and initiate new high priority Phase 1 projects in the core technology topics. For GATE, provide research fellowships to 25 students for research in advanced automotive technologies. Conduct GATE Forum with industry, universities, and government agencies to increase partnering opportunities. Initiate solicitation of new GATE schools focusing on technologies not currently being addressed.

E. Electric Vehicles R&D

Long Term Goals and Benefits

The Electric Vehicles R&D activity supports EERE and National Energy Policy (NEP) strategic objectives by developing and validating advanced electric vehicle battery technologies that will enable full-range electric vehicles and facilitate their commercial viability. Advanced lithium batteries are being developed under a cooperative agreement with the United States Advanced Battery Consortium (USABC). Exploratory work on new electrode and electrolyte materials is conducted by the national laboratories and selected university researchers under Exploratory Technology Research.

Advanced electric vehicles can provide the same level of comfort, performance, and affordability as today's internal combustion engines without their associated air and noise pollution. The Electric Vehicles R&D activity also helps support the automobile industry's response to the California Air Resources Board's Zero Emissions Vehicle program, as reaffirmed in January 2001. Projected benefits are shown below.

Electric Vehicles R&D	2005	2010	2020
Petroleum Displaced (Millions Barrels per Day)	0.01	0.02	0.10
Total Primary Energy Displaced (Trillion Btu)	15	34	142
Energy Costs or Savings (Millions of $)	662	1,460	3,470
Carbon Equivalent Emissions Displaced (MMTCe)	0.01	0.12	2.01

Note: Program benefit projections are developed through an impact analysis process undertaken annually by EERE, based on assumptions for future energy markets derived from EIA's annual energy outlook. EERE's sectors analyze the impacts their programs will have on energy savings, energy cost savings, and carbon reductions if all program goals are met, and future energy markets develop as expected. A sample of program benefit estimates are externally reviewed by Arthur D. Little.

Electric vehicle range is still limited by battery performance and life, and battery cost remains high.

- By 2008, develop and validate a lithium-based advanced battery capable of 200 mile range.
- By 2010, reduce electric vehicle battery cost to $150/kilowatt-hour, as compared to $1,000/kilowatt-hour in 1998.

Program Strategic Performance Goal

ER1-13: Electric Vehicles R&D
Electric Vehicles R&D activities will reduce the production cost of a 40kWh lithium ion battery from $365/kWh in 2001 to $295/kWh in 2004 and to $150/kWh in 2010.

Performance Indicator
The lithium ion battery cost for electric vehicles is the indicator of performance for the electric vehicle activity. Estimated cost targets are based upon production of 20 thousand, 40kWh batteries per year.

Annual Performance Results and Targets

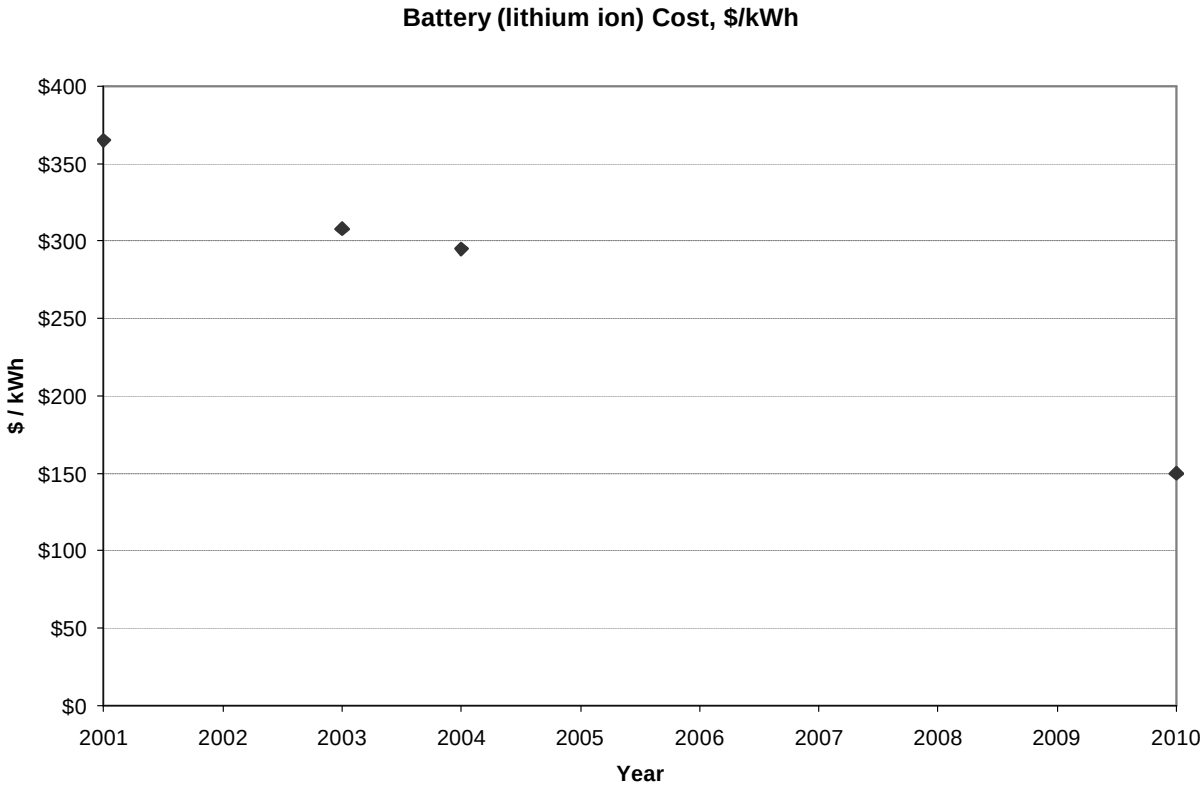
FY 2001 Results	FY 2002 Target	FY 2003 Proposed Target
Completed explorations of lithium-polymer and lithium ion battery technologies; lithium ion was selected as the most promising approach for continued development.	Reduce gassing in sealed lithium ion batteries so that cells do not vent after 5 year storage at full charge.	Reduce estimated cost of battery systems to $308 per kWh in 40 kWh systems, based on a production level of 20,000 batteries per year.

Significant Accomplishments

FY 2001. Completed extended testing of USABC lithium ion and lithium polymer batteries to determine life.

FY 2002. Assess capability of novel lithium-based system to meet the long-term USABC electric vehicle battery technical goals. Reduced gassing in sealed lithium ion batteries.

FY 2003. Under Advanced Battery Development demonstrate a lithium-based battery specific energy greater than 140 Wh/kg. Reduce estimated cost of battery systems to $308 per kWh in 40 kWh systems. Through Exploratory Technology Research, develop cathodes with greater than 200 mAh/g at a cost of less than $7/kg.



The program target for FY 2003, which is an important milestone to achieving the overall goal, is projected to be achieved with funding at the FY 2003 level.

Cost per kWh of battery, based on production of 20 thousand, 40 kWh batteries per year.

F. Heavy Vehicle Systems R&D

Long Term Goals and Benefits

The major goal of the Heavy Vehicle Systems R&D activity is to substantially reduce the non-engine parasitic energy losses in heavy vehicles, thus simultaneously increasing energy efficiency and reducing undesirable emissions without reducing vehicle functionality, durability, reliability or safety, and to achieve this goal in a cost effective manner. This reduction in weight will be reflected in increased productivity of the heavy duty fleet, since a smaller number of trucks will be capable of carrying the same freight tonnage. Innovative design of components, investigation and application of new physical concepts such as nanoparticle cooling for heat rejection systems, and development of manufacturing and production methodologies are essential parts in the technological portfolio of the activity.

Heavy Vehicle Systems R&D	2005	2010	2020
Petroleum Displaced (Millions Barrels per Day)	0	0.04	0.37
Total Primary Energy Displaced (Trillion Btu)	1	83	775
Energy Costs or Savings (Millions of $)	6	742	6,976
Carbon Equivalent Emissions Displaced (MMTCe)	0.01	1.66	15.50

Note: Program benefit projections are developed through an impact analysis process undertaken annually by EERE, based on assumptions for future energy markets derived from EIA's annual energy outlook. EERE's sectors analyze the impacts their programs will have on energy savings, energy cost savings, and carbon reductions if all program goals are met, and future energy markets develop as expected. A sample of program benefit estimates are externally reviewed by Arthur D. Little.

– By 2003:
  1. Verify fuel economy improvements predicted from modeling and simulation calculations with on-road test of full scale (in place of quarter scale) tractor-trailer with active airflow control
  2. Evaluate innovative designs and coolants to improve underhood thermal rejection
– By 2004:
  1. Initiate technology transfer to industry of reduced areodrag reduction methodology for heavy trucks
  2. Complete competitive solicitation to conduct R&D of on-board Essential Power Systems for electrically driven truck accessories
– By 2005:
  1. Evaluate stability and safety characteristics of tractor-trailers utilizing active airflow control
  2. Construct and test prototype higher efficiency cooling system

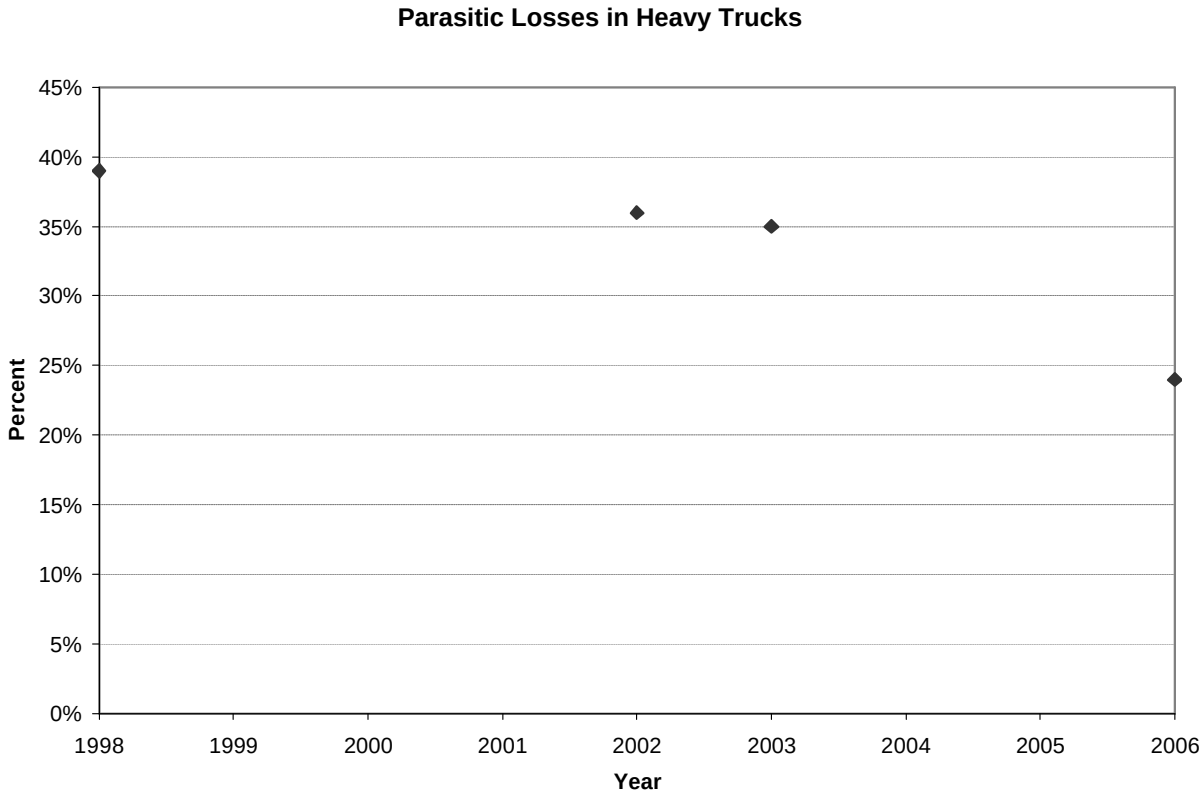
Program Strategic Performance Goal

ER1-14: Heavy Vehicle Systems R&D
Heavy Vehicle Systems R&D activities will reduce the parasitic losses, including aerodynamic drag from 39 percent in 1998 to 24 percent in 2006.

Performance Indicator
The parasitic loss (e.g., aerodynamic drag) is the indicator of performance for heavy duty vehicle systems.

Annual Performance Results and Targets

FY 2001 Results	FY 2002 Target	FY 2003 Proposed Target
Simulation calculation indicated potential reduction of aerodynamic drag by greater than 30 percent. Wind tunnel tests at 1/16 scale indicated reduction of aerodynamic drag by greater than 51 percent.	Reduce parasitic losses of heavy vehicle systems to 36 percent.	Reduce parasitic losses of heavy vehicle systems to 30 percent and benchmark additional reductions through heavy truck electrification.



The program target for FY 2003, which is an important milestone to achieving the overall goal, is projected to be achieved with funding at the FY 2003 level.

Significant Accomplishments

FY 2001. Completed wind tunnel testing of aerodynamic drag heavy duty truck scale model.

FY 2002. Identify and test aerodynamic changes to full scale heavy duty truck that result in 15 percent reduction in aerodynamic drag.

FY 2003. Identify and test aerodynamic changes to heavy duty truck that result in an additional 10 percent reduction in aerodynamic drag.

II. A. Funding Table: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001 Enacted [a]	FY 2002 Enacted	FY 2003 Request	$ Change	% Change
Hybrid Systems R&D	$48,979	$46,606	$42,600	$-4,006	-8.6%
Fuel Cell R&D	$40,663	$41,925	$50,000	$8,075	19.3%
Advanced Combustion Engine R&D	$52,205	$49,092	$40,680	$-8,412	-17.1%
Cooperative Automotive Research for Advanced Technologies	$1,500	$500	$1,000	$500	100.0%
Electric Vehicles R&D	$8,820	$7,019	$3,500	$-3,519	-50.1%
Heavy Vehicle Systems R&D	$4,894	$9,980	$11,500	$1,520	15.2%
Total, Vehicle Technologies R&D	$157,061	$155,122	$149,280	$-5,842	-3.8%

[a] FY 2001 reduced by $2,549,000 for SBIR/STTR

II. B. Laboratory and Facility Funding Table: VEHICLE TECHNOLOGIES R&D

	FY 2001 Enacted	FY 2002 Enacted	FY 2003 Request	$ Change	% Change
Ames Laboratory	$300	$290	$290	$0	0.0%
Argonne National Lab (East)	$25,083	$21,921	$21,500	$-421	-1.9%
Brookhaven National Lab	$1,279	$885	$280	$-605	-68.4%
Idaho National Engineering and Environmental Lab	$2,599	$2,285	$1,420	$-865	-37.9%
Lawrence Berkeley National Lab	$4,038	$4,595	$4,000	$-595	-12.9%
Lawrence Livermore National Lab	$1,500	$790	$676	$-114	-14.4%
Los Alamos National Laboratory	$8,435	$5,970	$7,000	$1,030	17.3%
National Renewable Energy Lab	$7,209	$4,500	$4,575	$75	1.7%
Oak Ridge National Lab	$14,477	$12,749	$10,500	$-2,249	-17.6%
Pacific Northwest National Lab	$3,850	$2,850	$2,500	$-350	-12.3%
Sandia National Laboratories	$8,043	$6,244	$6,754	$510	8.2%
All Other	$80,248	$92,043	$89,785	$-2,258	-2.5%
Total, Vehicle Technologies R&D	$157,061	$155,122	$149,280	$-5,842	-3.8%

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Hybrid Systems R&D	**Light Vehicles Propulsion & Ancillary Subsystems** Continued to focus on R&D directed at achieving the overall goal for the light vehicles program, by developing propulsion and ancillary technologies to enable 80 mpg mid-size automobiles. In addition, studies were completed to determine preliminary performance targets for sport utility vehicles and technology shortfalls. Made progress on performance models for aftertreatment devices and for predicting emissions from advanced engines. The government/ industry performance models (ADVISOR and PSAT) were redesigned to be more user friendly, by developing similar graphical user interfaces and data files to facilitate ease of use in evaluating vehicle control strategies and performing design trade-off studies. The Toyota Prius and Honda Insight hybrid vehicle models were validated to within 5 percent of test results.	**Light Vehicles Propulsion & Ancillary Subsystems** Shift focus to setting performance targets and developing technologies applicable to a wide range of vehicle classes. A target setting process is being developed, with the objective of ensuring that technology targets apply to multiple vehicle classes and are consistent with achieving out-year fuel reduction goals. Develop neural network emissions predictors for advanced internal combustion engines, to accurately predict emissions during warm-up and transient conditions. Demonstrate advanced control techniques to improve fuel economy and reduce emissions of a parallel hybrid propulsion system in the laboratory, using a combination of components including a motor, engine, and transmission. Continue to develop cost models, focusing on model calibration,	**Light Vehicles Propulsion & Ancillary Subsystems** Complete target setting process and make available to industry partners on the Web for purpose of managing and tracking programs. Use hardware-in-the-loop to validate, in a systems environment, performance targets for an advanced electric motor and power electronics modules being developed by industry partners. Continue developing emissions models to enable prediction of exhaust emissions for internal combustion engines. Complete development of thermal manikin and integrate with psychological, physiological, and vehicle cabin climate models. Begin assessment of manikin response to complete environment. Perform trade-off studies using the cost model to determine optimal

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Hybrid Systems R&D (Cont'd)	Cost model framework was completed and linked to ADVISOR for powertrain component sizing. Initiated gathering of component data for the cost model and algorithms, reflecting component cost as a function of size and power, to enable cost/benefit trade-offs. The Digital Functional Vehicle process was further developed with industry partners, to show energy saving benefits from optimizing related subsystems in a vehicle. Several projects were completed using this process on designing tires, brakes, electric steering, body pillars, and body-in-white weight reduction via probabilistic durability modeling of manufacturing variations. The sum total from each project showed that significant energy savings (approximately 0.5 million barrels per day) can be realized when energy savings is factored into the design process. Hardware-in-the-loop (HIL) testing allows individual components or	facilitated by the development of a credible cost database, and a limited number of "cost roll-ups," for several generic vehicle configurations. Further quantify the energy savings associated with the application of the Digital Functional Vehicle. Investigate potential application of the Digital Functional Vehicle process to fuel cell systems design. Evaluate response of thermal comfort manikin to changes in temperature and humidity and correlate results with psychological model. Validate the transient air conditioning model with "real system" experimental data using an industry collaborative project. Validate performance targets of an advanced lithium ion battery pack in a vehicle system environment using hardware-in-the-loop techniques. Begin testing battery thermal management system in a test vehicle. Validate the battery pack model in	hybrid vehicle configurations which provide maximum fuel economy at the lowest vehicle cost. Complete testing of battery thermal management system for an advanced battery pack, and use results to develop hardware/software for self-heating system for cold climates.

Program Activity	FY 2001	FY 2002	FY 2003
Hybrid Systems R&D (Cont'd)	groups of components to be operated and controlled on the test bench as if they were in a vehicle. Generic software to control powertrains and components being tested in HIL was completed. Capability to test a parallel hybrid vehicle configuration with a continuously variable transmission (CVT), simulating vehicles from 1,500 to 6,500 lb., was completed. A variable gap electric motor was successfully tested in a simulated vehicle using HIL. Benchmarking of several hybrid vehicles and an advanced electric motor was completed. Demonstrated ability to achieve a 20 percent reduction in vehicle ancillary loads. Completed optimization software for transient A/C systems and testing of advanced technologies for reducing vehicle soak temperature, including solar infrared reflective glazings, visibly reflective glazings, reflective shades, gas-filled body insulation, reflective roof surfaces, heat pipes and active and	ADVISOR with a NiMH battery pack.	

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
	passive parked car ventilation.		
Hybrid Systems R&D (Cont'd)	Developed, constructed, and tested a spatial and temporal resolution prototype limb for the self-contained thermal manikin. Advanced lithium and nickel metal hydride batteries were tested and a control strategy developed to improve subsystem life and operating efficiency. Participants included: ANL, NREL, ORNL, USCAR, other contractors. ($13,624) **High Power Energy Storage** Supported R&D on high power batteries with the U.S. Advanced Battery Consortium (USABC), with an industry cost share of 50 percent. Continued benchmarking nickel-metal hydride technologies to verify performance and life capabilities of production-feasible designs. Continued development of lithium	Participants include: ANL, NREL, ORNL, USCAR, other contractors. ($9,118) **High Power Energy Storage** Support R&D on high power batteries with the U.S. Advanced Battery Consortium (USABC), with an industry cost share of 50 percent. Continue testing of nickel-metal hydride cells at a DOE laboratory, to assess the performance against	Participants include: ANL, NREL, ORNL, USCAR, other contractors. ($6,835) **High Power Energy Storage** Support R&D on high power batteries with the U.S. Advanced Battery Consortium (USABC), with an industry cost share of 50 percent. Complete first Phase 3 monoblock nickel-metal hydride module technology development efforts. Assess performance against energy

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Hybrid Systems R&D (Cont'd)	ion battery subsystems, including cells and modules with acceptable life and abuse-tolerance, subsystem controls and software, and all subsystem/vehicle interfaces. Initiated testing to validate performance, life, and abuse-tolerance relative to government/industry partnership requirements. Delivered two complete subsystems for bench testing at a national laboratory. Assessed subsystem manufacturing processes; and identified components and processes needed to achieve the energy storage cost goals for the candidate lithium ion technologies. Developed a plan for verification of candidate cost reduction measures.	energy storage requirements. Continue development of low-cost, liquid-cooled, high power nickel-metal hydride modules. Continue development of lithium ion cells and modules. Initiate validation testing of modules relative to technical performance targets. Complete validation of 276-volt lithium ion mini-battery pack at 30EC. Validate performance of 276-volt lithium ion mini-battery pack in hardware-in-the-loop test facility. Initiate the development of a low-cost lithium ion battery separator. Develop specifications and test procedures for 42-volt battery technology.	storage requirements. Based on results, select baseline and accelerate development of nickel-metal hydride modules and/or battery packs for life verification and validation testing. Continue development of lithium ion full size cells and modules, which are abuse tolerant and have thermal and electrical controls, for use in hybrid electric vehicles. Validate module performance against energy storage technical targets and 15-year calendar life requirement. Develop and deliver full-current subsystems with enhanced life and abuse tolerance to a national laboratory for test, evaluation, and life demonstration. Initiate hardware cost reduction development efforts. Develop a plan for verification of candidate cost reduction measures.
	Incorporated lithium ion electrochemistry and packaging improvements from the Advanced Technology Development program into laboratory test cells for	Incorporate second generation lithium ion electrochemistry from	Incorporate low-cost, advanced lithium ion electrochemistry from the Advanced Technology Development program into full-size

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Hybrid Systems R&D (Cont'd)	validation of performance, life, and abuse-tolerance capabilities. Transferred validated technology improvements to candidate industrial suppliers for incorporation into full subsystem modules. Validated improved diagnostic tools and techniques to identify lithium ion degradation/failure mechanisms that limit life and abuse-tolerance capabilities. Participants included: USABC, Saft America, PolyStor, Texaco Ovonic Battery Systems Incorporated, ANL, BNL, LBNL, INEEL, SNL. ($17,511)	the Advanced Technology Development program into full-size cells. Continue transfer of technology improvements to industrial suppliers for validation in small cells prior to incorporation into full size, prototype, lithium-based cells. Assess diagnostic tools and techniques and select those that have the potential to identify lithium ion degradation/failure mechanisms that limit life and abuse-tolerance capabilities. Initiate an accelerated calendar life study to predict the life of lithium ion batteries. Participants include: USABC, Saft America, PolyStor, Texaco Ovonic Battery Systems Incorporated, ANL, BNL, LBNL, INEEL, SNL. ($17,794)	cells. Continue transfer of technology improvements to industrial suppliers for validation in small cells prior to incorporation into full size, prototype, lithium-based cells. Complete low-cost packaging efforts and transfer technology to battery developers. Complete accelerated calendar life study to predict the life of lithium ion batteries, and transfer to developers an accelerated method to evaluate calendar life. Participants include: USABC, ANL, BNL, LBNL, INEEL, SNL, TBD. ($17,675)
	Advanced Power Electronics	**Advanced Power Electronics**	**Advanced Power Electronics**
	Under 50 percent cost-shared agreements, fabricated Generation 2 Automotive Integrated Power	Evaluate second generation Automotive Integrated Power Module (AIPM) and Automotive	Perform baseline independent evaluation relative to the technical targets of the final Automotive

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Hybrid Systems R&D (Cont'd)	Module (AIPM) prototypes. Validated performance of prototypes relative to the technical targets. Fabricated the first generation high-performance electric motors and delivered prototype motors to the national laboratories for validation relative to the technical targets. With the developers, initiated integration of the AIPM and advanced motor technologies. Incorporated advanced component technology improvements into prototype motors. Assessed performance relative to technical targets for increased specific power and lower production cost. Scaled up advanced capacitor developments to the component level. Validated improvements and performance, and transferred technology to the AIPM developers. Participants included: SatCon, SPCO, Semikron, ORNL, SNL, LLNL. ($13,625)	Electric Motor Drive (AEMD) production prototypes developed under 50 percent cost-shared agreements. Complete work with at-least one AIPM contractor. Validate AIPM and AEMD development efforts at the national laboratories. Develop and explore improved materials and architectures for advanced automotive propulsion systems and flexible manufacturing. Evaluate prototype high temperature polymer capacitors and continue materials development to increase capacitor energy storage at high temperature. Study advanced cooling methods with carbon foam. Participants include: SatCon, SPCO, Semikron, ORNL, SNL, LLNL, ANL, Ames, TBD. ($14,403)	Integrated Power Module (AIPM) and Automotive Electric Motor Drive (AEMD) production prototypes developed under 50 percent cost-shared agreements. Baseline evaluation performed by national laboratories. Transfer production prototype high temperature polymer capacitor technology to industry. Continue materials development to increase capacitor energy storage at high temperature. Evaluate improved magnetic material. Start new effort to integrate developments from AIPM and AEMD. Start advanced energy study for long-range transportation solutions. Participants include: SPCO, Semikron, Delphi, Delco-Remy, Lynx, ORNL, SNL, LLNL, ANL,

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
			Ames, TBD. ($13,690)
Hybrid Systems R&D (Cont'd)	**Heavy Vehicle Propulsion and Ancillary Subsystems** With natural gas as the fuel of choice, completed component selection and system design definitions for candidate hybrid technologies, and targeted the development of regenerative braking technologies to improve efficiency and braking system durability of heavy hybrid vehicle designs. Conducted systems integration efforts focused on development of vehicle prototype architectures to achieve efficiency and emission goals consistent with the needs of urban truck and bus industry/users. The industrial partners funding participation in this competitively solicited activity was 50 percent. Maintained coordination with the U.S. Department of Transportation Advanced Vehicle Program and appropriate Department of Defense (DoD) technology development activities.	**Heavy Vehicle Propulsion and Ancillary Subsystems** Integrate the latest technologies for heavy hybrid vehicles. Finalize design and establish preliminary manufacturing techniques for cost-effective mass production of hybrid components/subassemblies. Perform analytical modeling to confirm industry predictions of fuel economy improvement and emission reduction. Fund research and development of a new natural gas engine.	**Heavy Vehicle Propulsion and Ancillary Subsystems** In conjunction with industry teams, continue development of efficient, cost effective heavy hybrid electric vehicles for urban cycle operation with commercial viability by 2006. Finalize integration of the advanced hybrid propulsion systems into prototype vehicle designs targeted at specific performance goals, using powertrain characteristics consistent with market requirements. Apply advanced computer models for vehicle simulations to assist in component optimization and final confirmation of industry performance predictions. Maintain coordination with the Department of Transportation (DOT) Advanced Vehicle Program and appropriate, related DOD technology development activities. Adopt current light duty

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
	Participants included: Honeywell, Allison, DOT, DoD, ORNL, ANL ($3,874) Provide critical technical and program management support services. (CSMI, Antares). ($345)	Participants include: Honeywell, Allison, DOT, DoD, ORNL, ANL ($4,941) Provide critical technical and program management support services. (Sentech, Antares). ($350)	performance models to address heavy vehicles. Participants include: Honeywell, Allison, DOT, DoD, ORNL, ANL, TBD ($4,038) Provide critical technical and program management support services. (Sentech, Antares). ($362)
Total, Hybrid Systems R&D	**$48,979**	**$46,606**	**$42,600**
Fuel Cell R&D	**Systems** Completed test and evaluation of integrated 50-kW fuel cell power system to verify achievement of year 2000 performance targets for system power density, specific power, emissions, efficiency, cost, and durability. Tested and evaluated 10-kW system that addresses resolution of fuel processing and system control issues such as start-up and transient response. Updated the rigorous systems cost analysis to include	**Systems** Complete test and evaluation of 10-kW system, addressing system control issues such as start-up and transient response. Update and validate integrated power system model to include data from 50-kW integrated systems testing, and update cost and system trade-off analyses. Benchmark progress of available technology relative to achieving revised year 2005 performance targets of 250 W/l system power density, 250 W/kg system specific power, near-zero	**Systems** Benchmark progress of available technology relative to achieving revised year 2005 performance targets of 250 W/l system power density, 250 W/kg system specific power, near-zero emissions, 40 percent efficiency at 25 percent power, $125/kW cost and more than 2,000 hours durability in a fuel-flexible fuel cell system. Update and validate integrated power system model to include data from 10-kW integrated system testing with advanced start-up and transient

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
	advanced materials and low-cost fabrication processes.	emissions, 40 percent efficiency at 25 percent power, $125/kW cost and more than 2,000 hours durability in a fuel-flexible fuel cell system.	response. Update system cost and trade-off analyses.
Fuel Cell R&D (Cont'd)	Initiated development of fuel cell system sensors and actuators suitable for automotive use. Initiated benchmarking of integrated fuel-flexible fuel cell power system that meets year 2004 performance targets of 300 W/l system power density, 300 W/kg system specific power, near-zero emissions, 48 percent efficiency at 25 percent power, $125/kW cost, and more than 4,000 hours durability. Updated and validated existing system model using data from 10-kW integrated system tests. Leveraged cost analyses and system modeling activities through international cooperation.	Continue development of fuel cell system sensors (CO, H_2, NH_3, H_2S, etc.) and actuators suitable for automotive use. Initiate development of compact humidifiers/heat exchangers.	Integrate and test fuel cell system sensors (CO, H_2, NH_3, H_2S, etc.) and actuators in sub-scale subsystems. Continue development of compact humidifiers/heat exchangers. Initiate establishment of a Fuel Cell National Resource Center at Los Alamos National Laboratory to provide national focus and an integrated approach to addressing technical barriers to polymer electrolyte membrane fuel cell commercialization. This will be a national user facility for research, development, and testing.
	Participants included: International Fuel Cells, Plug Power, Energy Partners, Honeywell, Nuvera, IIT,	Participants include: Teledyne, BTI, SAE, Honeywell, Caterpillar, NREL,	Participants include: Nuvera, UTC Fuel Cells, IIT, A.D. Little,

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
	Arthur D. Little, ANL, Directed Technologies. ($7,405)	LLNL, A.D. Little, ANL, UTC Fuel Cells, IIT, Directed Technologies, Nuvera. ($7,600)	Honeywell, BTI, SAE, Caterpillar, NREL, LLNL, ANL, LANL. ($7,600)
Fuel Cell R&D (Cont'd)	**Stack Subsystems Components** Conducted research on low-cost, high performance components which are needed to meet the PEM fuel cell stack system year 2004 cost target of $100/kW. Continued long-term tests to provide data on durability of stack components and small stack subsystems. Demonstrated advanced O_2-reduction electrodes and membrane electrode assemblies (MEAs) operating at higher voltage (0.7-0.8 V) to enable high efficiency. Developed advanced CO-tolerant (>200 ppm) membrane electrode assemblies enabling lower platinum loading, higher efficiency, and quicker system start-up. Demonstrated polymer membranes at higher fuel cell operating temperatures (120-150°C), in order to increase CO tolerance and facilitate heat rejection.	**Stack Subsystems Components** Continue research on low-cost, high performance components, increasing power density from 250 to 320 mW/cm^2 at 0.8V, to meet PEM fuel cell stack system 2005 cost target of $100/kW and durability target of 2,000 hours. Continue long-term tests to provide data on durability of stack components and small stack subsystems to fuel impurities and cycling. Develop advanced O_2-reduction electrodes and membrane electrode assemblies (MEAs) into short stacks to enable high efficiency. Develop polymer membranes and MEAs for higher fuel cell operating temperatures (120-150°C), in order to increase CO tolerance and facilitate heat rejection. Investigate electrode structure and cell design for higher operating temperatures.	**Stack Subsystems Components** Continue research and development of low-cost, high performance components, increasing power density from 250 to 320 mW/cm^2 at 0.8V, to meet PEM fuel cell stack system 2005 cost target of $100/kW and durability target of 2,000 hours. Continue long-term tests to provide data on durability of stack components and small stack subsystems to fuel impurities and cycling. Validate performance of advanced O_2-reduction electrodes and membrane electrode assemblies (MEAs) in short stacks to enable high efficiency. Downselect polymer membranes and MEAs for higher fuel cell operating temperatures (120-150°C), to increase CO tolerance and facilitate heat rejection. Continue investigation of electrode

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Fuel Cell R&D (Cont'd)	Demonstrated feasibility of low-cost fabrication processes for MEAs to meet MEA cost target of $10/kW. Initiated development of reformate-capable fuel cell stack subsystem to meet more challenging targets associated with the 2004 goal. Demonstrated low-cost fabrication processes for lightweight, low-cost composite bipolar plate in pilot plant operation, to meet plate cost target of $10/kW. Developed and tested low-crossover membrane, high activity methanol oxidation catalyst, and direct methanol fuel cell with improved power density. Some direct methanol activities were leveraged through international cooperation. Based on outcome of peer review, continued development of advanced, high efficiency compressor/expander to meet 2004 system level targets. Continued evaluation of ambient pressure fuel cell stack subsystem to minimize the risk of potentially	Demonstrate feasibility of low-cost fabrication processes for MEAs in pilot plant operation to meet MEA cost target of $10/kW, and initiate development of advanced catalyst deposition techniques to meet the 2005 precious metal loading target of 0.6g/kW. Build and test 1-kW direct methanol fuel cell stack incorporating low platinum MEA. Demonstrate advanced, mixed-flow turbocompressor which meets established pressure-ratio turndown requirements. Initiate development of oxygen enhancement technology to improve cathode performance and meet efficiency target.	structure and cell design for higher operating temperatures. Develop fuel cell for portable power to accelerate manufacturing capability and cost reduction of fuel cell stacks. Develop fuel cell for auxiliary power in cars and trucks. Continue development of low-cost MEA fabrication processes for pilot plant operation, including quality control, to meet MEA cost target of $10/kW and 2005 durability target of 2,000 hours. Research and develop advanced catalyst deposition techniques to meet the 2004 precious metal loading target of 0.6g/kW. Investigate non-precious metal catalysts to reduce MEA cost. Integrate and test advanced, mixed-flow turbocompressor which meets established pressure-ratio turndown requirements in a sub-scale stack

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
	unsuccessful air compressor system. Participants included: Honeywell, Plug Power, International Fuel Cells, Energy Partners, GTI, 3M, Southwest Research Institute, W.L. Gore, Foster Miller, LANL, ANL, LBNL, NREL. ($12,052)	Participants include: Honeywell, UTC Fuel Cells, Teledyne, Porvair, A.D. Little, Mechanology, DeNora, DuPont, Superior Micropowders, GTI, 3M, Southwest Research Institute, W.L. Gore, LANL, ANL, ORNL, LBNL, NREL, TBD. ($12,825)	system. Participants include: Honeywell, UTC Fuel Cells, 3M, Southwest Research Institute, W.L. Gore, Porvair, Arthur D. Little, Mechanology, DuPont, DeNora, Superior Micropowders, LANL, ANL, LBNL, NREL, TBD. ($14,900)
Fuel Cell R&D (Cont'd)	**Fuel Processor/Storage** Researched innovative concepts for hydrogen storage, in collaboration with DOE Hydrogen Program. Proceeded with development of advanced fuel processor to meet revised 2004 technical targets of 78 percent efficiency, 700 W/1, 700 W/kg, less than $25/kW, 4,000 hours durability, less than 1 minute start-up, and less than Tier 2 emissions. Fuel processor will be	**Fuel Processor/Storage** Develop advanced on-board hydrogen storage technologies, in collaboration with DOE Hydrogen Program, to meet goals of 1100 Wh/l and 2000 Wh/kg. Demonstrate components of an advanced fuel-flexible fuel processor meeting 2005 technical targets of 78 percent efficiency, 700 W/1, 700 W/kg, less than 1 minute start-up, and less than Tier 2 emissions.	**Fuel Processor/Storage** Establish independent evaluation capability for low pressure hydrogen storage technologies suitable for fuel cell vehicle use. In collaboration with the DOE Hydrogen Program, accelerate development of innovative low pressure hydrogen storage technologies, including carbon-based nanotechnology and chemical hydrides.

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Fuel Cell R&D (Cont'd)	capable of processing methanol, ethanol, natural gas and gasoline, and will be completely integrated with required shift reactors and CO cleanup system. Evaluated low pressure fuel processor operation to reduce air management requirements, start-up, and transient response. Fabricated a prototype CO clean-up device based on low-cost design, eliminating the need for precise measurement of input gas composition and metering of air injection, and achieving less than 10 ppm CO under steady state operation and less than 500 ppm during transients. Preliminary results indicated that microchannel technology can reduce the size and weight of conventional fuel processing technology by a factor of 10. Using this approach, demonstrated and tested a highly compact (>1500W/l) prototype 50 kW microchannel steam reformer capable of reforming methanol,	Demonstrate low pressure fuel processor operation to reduce air management requirements. Investigate innovative fuel processing techniques to allow rapid start-up (<30sec.). Continue demonstrating a highly compact (>1500W/l) prototype 50kW microchannel steam reformer capable of reforming methanol, ethanol, natural gas and gasoline. Demonstrate microchannel technology in conjunction with other fuel processing components, such as heat exchangers and steam generators. Develop high activity, sulfur tolerant shift catalysts for fuel processor system, needed to reduce reactor size and precious metal content, to meet 2,000 hour durability requirement, and to reduce a 200,000 ppm CO input to <2,000 ppm, allowing final reduction to <10 ppm by preferential oxidation.	Validate performance of advanced components/concepts in a sub-scale fuel processing system meeting 2005 technical targets. Develop innovative fuel processing techniques to allow rapid start-up (<30sec.). Demonstrate a microchannel fuel processing system, including the reformer, heat exchangers, steam generators, sensors, controls, etc. Demonstrate high-activity, sulfur-tolerant shift catalysts for fuel processor systems, needed to reduce reactor size and reduce precious metal content. Develop and demonstrate automotive sensors and controls for fuel processor systems. Build, test, and evaluate prototype hydrogen enhancement and purification technologies to improve system performance.

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
	ethanol, natural gas and gasoline. Developed and tested high activity, sulfur tolerant reforming and shift catalysts for fuel processor system. Initiate low-cost fabrication processes for applying catalysts to monolithic support structures. Participants included: Epyx, Hydrogen Burner Technology, Plug Power/UOP, Catalytica, Corning, United Catalysts, McDermott, ANL, LANL, PNNL. ($20,806)	Initiate development of hydrogen enhancement technologies to improve system performance. Participants include: Nuvera, University of Michigan, United Technologies, University of Kentucky, Southwest Research Institute, Catalytica, Corning, United Catalysts, McDermott, ANL, LANL, PNNL. ($21,300)	Participants include: Nuvera, University of Michigan, Catalytica, Corning, United Catalysts, United Technologies, University of Kentucky, Southwest Research Institute, ANL, LANL, PNNL. ($24,100)
Fuel Cell R&D (Cont'd)	**Field Evaluations** No activities ($0)	**Field Evaluations** No activities ($0)	**Field Evaluations** Initiate new government/industry cooperative program to test and evaluate fuel cell research vehicles to determine future research needs and to validate energy efficiency and environmental benefits. This cooperative program will be based on the study directed by Congress to be completed in 2002. Test and evaluate performance,

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Fuel Cell R&D (Cont'd)			durability, and safety of fuel options (methanol, ethanol, natural gas, and petroleum) for generation of hydrogen both on-board and off-board the fuel cell vehicle. This includes research to determine the effects of fuel properties and impurities on the fuel cell system. Participants include: auto manufacturers, fuel providers, Air Products and Chemicals, Southwest Research Institute, Gas Technology Institute, General Electric, States, NREL, ANL, California Fuel Cell Partnership members. ($3,000)
	Provided critical technical and program management support services. (Sentech) ($400)	Provide critical technical and program management support services. (Sentech) ($200)	Provide critical technical and program management support services. (Sentech) ($400)
Total, Fuel Cell R&D	**$40,663**	**$41,925**	**$50,000**
Advanced Combustion Engine R&D	**Hybrid Direct Injection Engine** Completed the development of sensors by four national labs participating in a cooperative	**Hybrid Direct Injection Engine** Terminate SIDI program in FY 2002. Initiate testing of the variable compression ratio (VCR) engine	**Hybrid Direct Injection Engine** No Activities. ($0)

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
	research and development (CRADA) agreement with the auto industry. Completed testing of advanced NOx catalyst formulations with simulated spark ignition, direct injection (SIDI) exhaust and shared results with industry. Discontinued development of SIDI components and supporting technologies. Demonstrated a viable mechanism for the variable compression ratio (VCR) engine in an engine block under full load operating in the laboratory.	using a modified engine head to verify efficiency and emissions potential. VCR effort now under Combustion and Emission Control R&D. ($0)	
Advanced Combustion Engine R&D (Cont'd)	Terminated modeling and fundamental combustion research at national labs and universities. Participants included: SNL, ORNL, ANL, LANL, LLNL, Delphi, universities. ($5,769)		

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Advanced Combustion Engine R&D (Cont'd)	**Combustion and Emission Control R&D** Conducted R&D which will enable passenger cars and light trucks to utilize fuel efficient compression-ignition, direct-injection (CIDI) engines while meeting Federal Tier 2 and State emissions requirements. Combustion: Applied understanding of the diesel combustion process to optimize fuel injection and combustion chamber design. Using laser diagnostics and high-speed photography, visualized the formation of oxides of nitrogen (NOx) and particulate matter (PM) in optically accessible light- and heavy-duty diesel engines, and in an ultra-high-pressure combustion vessel. Used the experimental data in the validation of computer models which simulate fuel injection spray, combustion, and emissions formation. Evaluated efficiency and emissions characteristics of advanced combustion concepts such	**Combustion and Emission Control R&D** Continue R&D which will enable passenger cars and light trucks to utilize fuel efficient compression-ignition, direct-injection (CIDI) engines while meeting Federal Tier 2 and State emissions requirements. Combustion: Continue CIDI Combustion CRADA work at Sandia National Laboratories (SNL), focused on optical engine studies. This work is cost-shared (50-50) with industry. Continue investigations of control systems for Homogeneous Charge Compression Ignition (HCCI) technologies to reduce engine-out emissions at SNL and several universities. The work at the universities is cost-shared at 20 percent. Perform laser diagnostic and high speed imaging work at SNL; used to visualize formation and oxidation of in-cylinder soot and evaluate various	**Combustion and Emission Control R&D** Continue R&D which will enable passenger cars and light trucks to utilize fuel efficient compression-ignition, direct-injection (CIDI) engines while meeting Federal Tier 2 and State emissions requirements. Combustion: Continue CIDI Combustion work at SNL, focused on optical engine studies. This work is cost-shared (50-50) with industry. Continue investigations of control systems for HCCI technologies to reduce engine-out emissions. Continue laser diagnostic and high speed imaging work used to visualize formation and oxidation of in-cylinder soot, and evaluate various fuel injection strategies to minimize emission formation. Continue combustion, fuel injection, and emissions formation simulation projects. Evaluate

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
	as Homogeneous Charge Compression Ignition and other methods to reduce in-cylinder emissions formation. DOE's Office of Science collaborated on this research effort, primarily by providing research facilities and data exchange.	fuel injection strategies to minimize emission formation. Also continue combustion, fuel injection, and emissions formation simulation projects.	membrane technologies to generate nitrogen to use as diluent instead of exhaust gas recirculation (EGR). Develop strategies to reduce NOx with late cycle air/oxygen injection.
Advanced Combustion Engine R&D (Cont'd)	Emission Controls: Developed exhaust emission control technologies to meet EPA Tier 2 NOx and particulate emissions standards for light duty vehicles, through 35 percent cost shared cooperative agreements. Evaluated feasibility of selective catalytic reduction (SCR) technologies for automotive-sized engines. Conducted full-scale device testing of non-thermal plasma and lean NOx catalysts. Performed testing of advanced exhaust gas recirculating (EGR) components for improved cylinder-to-cylinder distribution and control under transient operation conditions. Began integration and initial testing of advanced emission control devices with engines, to	Emission Controls: Continue the lean NOx catalyst CRADA program, focusing on developing urea-based catalysts with improved activity and durability at the low exhaust temperatures characteristic of light duty compression ignition, direct injection (CIDI) engines. Ford, GM, and DaimlerChrysler are cost sharing partners on this CRADA. Develop late cycle injection and other strategies to generate reductants for lean NOx catalysts and adsorbers. Continue program using combinatorial chemistry to screen high volumes of NOx catalyst materials. Industry cost-shares this program at 35 percent. At a reduced pace, continue program with Ford to	Emission Controls: Continue lean NOx catalyst CRADA program, focusing on developing urea-based catalysts with improved activity and durability at the low exhaust temperatures characteristic of light duty CIDI engines. Ford, GM, and DaimlerChrysler are cost-sharing partners on this CRADA. Develop late cycle injection and other strategies to generate reductants for lean NOx catalysts and adsorbers. Continue program at GM using combinatorial chemistry to screen high volumes of NOx catalyst materials. Industry cost-shares this program at 35 percent. Continue program with Ford to develop and

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
	measure NOx and particulate reduction conversion efficiencies under real operating conditions. Conducted system level testing and began engineering simulation and model validation of selected emission control components for automotive and light truck applications. Conducted collaborative exploratory R&D projects with emission control manufacturers to develop more advanced catalysts and components. Tested emission control components which can meet the higher horsepower and more demanding duty cycle required for light truck applications.	develop and test urea-based SCR catalysts. Continue programs at Detroit Diesel and Cummins on emission control system technologies to achieve stretch targets of 0.07 g/mi NOx and 0.01 g/mi PM for automotive and light truck applications by 2010. The contracts with Ford, Detroit Diesel and Cummins include a 35 percent cost share. Continue non-thermal plasma CRADAs for light-duty vehicles between PNNL and GM, Ford, and Daimler-Chrysler, and for heavy-duty vehicles between PNNL and Caterpillar and Delphi.	demonstrate a urea selective catalytic reduction (SCR) emission control system on a light-duty vehicle. On a lengthened schedule, continue programs at Detroit Diesel and Cummins on emission control system technologies to achieve Tier 2 emissions standards of 0.07 g/mi NOx and 0.01 g/mi PM for automotive and light truck applications by 2010. The cooperative agreements with Ford, GM, Detroit Diesel and Cummins include a 35 percent cost-share. Continue non-thermal plasma CRADAs with industry partners, to reduce NOx and PM emissions.
Advanced Combustion Engine R&D (Cont'd)	Engine/Emission Controls Integration: Conducted research on optimizing control system for combustion and emission control efficiency, utilizing sensors (NOx/PM) and feedback loops. Continued projects in partnership with DOE laboratories, universities, and industry.	Terminate programs at Oak Ridge National Laboratory to develop and test NOx adsorber and sulfur trap systems. Continue programs at Oak Ridge and Sandia National Laboratories to determine how engine parameters, such as Exhaust Gas Recirculation (EGR) level, can be adjusted to	Continue testing of variable compression ratio (VCR) engine to verify ability to achieve emission and fuel economy goals. Develop NOx, PM, and wide-range oxygen sensors through cost-shared CRADAs with automotive suppliers, to enable closed-loop control of fuel injection and

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
		reduce NOx and particulate emissions. Complete programs at Lawrence Berkeley and Oak Ridge National Laboratories to develop and test a state-of-the-art particulate measurement device. Continue Engine Control System work at Oak Ridge National Laboratory necessary for complex manipulation of EGR, timing multiple fuel injection events, making temperature adjustments, and other control strategies necessary for proper emission control device operation and regeneration.	emission control devices. Develop exhaust sulfur traps that enable catalyst-based emission control systems to meet federal 120,000-mile durability requirements. Develop microwave-regenerative particulate traps that achieve 0.01 gram/mile. Benchmark performance and cost of available worldwide technology against program performance targets of 0.07 g/mile NOx and 0.01 g/mile PM. Terminate programs at ORNL and SNL to determine how parameters, such as exhaust gas recirculation, can be adjusted to reduce emissions.
Advanced Combustion Engine R&D (Cont'd)		Engine/Emission Controls Integration: Continue program to develop a PM sensor to provide feedback for optimizing control systems for combustion and emission control. This work is cost-shared by industry at 20 percent.	

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
	Participants include: SNL, LANL, ORNL, PNNL, ANL, Ford, GM, DaimlerChrysler, Delphi, Detroit Diesel/Johnson Matthey, Cummins/Engelhard, Diesel and catalyst manufacturers, Tier 1 suppliers, and universities. ($20,030)	Participants include: SNL, LANL, ORNL, PNNL, LLNL, ANL, Ford, GM, DaimlerChrysler, Detroit Diesel, Cummins, Engelhard, Caterpillar, Delphi, Mack, ExxonMobil, Diesel engine and catalyst manufacturers, Tier 1 suppliers, and universities. ($19,857)	Participants include: SNL, LANL, ORNL, PNNL, LLNL, ANL, Ford, GM, DaimlerChrysler, Detroit Diesel, Cummins, Engelhard, ExxonMobil, Caterpillar, Mack, International, Delphi, Honeywell, University of Michigan, University of Wisconsin, catalyst manufacturers, other Tier 1 suppliers, other universities. ($17,571)
	Light Truck Engine	**Light Truck Engine**	**Light Truck Engine**
Advanced Combustion Engine R&D (Cont'd)	Interactively tested, evaluated, and redesigned production prototype diesel engine (200-275 hp), integrated with vehicle chassis, for the light truck (pickup, van, or sport utility vehicle). Optimized the exhaust aftertreatment, fuel injection system, boost air, exhaust gas recirculation (EGR) and associated cooling with microprocessor control, to comply with emissions standards. Evaluated exhaust energy recovery systems to further improve the efficiency with respect to commercial viability. Reduced	Optimize production-ready prototype clean diesel engines for light trucks (pickups, vans, and sport utility vehicles). Incorporate emission reduction technology to achieve compliance with EPA emission standards. Initiate reliability testing of engine and emissions reduction technology. Continue development of promising NOx reducing homogeneous charge compression ignition (HCCI) combustion and fuel injection systems.	Integrate in-cylinder and aftertreatment NOx and particulate reduction devices with the engine control microprocessor in a vehicle; conduct efficiency, emissions, reliability, and durability testing. Finalize iterative test and redesign of diesel engine and emission control system compliant with EPA Tier 2 emissions standards. Develop fuel injection system components and redesign of combustion chamber as necessary for homogeneous charge

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
	emissions by an order of magnitude since program inception. The goal is to demonstrate feasibility of meeting EPA Tier 2 standards by 2003. Two of the three teams are on schedule and have exceeded the efficiency goal. The 3rd team is developing more advanced technology which promises even greater efficiency.	Develop non-thermal plasma for 80 hp diesel engine. Scale-up non-thermal plasma devices for both light and heavy trucks, utilizing solid state power systems compatible with vehicle installation. Design, fabricate, and test the first quantum well thermoelectric device to convert waste exhaust energy directly to electricity, which will increase the fuel economy by up to 7 percent.	compression ignition (HCCI) system. Continue iterative single cylinder engine optimization. Initiate multi-cylinder evaluation of HCCI. Scale up non-thermal plasma for nominal 250 hp engine NOx and particulate reduction to achieve greater than 80 percent NOx reduction. Complete prototype solid state power supply development. Develop greater than 1 kW quantum-well thermoelectric generators that will convert exhaust waste heat into enough electricity to replace a conventional light truck alternator and supply power to electrical components. Quantum-well thermoelectric generators are 5 times more efficient than current state-of-the-art bulk semiconductors.
Advanced Combustion Engine R&D (Cont'd)	Participants included: Caterpillar Inc., Cummins Engine Co., Detroit Diesel Corp., and Tier 1 suppliers.	Participants include: Caterpillar Inc., Cummins Engine Co., Detroit Diesel Corp., Hi-Z, NoxTech, national laboratories). ($16,768)	Participants include: Caterpillar Inc., Cummins Engine Co., Detroit Diesel Corp., Hi-Z, NoxTech, national laboratories). ($13,106)

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
	($17,483)		
	Heavy Truck Engine Once emissions standards are demonstrated, while maintaining or improving thermal efficiency, the focus of the program will shift to developing technologies that will further improve engine thermal efficiency to 50 percent, from the current 45 percent. The emissions will be reduced to near-zero levels. Conducted 50 percent cost-shared R&D with industry to develop and test laboratory diesel engines which reduce emissions while maintaining or improving the thermal efficiency. Investigated technologies to reduce friction with improved lubricants containing no sulfur or phosphates which poison emission control catalysts. Optimized fuel injection, emissions control, and waste heat recovery systems.	**Heavy Truck Engine** Develop and test laboratory diesel engines, through competitively awarded 50 percent cost-shared R&D with industry, that will meet EPA emissions standards while improving the thermal efficiency to 50 percent from the current 45 percent. Investigate technologies to optimize fuel injection, emissions control, and waste heat recovery systems, and reduce friction and pumping losses. Continue evaluating technologies developed in the Combustion and Emission Control R&D and Light Truck Engine programs to determine their applicability to the higher pressures and temperatures experienced in heavy duty engines.	**Heavy Truck Engine** Shift focus to the development of technologies for diesel and emission control systems that will meet the very stringent EPA 2007 emission standards with a thermal efficiency of 50 percent. Continue investigating technologies to optimize emissions control, combustion, fuel injection and waste heat recovery systems, and reduce friction and pumping losses. Develop emission control technologies from the Combustion and Emission Control R&D and Light Truck Engine Component Development programs for the higher pressures, temperatures, and durability requirements of heavy duty diesel engines.
Advanced Combustion Engine R&D (Cont'd)	Evaluated technologies developed in the Combustion and Emission Control R&D and Light Truck Engine R&D programs to determine	Develop a Multi-Year Program Plan for the Heavy Duty Diesel Engine Emissions Control Technology Program to address the recommendations from the National Research Council (NRC) peer	Implement Multi-Year Program Plan for the Heavy Duty Diesel Engine Emissions Control Technology Program, to address the

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
	their applicability to heavy duty engines. Explored engine and emission control strategies (e.g., fuel/air injection timing) that have the potential to increase thermal efficiency to 55 percent and approach near-zero emission levels. Participants included: Caterpillar Inc., Cummins Engine Co., Detroit Diesel Corp., suppliers, national labs. ($5,814)	review of the Office of Heavy Vehicle Technologies (OHVT) Program. Participants include: Caterpillar Inc., Cummins Engine Co., Detroit Diesel Corp., suppliers, national labs. ($9,396)	recommendations from the National Research Council (NRC) peer review of the Office of Heavy Vehicle Technologies (OHVT) Program. Participants include: Caterpillar Inc., Cummins Engine Co., Detroit Diesel Corp., suppliers, national labs. ($6,979)

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Advanced Combustion Engine R&D (Cont'd)	**Engine Boosting Technology**	**Engine Boosting Technology**	**Engine Boosting Technology**
	Initiated cooperative agreements to develop electrically driven turbocharger to increase response and reduce particulate emissions. Initiated development of electric turbocompounding combined with starter motor-alternator and damper technology, to eliminate turbo-lag and improve thermal efficiency by up to 10 percent.	Continue work under cooperative agreements to develop electric turbocompounding combined with starter motor-alternator and damper technology to eliminate turbo-lag, reduce particulate emissions and improve thermal efficiency by up to 10 percent.	Complete laboratory tests of electric turbocompound units designed for heavy- and light-duty trucks that increase low-speed torque, improve engine transient response, and reduce particulate emissions. The unit will also provide 1.8 kW for electrically powered accessories (currently belt driven) and will be incorporated in the "More Electric Truck" initiative being developed by the Heavy Vehicle Systems R&D Program. The light truck design will be integrated into a vehicle for evaluation.
	Participants included: Honeywell, Caterpillar, suppliers. ($1,000)	Participants include: Honeywell, Caterpillar, suppliers. ($500)	Participants include: Honeywell, Caterpillar, and International Truck and Engine Co. ($500)
	T RANSFERRED FROM: Fuels Utilization R&D/Alternative Fuels		
	Health Impacts	**Health Impacts**	**Health Impacts**
	Extended health impacts investigations to interspecies	Continue comparison of toxicity of diesel and gasoline emissions by	Extend application of validated rapid toxicity tests or inhalation

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Advanced Combustion Engine R&D (Cont'd)	comparisons of the toxicity of emissions from gasoline and diesel samples. Performed short-term health impacts testing on samples representing newly-developed candidate fuel, engine, and exhaust aftertreatment technologies. Included in the health impacts studies were selected inhalation experiments to help determine short and intermediate-term health risks from engine emissions. Participants included: Lovelace Respiratory Research Institute, NIOSH ($1,473)	sub-chronic inhalation exposures. Complete exposures to diesel emissions and begin exposures to gasoline emissions. Perform short-term biological assays of new technology diesel emissions, including organic and solid nanoparticles, without emissions passing through trap and catalyst aftertreatments. Participants include: Lovelace Respiratory Research Institute, NIOSH. ($1,500)	studies to emissions from new engine, fuel, and aftertreatment technologies. Determine toxicity effect of exposing cells to airborne nanoparticles. Apply rapid toxicity tests to determine contribution of lube oil to toxicity. Participants include: Lovelace Respiratory Research Institute, NIOSH. ($1,500)
	Off-Highway Engine R&D No Activities. ($0)	**Off-Highway Engine R&D** Off-highway (agriculture, construction, locomotive, mining and in-land marine) engines operate at higher temperatures due to limited air flow and harsher operating conditions (higher load, severe vibration and mechanical shock) than on-highway diesel engines. These engines consume approximately 10 percent of the total diesel fuel while emitting more than	**Off-Highway Engine R&D** Utilize the industry-government roadmaps developed to identify off-highway vehicle and locomotive research needs. Develop technologies that will allow diesel engines used for off-highway applications to meet future EPA emissions standards without sacrificing efficiency.

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Advanced Combustion Engine R&D (Cont'd)		30 percent of the total NOx and particulate matter. Complete development of industry-government technology road map to identify research needs for off-highway vehicles, including locomotive. Award cost shared competitive cooperative agreements to develop technologies that will improve the efficiency of diesel engines used in these unique applications and reduce their emissions to meet more stringent EPA regulations. Evaluate technologies developed in the Heavy Truck Engine program, to determine their applicability to off-highway engines. (TBD-Competitive solicitation) ($500)	Evaluate technologies developed in the Heavy Truck Engine program and determine their applicability to off-highway engines. Investigate areas for system efficiency improvements including advanced powerplants and thermal management. (TBD-Competitive solicitation) ($500)
	Provided critical technical and program management and support services (Antares, CSMI). ($636)	Provide critical technical and program management and support services (Sentech, Antares). ($571)	Provide critical technical and program management and support services (Sentech, Antares). ($524)

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Total, Advanced Combustion Engine R&D	**$52,205**	**$49,092**	**$40,680**
Cooperative Automotive Research for Advanced Technologies (CARAT)	**CARAT** Continued development efforts of the seven Phase 2 contracts which were competitively selected from the original 26 Phase 1 projects. Completed the Phase 1 projects that were initiated in FY 2000. Initiated solicitation of new Phase 1 projects for FY 2002. Participants included: ANL, Penn State Univ., Univ. of Michigan, Univ. of Miami, Illinois Institute of Technology, NexTech Materials, BST Systems, Superior Graphite, Virginia Power Technologies, Energy Conversion Devices, Makel Engineering, Univ. of Michigan-Dearborn, North Carolina State University. ($1,000)	**CARAT** Conduct three new CARAT Phase 1 projects to tap innovation and expertise that small businesses and universities offer for developing advanced automotive technologies. Participants include: ANL, small businesses and universities. ($500)	**CARAT** Conduct three new high priority CARAT Phase 1 projects in the core advanced automotive technology topic areas. Initiate solicitation of new Phase 1 projects for FY 2004. Participants include: ANL, small businesses and universities. ($500)

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Cooperative Automotive Research for Advanced Technologies (Cont'd)	**GATE** Continued curriculum development and provided second academic year fellowship funding. Conducted Graduate Automotive Technology Education (GATE) Forum with industry and universities to encourage industry-university collaborations. Conducted an evaluation of GATE to determine costs and benefits. Participants included: ANL, universities. ($500)	**GATE** No activities. Terminate GATE efforts. ($0)	**GATE** Provide research fellowships for 25 students for research in advanced automotive technologies. Conduct GATE Forum with industry, universities, and government agencies to increase partnering opportunities. Participants include: ANL, universities. ($500)
Total, Cooperative Automotive Research for Advanced Technologies	**$1,500**	**$500**	**$1,000**
Electric Vehicles R&D	**Advanced Battery Development** Supported R&D on long-term advanced batteries for electric	**Advanced Battery Development** Continue R&D on long-term advanced batteries for electric	**Advanced Battery Development** Continue R&D on long-term advanced batteries for electric

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Electric Vehicles R&D (Cont'd)	vehicles with the USABC under Phase III cooperative agreement, with an average industry cost-share of 65 percent.	vehicles under the United States Advanced Battery Consortium (USABC) Phase III Cooperative Agreement with an average cost-share of 65 percent.	vehicles under the United States Advanced Battery Consortium (USABC) Phase III Cooperative Agreement, with an industry average cost-share of 65 percent.
	Mid-term Battery R&D: No Activities.	Mid-term Battery R&D: No Activities.	Mid-term Battery R&D: No Activities.
	Environmental, health, and safety: Continued assessment of recycling issues and abuse tolerance requirements for lithium-based battery technology for electric and hybrid vehicles, through the Advanced Battery Readiness Working Groups. Coordinated these activities with the National Highway Traffic Safety Administration and the Environmental Protection Agency.	Environmental, health, and safety: Complete and wrap up assessment of recycling issues, and shipping and abuse tolerance requirements, for lithium-based battery technology in electric and hybrid vehicles, through the Advanced Battery Readiness Working Groups. Coordinate these activities with the National Highway Traffic Safety Administration and the Environmental Protection Agency.	Environmental, health, and safety: No activities.
	Long-term Battery R&D: Investigated alternative materials and fabrication processes for advanced lithium battery technology, incorporating knowledge from other Federally funded research and development battery programs.	Long-term Battery R&D: Characterize life limitations of lithium ion battery technology at high state of charge and temperature, and develop potential solutions. Reduce the severity of lithium ion thermal events by cell engineering	Long-term Battery R&D: Complete study of life limitations of lithium ion battery technology at high states of charge and extreme temperatures. Develop and validate, at the full-size cell level, solutions to life limitation. Based on progress

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Electric Vehicles R&D (Cont'd)	Focused technology development on enhanced manufacturing processes which control fabrication variables to improve battery performance, life and abuse tolerance, and to reduce battery costs. Continued development of ambient temperature, lithium-based advanced battery technologies. Validated fifth generation of lithium polymer battery modules in laboratory prototypes. This included extended testing of prototype cells and modules of lithium-based batteries to determine life and response to abusive test conditions.	redesign and developing abuse tolerance chemistries. Initiate assessment of lithium-sulfur electrochemical couples, including focus on anode dendrite formation and cycling performance. Focus technical efforts to solve the poor cycling efficiency of the lithium anode. Assess advanced battery technologies which have the potential to meet or exceed the USABC long-term battery goal.	to solve poor cycling efficiency, reassess the viability of the lithium-sulfur technology to meet the USABC long-term goals.
	Continued international cooperation on advanced batteries through the International Energy Agency. Cooperated with Japanese Lithium Battery Energy Storage Research Association.		
	Participants included: ANL, INEEL, LBNL, NREL, SNL, USABC, 3M/Hydro-Quebec, Avestor. ($5,591)	Participants include: ANL, INEEL, SNL, SAFT, USABC. ($4,579)	Participants include: ANL, USABC, SAFT, TBD. ($1,500)

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Electric Vehicles R&D (Cont'd)	**Exploratory Technology Research** Research and development efforts continued to address the key barriers impeding the successful development of lithium ion and lithium polymer battery technologies. Focused on understanding and improving the performance of advanced solid polymer electrolytes by studies of the transport properties and interactions at the electrode and polymer interfaces. Developed and characterized novel anode and cathode materials that have higher capacity, are lower in cost, and inherently safer. Developed non-flammable or fire retardant electrolytes that are abuse tolerant for lithium ion batteries. Continued research and development of advanced diagnostic methods to investigate life-limiting and performance-limiting processes in lithium batteries. Refined improved	**Exploratory Technology Research** Continue research and development efforts to address the key barriers impeding the successful development of lithium ion and lithium polymer battery technologies. Develop and characterize novel anode, electrolytes and cathode materials that have higher capacity and are lower in cost. Continue research and development of advanced diagnostic methods to investigate life-limiting and performance-limiting processes in lithium batteries. Refine electrochemical models to understand the failure mechanisms and the mechanisms for thermal runaway of lithium ion and lithium polymer systems. Conduct evaluations of specific integrated electrochemical systems at the cell level to demonstrate that these innovative technologies address advanced automotive program goals	**Exploratory Technology Research** Continue research and development efforts to address the key barriers impeding the successful development of lithium ion and lithium polymer battery technologies. Develop and characterize novel anode, electrolytes and cathode materials that have higher capacity and are lower in cost. Continue development of advanced diagnostic methods to investigate life-limiting and performance-limiting processes in lithium batteries. Continue to develop improved electrochemical models to understand the failure mechanisms and the mechanisms for thermal runaway of lithium ion and lithium polymer systems. Evaluate integrated electrochemical systems at the cell level to demonstrate that novel anodes, cathodes, and electrolytes are addressing the key electric vehicle

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Electric Vehicles R&D (Cont'd)	electrochemical models to understand the failure mechanisms and the mechanisms for thermal runaway of lithium ion and lithium polymer systems. Continued to investigate novel electrode couples for the next generation of batteries which could meet or exceed the USABC long-term requirements. Participants included: ANL, LANL, LBNL. ($3,104) Provided critical technical and program management support services. (CSMI). ($125)	for performance, life, abuse tolerance, and cost. Participants include: ANL, BNL, LANL, LBNL, SNL. ($2,375) Provide critical technical and program management support services. (Sentech). ($65)	battery barriers of performance, life, abuse tolerance, and cost. Participants include: ANL, BNL, LANL, LBNL, SNL.($1,935) Provide critical technical and program management support services. (Sentech). ($65)
Total, Electric Vehicles R&D	**$8,820**	**$7,019**	**$3,500**
Heavy Vehicle Systems R&D	**Vehicle Systems Optimization** Continued reduction of parasitic energy losses which account for almost 50 percent of the total energy consumption in heavy trucks. Aerodynamic drag causes more than 52 percent of non-engine losses; 28 percent is from rolling resistance	**Vehicle Systems Optimization** Distribute peer group- and industry-reviewed Multi-Year Program Plan (MYPP) for each of the heavy vehicle parasitic energy loss categories: Aerodynamic Drag, Friction and Wear, Rolling Resistance, and Underhood Thermal	**Vehicle Systems Optimization** Based on peer group and industry-reviewed Multi-Year Program Plans, which have identified key R&D needs, initiate priority projects in the parasitic energy loss categories of Aerodynamic Drag, Rolling Resistance, Friction and

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
	(tire, transmissions, gears), and the remainder is from auxiliary systems and accessories.	Management. Identify key R&D needs, prioritize potential project areas, and identify current and outyear funding requirements.	Wear, and Underhood Thermal Management.
Heavy Vehicle Systems R&D (Cont'd)	Conducted a series of targeted technical workshops with industry, government, and academia to identify broad areas of R&D needs, and formulated multi-year program plans. The technical areas addressed were Aerodynamic Drag, Friction, Wear and Lubrication, Thermal Management, Running Resistance and Brakes.	Compare longer-term Computational Fluid Dynamics (CFD) approach, advanced modeling and simulations of aerodynamic drag of heavy vehicles as integrated systems to results from tests in 8-foot wind tunnel. Validate, refine formulations with results to be obtained from full size trucks in NASA Ames large wind tunnel.	Complete the final runs in the 7'x10' wind tunnel to provide the data for the Computational Fluid Dynamics (CFD) analytical modeling. Design scale-up tests for the NASA Ames 12-foot wind tunnel. All tests use the generic truck model specifically designed for this project. Initiate instrumented full-size truck tests in the NASA Ames large wind tunnel.
	Initiated specific projects to significantly reduce parasitic energy losses in heavy vehicles and measurably contribute to increased energy efficiency, safety, and cost effectiveness.	Begin aerodynamic redesign of over-the-road tractor-trailer combinations that meet operational, freight-loading, and maintenance needs of the truck industry; dimensional and safety requirements of DOT; DOE mission of enhanced efficiency and reduced exhaust emissions.	Plan and perform first phase verification of fuel economy improvements with active control of airflow around modified tractor-trailer combinations in full scale on-road tests. Reduction of aerodynamic drag of 50 percent, resulting in a possible 20 percent reduction in fuel consumption, has been indicated. For increased heavy vehicle safety, trailer stability control and braking assist aspects of the Circulation Control method will be designed and preliminary
	Continued the industry-acceptable redesign of trailers with Computational Fluid Dynamics (CFD) and advanced modeling and simulation. Obtained confirmation	Perform wind tunnel tests of 1/16th scale model truck to validate and refine mathematical models developed using Circulation Control	

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Heavy Vehicle Systems R&D (Cont'd)	and validation in wind tunnel tests to guide construction of over-the-road vehicle demonstrations with the trucking industry. Utilized Circulation Control for aero drag reduction. in conjunction with the CFD-generated projections, to attain vehicle stability control and braking assist. Continued development and testing of the plasmatron on-board reformer for spark ignition (SI) and diesel applications. Both diesel and SI engine tests were performed to validate the large efficiency increases and substantial reductions of both greenhouse gases and particulates. Utilizing industry guidance, evaluated concepts of on-board thermal management systems for Class 7 and 8 heavy vehicles to improve fuel economy, reduce emissions, and enhance engine performance. Determined relative efficiency of new, down-sized coolant system designs, relocation of coolant systems, and the effects of	theory for aerodynamic drag reduction, achieving greater vehicle stability and braking assist. Design and modify trailers for field-service road testing with industry partners. Determine energy efficiency, operational stability, sensor requirements, and maintenance issues for redesigned trailers. Complete study of near-term application of "off-the-shelf" technology to achieve 12 mile per gallon heavy truck (current industry average: 6 mpg). With industry cost-share, design this advanced vehicle. Initiate teaming and R&D efforts for building and testing this vehicle. Cooperate with industry, trade associations to reduce unnecessary idling of heavy truck engines. Continue R&D of heavy vehicle electrification, axle improvements, and improved braking materials,	validation tests will be performed. Detailed test plans will be formulated based on these scoping trials and an initial full-scale test will be conducted. Substantial industry operational participation and cost sharing is anticipated in these efforts. Expand tests of "off-the-shelf" technology to achieve 12 mile per gallon heavy truck fuel economy. Investigate with industry and DOT the replacement of truck mirrors with electronic devices, to reduce aerodynamic drag. Continue the competitively-awarded, industry cost-shared project on the More Electric Truck, decoupling mechanically-driven underhood components from the engine and utilizing electric drives to achieve a potential increase in efficiency of over 18 percent; the advanced axle project, designed to increase the efficiency of energy transfer in a heavy vehicle by over 2 percent, and the project for the transfer of highly effective aircraft

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Heavy Vehicle Systems R&D (Cont'd)	air management and control on heavy-duty coolant systems. Utilized results of the Friction, Wear, and Lubrication Industry/Government workshop to attain higher energy efficiency and reduction of emissions, as well as the development of exhaust gas resistant/tolerant coatings for engine components. Selected and evaluated candidate braking materials and systems, to improve by 50 percent or more the braking performance of conventional heavy-duty vehicles. Evaluated new braking systems to enable utilization of anticipated aerodynamic drag reductions. Continued cooperation with industry and trade associations to reduce unnecessary idling of heavy truck engines, which could achieve fuel savings of up to 1 percent of the fuel used in U.S. surface transport, cost savings of $2 billion per year and reduction of exhaust gases by up to 1	based on competitive awards for greater energy efficiency. Explore feasibility of reducing parasitic energy losses by using on-board Essential Power Systems to provide power-on-demand to electric water, fuel, and oil pumps of heavy duty truck engines. Issue competitive solicitation for Essential Power Systems, and make awards. Prepare peer-reviewed multi-year program plan for increased locomotive energy efficiency and reduction of emissions. Issue competitive solicitation in these areas and make awards. Conduct workshop on reduction of emissions of off-road vehicles. Utilize results to issue competitive solicitation and make awards.	brake technologies to improved braking materials for heavy vehicles. This latter is a key enabling safety technology as a result of the success anticipated in substantially reducing heavy vehicle aerodynamic drag. Continue the projects to develop Essential Power Systems, methods for improving locomotive efficiencies and reducing their emissions, and projects aimed at reducing emissions from off-road vehicles and their auxiliary power requirements. With the Environmental Protection Agency (EPA) and the OTT Office of Deployment, expand efforts with industry trade associations to reduce idling of heavy truck engines. Continue development of on-board Essential Power Systems (EPS) to provide power-on-demand for truck auxiliary electric power, such as water, fuel, and oil pumps, and heating, ventilating and air

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
	percent.		conditioning equipment. This comprehensive EPS approach will include the energy- and power-producing systems, the energy distribution system, and the energy- and power-utilizing components aboard the vehicle.
Heavy Vehicle Systems R&D (Cont'd)	Participants included: ANL, PNNL, ORNL, LLNL, SNL, MIT, CalTech, NASA, USC, PSU, Tufts University, GTRI, Tranergy, Delphi, Texaco. ($4,150)	Participants include: ANL, PNNL, ORNL, MIT, Cal Tech, NASA, USC, PSU, Tufts University, GTRI, Caterpillar Corp., Navistar, LLNL, Sandia, Castrol, Norfolk and Southern Railroad, Burlington Northern-Santa Fe Railroad, CSX, and competitive solicitations. ($9,369)	Participants include: American Trucking Associations, PACCAR, Freightliner, Kenworth, Peterbuilt, Honeywell, Caterpillar, ANL, PNNL, ORNL, MIT,NASA, USC, PSU, GTRI, LLNL, Tufts University, Sandia, Castrol, Navistar, EMP, TBD. ($10,314)
	Truck Safety Systems	**Truck Safety Systems**	**Truck Safety Systems**
	With the U.S. Department of Transportation, Division of Motor Carriers leading the effort, conducted collaborative planning to identify the origins of time- and/or design-dependent deterioration in heavy truck operational safety. Implemented planned program to investigate, with truck brake	Support activities in key safety areas for heavy vehicles. Conduct planning activities with trucking industry/government agencies to identify specific R&D needs for future brake requirements, including materials, cost-effectiveness, and brake system lightweighting. Conduct risk assessment of high	Continue to support activities in key safety areas for heavy vehicles, particularly in conjunction with DOT. Evaluate advanced monolithic composite materials for advanced heavy vehicle braking applications. Complete risk assessment of high pressure gaseous fuel storage tanks. Determine test

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
	industry partners, mechanisms of heat transfer, to develop improved braking materials. Capitalized on the state-of-the-art Aberration Corrected Electron Microscope (ACEM) at the High Temperature Materials Laboratory to characterize candidate improved brake materials.	pressure gaseous fuel storage tanks.	protocols and initiate preliminary tank tests. Initiate material substitution studies for the crash-worthiness of heavy vehicle tractors and automobile under-ride protectors for trailers.
Heavy Vehicle Systems R&D (Cont'd)	Implemented planning to develop Non-Destructive Testing (NDT) methods to predict, through computer simulation and modeling, and detect deterioration such as crack propagation in gas pressure vessels such as those used for Compressed Natural Gas (CNG) and cryogenic liquids including Liquified Natural Gas (LNG). There is no existing simple method for interrogating pressure vessels that are in use for some time.		
	Participants include: DOT, ATA, trailer manufacturers, Honeywell, Materials Performance Group. ($500)	Participants include: DOT, ATA, trailer manufacturers, Honeywell, Materials Performance Group. ($400)	Participants include: DOT, ATA, trailer manufacturers, Honeywell, Materials Performance Group. ($400)

III. Performance Summary: VEHICLE TECHNOLOGIES R&D

Program Activity	FY 2001	FY 2002	FY 2003
Heavy Vehicle Systems R&D (Cont'd)	**Stimulate Truck Innovative Concepts and Knowledge (STICK)**	**Stimulate Truck Innovative Concepts and Knowledge (STICK)**	**Stimulate Truck Innovative Concepts and Knowledge (STICK)**
	No activities. ($0)	Establish program to stimulate truck innovative concepts and knowledge, which consolidates small business / university projects and accelerates progress on technologies and inventions primarily applicable to heavy-duty vehicles.	Continue efforts which stimulate truck innovative concepts and knowledge by consolidating small business/university projects to achieve accelerated progress on technologies and inventions primarily applicable to heavy-duty vehicles.
		Participants include: TBD ($100)	Participants include: TBD ($600)
	Provided critical technical and program management support services. (Antares). ($244)	Provide critical technical and program management support services. (Antares). ($111)	Provide critical technical and program management support services. (Antares). ($186)
Total, Heavy Vehicle Systems R&D	**$4,894**	**$9,980**	**$11,500**
TOTAL, VEHICLE TECHNO-LOGIES R&D	**$157,061**	**$155,122**	**$149,280**

TRANSPORTATION TECHNOLOGIES
TRANSPORTATION SECTOR
(Dollars in Thousands)

FUELS UTILIZATION R&D

I. Mission Supporting Goals and Objectives

Mission**:** The Fuels Utilization R&D subprogram, along with partners in the energy and transportation industries, supports R&D that will provide transportation vehicle users with fuel options that are cost competitive, achieve high fuel economy, and deliver low emissions.

Summary: The Advanced Petroleum Based Fuels (APBF) activity is essential to the development of petroleum-based fuels and lubricants that will allow high efficiency diesel engines for passenger vehicle, light truck, and heavy truck applications to achieve low emissions with minimal efficiency penalties while employing the use of advanced aftertreatment technologies. It is also paving the way for inclusion of renewable fuels such as oxygenates and biodiesel, as blends with petroleum-based clean diesel fuel, to reduce greenhouse gas emissions and enhance energy security. Other advanced fuels being researched, such as liquids made from natural gas, will facilitate expanded use of domestic energy reserves to produce transportation fuels.

In the Alternative Fuels activity, the environmental impacts of fuels will be evaluated.

Context: The combined efforts of the Fuels Utilization R&D subprogram will support the recommendations of the National Energy Policy by providing the necessary fuel formulations for highly efficient advanced compression ignition, direct injection (CIDI) engine and fuel cell powerplants. These powerplants could be the prime movers for our transportation vehicles in the future. In order to prevent new environmental and health effects problems, the environmental and health impacts of these fuels will be fully evaluated prior to any new fuel being introduced into the fueling infrastructure.

The energy supply that serves the transportation sector is nearly all (95 percent) derived from petroleum: major products are gasoline, diesel, and jet fuel. Over half of the crude oil going into U.S. refineries is imported. Furthermore, imports of refined petroleum products make up about 10 percent of all petroleum products used. Imports of both crude and refined oil are projected to grow.

The Fuels Utilization R&D activities are integral to the success of other technology areas. Since Fuels Utilization R&D enables success of other specific technologies, the benefits are attributed to those specific technologies.

Management Strategy

The APBF activity is implemented through public/private partnerships that help to provide technical management for the program. An example of this is the Advanced Petroleum Based Fuels - Diesel Emission Control (APBF-DEC) project. The APBF-DEC has a steering committee of government and industry partners from vehicle and engine manufacturers, energy companies, emission control manufacturers and their trade associations (e.g., American Petroleum Institute (API), Manufacturers of Emission Controls Association (MECA), Engine Manufacturers Association (EMA), and American Chemistry Council) that identifies priorities. The effort is cost shared 50/50 between government and industry. Projects in this area are awarded competitively and are evaluated annually with industry partners. Recently, four solicitations were issued. The solicitations sought contractors to conduct efforts in advanced lubricant research, system evaluations with Selective Catalytic Reduction (SCR) and Diesel Particulate Filters (DPF), SCR infrastructure, and systems evaluations with Nitrogen Oxides (NOx) absorber catalysts and DPFs. Six projects over three years will be carried out at contractor laboratories, with technical support from DOE national laboratories.

All of the projects in the APBF activity are evaluated at the annual CIDI/Fuels review meeting by industry representatives. Based on the evaluations, project priorities are established, and decisions are made with respect to termination or re-direction.

Long Term Goals and Benefits

Advanced Petroleum Based Fuels

The Advanced Petroleum Based Fuels activity identifies and develops new fuel options that will enable conventional and advanced propulsion vehicles to meet increasingly challenging performance, fuel-efficiency, and emissions targets. The EPA Tier 2 emissions standards for light-duty vehicles, the Consent Decree to be implemented in 2002, and the EPA heavy-duty engine emission standards affecting heavy-duty trucks require advanced fuel formulations to enable these systems to meet applicable emission requirements while maintaining fuel efficiency.

- By 2004, develop advanced petroleum based fuels that will enable CIDI engines in automobiles and light trucks to achieve targets of 0.07 grams per mile NOx and 0.01 grams per mile Particulate Matter (PM) over full useful life of 120,000 miles, with a fuel economy penalty of less than 5 percent. At present, emissions performance for automobiles and light trucks, in laboratory conditions, meets the 0.07 grams per mile NOx and 0.01 grams per mile PM levels. However, current emissions system durability is less than 200 hours or less than 10,000 miles, which is far short of the required useful life (120,000 miles).

- By 2007 enable heavy duty trucks to achieve the new heavy duty emission standards, with minimal loss of fuel economy, while meeting the

full useful life requirement. Currently heavy duty trucks cannot meet the 0.2 grams/hp hour NOx, 0.01 grams/hp hour PM for the full useful life of 435,000 miles.

Long Term Goals and Benefits

Alternative Fuels

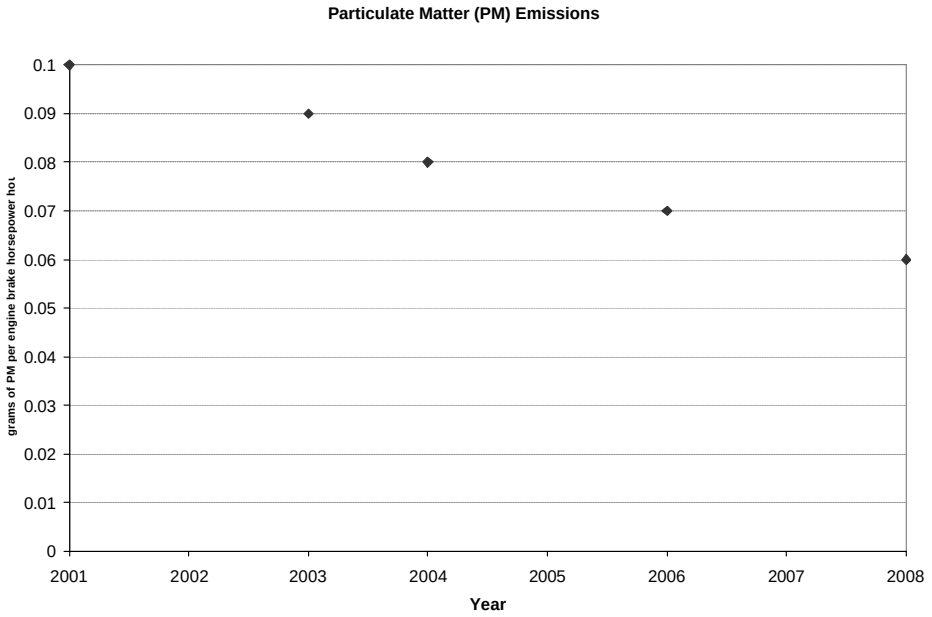
Activities in support of natural gas vehicle research and development are being discontinued in order to allow for funding of higher priority research activities. The most promising natural gas engines under development will be completed with available funds appropriated prior to FY 2003. Successfully developed natural gas vehicle technologies are expected to be deployed in revenue service vehicles.

The Environmental Impacts activity analyzes the atmospheric impacts and potential health effects that may be caused by the use of advanced petroleum-based fuels from mobile sources. The Environmental Impacts activity will develop more accurate measurement methods, which will then be applied to determine chemical and physical properties of emissions.

Program Strategic Performance Goal

ER1-15: Fuels Utilization

Fuel Utilization R&D activities will decrease light truck and passenger vehicle engine-out emissions of particulate matter from 0.1 grams per brake horsepower hour (g/bhp-hr) in 2001 to 0.06 g/bhp-hr by 2008.



The program target for FY 2003, which is an important milestone to achieving the overall goal, is projected to be achieved with funding at the FY 2003 level.

Performance Indicator

The number of grams of particulate matter (engine-out) per engine brake horsepower-hour is the indicator of performance for the fuels utilization activity.

Annual Performance Results and Targets

FY 2001 Results	FY 2002 Target	FY 2003 Proposed Target
Established benchmark particulate matter emissions at 0.1 grams per brake horsepower-hour (light duty).		Achieve 0.09 grams per brake horsepower-hour particulate matter emissions.

Significant Accomplishments and Program Shifts

Advanced Petroleum Based Fuels

The APBF activity is determining the effects of fuel composition on the efficiency and emissions performance of emerging, advanced compression ignition, direct injection (CIDI) engines. Through this research, the APBF activity will identify the most suitable fuels for these engines. Sulfur content in diesel fuel is a very important issue for the APBF activity. With the implementation of the EPA Tier 2 light-duty vehicle emission regulations and the heavy-duty engine emission regulations, the future viability of diesel-engine-powered vehicles will become dependent upon the ability of exhaust emission control devices to meet these emission standards. The most desirable emission control devices for NOx are deactivated by sulfur in currently available fuels. The fuels R&D activity is to support development of a complete system, with desulfurization and regeneration strategies, that will allow vehicles to meet very low emissions levels while keeping the fuel economy penalty at 5 percent or lower and meeting full useful life of 120,000 miles.

FY 2001 In conjunction with API, MECA, EMA, and the American Chemistry Council, completed the planning of cost-shared projects to characterize sulfur effects on emission control devices, and to develop engine control strategies to reduce the fuel economy impact associated with the regeneration of devices poisoned by sulfur for automotive, SUV and heavy duty application engines.

FY 2002 Complete the development of desulfurization and regeneration strategies on low sulfur fuel to enable very low emissions of 0.07 grams per mile NOx and 0.01 grams per mile particulate matter (PM) in automotive and sport utility vehicle applications, while keeping the fuel economy penalty less than at 5 percent.

FY 2003 Complete 1,000 hours aging of the emission control system, and evaluate desulfurization and regeneration strategies developed in Fiscal Year 2002.

Alternative Fuels

FY 2001 Collected samples for diesel and gasoline toxicity testing. Initiated program planning for weekend ozone study in Los Angeles. Completed development of Mack E7G 400 horsepower natural gas engine that meets California certification. Demonstrated feasibility of recovery of pure methane for LNG production and commercial quality carbon dioxide from landfill gas.

FY 2002 Validate methods to measure diesel particles and receive samples of natural gas exhaust emissions for morphology testing. Steady state demonstration of certification-ready low NOx (.5g/bhp-hr) heavy duty 400 horsepower natural gas engine.

FY 2003 Complete the gasoline/diesel particulate matter split study and will characterize gasoline particulate exhaust as a function of particulate size. The weekday/weekend particulate matter nitrate study will be conducted in Los Angeles. Start up a 20,000 gallon per day landfill gas to liquified natural gas (LNG) production facility in Aden, Pennsylvania at $0.40/LNG gallon.

II. A. Funding Table: FUELS UTILIZATION R&D

Program Activity	FY 2001 Enacted (a)	FY 2002 Enacted	FY 2003 Request	$ Change	% Change
Advanced Petroleum Based Fuels	$10,773	$11,928	$13,658	$1,730	15%
Alternative Fuels	$12,361	$13,980	$4,825	$-9,155	-65%
Total, Fuels Utilization R&D	$23,134	$25,908	$18,483	$-7,425	-28.7%

(a) FY 2001 reduced by $375,000 for SBIR/STTR

II. B. Laboratory and Facility Funding Table: FUELS UTILIZATION R&D

	FY 2001 Enacted	FY 2002 Enacted	FY 2003 Request	$ Change	% Change
Argonne National Lab (East)	$1,070	$410	$500	$90	22.0%
Brookhaven National Lab	$1,367	$2,490	$90	$-2,400	-96.4%
Idaho National Engineering & Environmental Lab	$675	$450	$0	$-450	-100.0%
Lawrence Livermore National Lab	$1,065	$850	$450	$-400	-47.1%
Los Alamos National Lab	$70	$250	$250	$0	0.0%
National Renewable Energy Lab	$7,669	$11,354	$10,089	$-1,265	-11.1%
Oak Ridge National Lab	$3,217	$3,324	$2,164	$-1,160	-34.9%
Pacific Northwest National Lab	$250	$0	$0	$0	0.0%
Sandia National Laboratories	$900	$200	$786	$586	293.0%
All Other	$6,851	$6,580	$4,154	$-2,426	-36.9%
Total, Fuels Utilization R&D	$23,134	$25,908	$18,483	$-7,425	-28.7%

III. Performance Summary of Program Activities: FUELS UTILIZATION R&D (Cont'd)

Program Activity	FY 2001	FY 2002	FY 2003
Advanced Petroleum Based Fuels	**Automobile/Light Truck and Heavy Truck** Conducted systematic development, test, and evaluation of advanced petroleum based fuels and blending additives, including biomass, natural gas derived fuels, and oxygenates, that enhance the performance and emissions characteristics of diesel engines for application in automobiles, light trucks, and heavy trucks. Iteratively tested and developed new lube oils for use in diesel engines that operate on advanced petroleum based fuels and which do not pose any deleterious effects on emissions. Continued to investigate potential compatibility issues with new fuels and engine components and seals. Increased cost-sharing through more coordination with energy, auto, heavy vehicle and emission control industries. Evaluated the overall ability of new fuels and blend options to utilize existing maintenance practices, liquid storage tanks, and refueling	**Automobile/ Light Truck and Heavy Truck** Continue testing of advanced petroleum based fuels and blending additives. Evaluate new fuel formulations in the context of a complete engine emission control and fuel system which is optimized for emissions and fuel economy. Evaluate new fuels and blend options for safety during refueling and on-board storage. Conduct combustion modeling and environmental assessment efforts focused on oxygenated diesel fuel. Conduct single cylinder combustion studies of oxygenates. Develop sulfur trap to remove sulfur from fuel on-board vehicle. Continue national laboratory activities to determine fuel impurity (e.g., sulfur) effects on fuel cell system durability. Conduct limited testing and development of lube oils for use in diesel engines that operate on advanced petroleum based fuels and	**Automobile/ Light Truck and Heavy Truck** Investigate combustion of reformulated diesel fuels, to optimize the particulate matter emissions reduction benefit of the fuel. Continue to evaluate the performance, emissions, and durability effects of advanced petroleum based fuels and additives on fuel system, power train, and emission control components. Complete initial durability testing of desulfurization and regeneration strategies for emission control devices which can achieve very low emissions levels and minimize fuel economy impacts. Characterize sulfur effects on emission control devices, and develop engine control strategies to reduce fuel economy impact associated with the regeneration of these devices for automotive, SUV and heavy duty application engines. Complete refueling and on-board

III. Performance Summary of Program Activities: FUELS UTILIZATION R&D (Cont'd)

Program Activity	FY 2001	FY 2002	FY 2003
Advanced Petroleum Based Fuels (Cont'd)	infrastructure. Conducted fundamental combustion studies of advanced petroleum based fuels and blends using computer simulation, to understand why the fuels and blends improve emissions, and their advantages for engine design. Continued to develop models to determine the optimum concentration and type of blending component for diesel fuel to minimize emissions. Studied injection spray characteristics of advanced petroleum based fuels to assess the options for combustion chamber reconfiguration to take advantage of their enhanced properties. Tested and evaluated fuel cell systems running on advanced fuels, to determine fuel and fuel contaminant effects on fuel cell systems and components. Continued to evaluate impurities and additives, including oxygenates, on fuel cell components. Determined life cycle energy efficiency and emissions of fuel cell power systems.	do not pose any deleterious emissions effects.	storage safety assessment of new fuels and blend options. Continue development and utilization of models to identify the optimum concentration and type of blending component for diesel fuel, consistent with minimizing emissions. Evaluate the impacts of lubricants on the long-term durability and conversion efficiency of advanced emission control devices.

III. Performance Summary of Program Activities: FUELS UTILIZATION R&D (Cont'd)

Program Activity	FY 2001	FY 2002	FY 2003
Advanced Petroleum Based Fuels (Cont'd)	Participants included: NREL, ORNL, SNL, ANL, LLNL, LANL, Southwest Research Institute. ($10,123)	Participants include: NREL, ORNL, ANL, Southwest Research Institute. ($11,432)	Participants include: NREL, ORNL, SNL ANL, LLNL, LANL, Southwest Research Institute, FEV. ($13,324)
	Provided critical technical and program management support services. (Antares, Sentech) ($650)	Provide critical technical and program management support services. (Antares, Sentech) ($496)	Provide critical technical and program management support services. (Antares, Sentech) ($334)
Total, Advanced Petroleum Based Fuels	**$10,773**	**$11,928**	**$13,658**
Alternative Fuels	**Alternative Fuels/ Automobile/ Light Truck**	**Alternative Fuels/ Automobile/ Light Truck**	**Alternative Fuels/ Automobile/ Light Truck**
	In cooperation with the DOE Hydrogen Program, developed critical technologies such as hydride-based on-board storage and related refueling infrastructure technology, distribution, and refueling issues surrounding development of alternative fuel infrastructure for fuel cell vehicles. Research implemented to overcome barriers associated with infrastructure materials compatibility, fuel processor	In cooperation with the DOE Hydrogen Program, develop critical technologies such as hydride-based on-board storage and related refueling infrastructure technology areas, such as purification and compression. Demonstrate fuel cell vehicle performance when fueled with gaseous hydrogen, including road testing and refueling. Analyze and test, in conjunction with fuel cell	No activities ($0)

III. Performance Summary of Program Activities: FUELS UTILIZATION R&D (Cont'd)

Program Activity	FY 2001	FY 2002	FY 2003
Alternative Fuels (Cont'd)	performance, and potential additives which may be necessary. Analyses and testing performed in conjunction with auto industry programs to measure vehicle performance (efficiency, emissions, etc.) and to resolve fuel infrastructure barriers associated with alternative fuels. Participants included: States, fuel providers, NREL, ANL. ($615)	vehicle industry programs, vehicle performance measurements and resolve barriers for alternative fuels, including hydrogen and methanol. Participants include: States, fuel providers, auto manufacturers, NREL, ANL, California Fuel Cell Partnership members. ($990)	
	Medium Trucks Selected most promising natural gas engine technologies, previously developed in this program, for further development, with the potential for increasing engine efficiencies from 40 percent to 45 percent. Continued on-road development projects, utilizing the West Virginia University Mobile Emissions Test Facility, with the intent of moving high efficiency (40 percent) natural gas engines toward production-ready status. Assessed natural gas bus technologies, comparing	**Medium Trucks** Initiate activities to explore the use of alternative fuels other than natural gas in medium trucks. Complete design/market study for conformable CNG fuel storage tanks for class 3-6 trucks. Initiate design and development of state-of-the-art class 3-6 CNG vehicle from the ground up as a natural gas vehicle, utilizing technologies developed over the past years under sponsorship from this program.	**Medium Trucks** Select one engine for completion, from among current natural gas engine projects, which has the greatest potential to meet 2004 emissions standards while improving efficiency by 15 percent.

III. Performance Summary of Program Activities: FUELS UTILIZATION R&D (Cont'd)

Program Activity	FY 2001	FY 2002	FY 2003
Alternative Fuels (Cont'd)	performance and emissions to conventional diesel and fuel celled counterparts. Developed design for lower cost, lighter weight CNG fuel storage tanks for class 3-6 trucks.		
	Participants include: NREL, ORNL, SNL, ANL, BNL, West Virginia University. ($3,190)	Participants include: NREL, ORNL, BNL, ANL, West Virginia University. ($3,903)	Participants include: NREL, TBD. ($1,000)
	Heavy Trucks	**Heavy Trucks**	**Heavy Trucks**
	Demonstrated, in a test cell, operation of a natural gas fueled engine that incorporates direct injection technology. Completed prototype and began testing of advanced liquified natural gas storage and fuel delivery system. Evaluated the use of neat natural gas derived liquid fuels in unmodified heavy duty trucks to assess emissions benefits of using these liquids as fuels in emissions non-attainment areas.	Complete full-scale laboratory testing of advanced liquified natural gas storage and fuel delivery systems. Initiate design development of state-of-the-art LNG fueled class 7-8 truck from the ground up as a natural gas vehicle, utilizing the technologies developed over the past years under sponsorship from this program. Initiate a competitive request for proposals to develop a next generation heavy duty natural gas engine.	Select one engine for completion from among current natural gas engine projects which has the greatest potential to meet 2004 emissions standards while improving efficiency by 15 percent.
	Participants included: NREL, ORNL, SNL, ANL, BNL. ($3,216)	Participants include: NREL, ORNL, BNL, ANL. ($3,903)	Participants include: NREL, TBD. ($1,000)

III. Performance Summary of Program Activities: FUELS UTILIZATION R&D (Cont'd)

Program Activity	FY 2001	FY 2002	FY 2003
	Environmental Impacts	**Environmental Impacts**	**Environmental Impacts**
Alternative Fuels (Cont'd)	Assessed the "on-the-road" contribution of mobile source emissions inventories. Using field studies, evaluated the contribution of heavy vehicle emissions to ozone, PM 2.5, regional haze, and hazardous air pollutants. Conducted studies to determine the reasons for higher ozone concentrations on the weekends in California. Collected gasoline and diesel exhaust samples for comparative toxicity testing. Collected natural gas exhaust samples for toxicity testing and characterization. Performed cold start emissions testing of gasoline vehicles.	Assess field studies of on-road contribution of mobile sources to emissions inventories and contribution of heavy vehicle emissions. Continue collection of on-road vehicle exhaust from new technology vehicles for health effect studies.	Evaluate contribution of emissions from new technology heavy-duty vehicles and alternative fuels to ambient air quality. Evaluate the results from field studies to quantify the regulated emissions contributions from existing heavy vehicles. Continue characterization of natural gas emissions using various aftertreatment devices, and ascertain toxicity of resulting emissions. Evaluate toxicity of cold start gasoline emissions. Continue real-world studies to assess the relative importance of mobile source air toxic emissions from light-duty and heavy-duty new and in-use vehicles.
	Participants included: NREL, SWRI, CRC. ($2,923)	Participants include: NREL, CRC, other industry groups. ($2,972)	Participants include: NREL, BNL, CRC, other industry groups. ($2,375)
	Fueling Infrastructure	**Fueling Infrastructure**	**Fueling Infrastructure**
	Tested and evaluated compressor technology prototype, small scale natural gas liquifier and gas clean-	Complete field installation and begin field testing of small scale natural gas liquefier and gas clean	Conduct total fuel cycle analysis for alternative fuels, considering terms of economic, energy, and

III. Performance Summary of Program Activities: FUELS UTILIZATION R&D (Cont'd)

Program Activity	FY 2001	FY 2002	FY 2003
Alternative Fuels (Cont'd)	up technologies. Accelerated activities in support of industry coordinated Infrastructure Working Group. Developed prototype CNG/LNG refueling facility that addresses safety concerns and allows for easy permitting. Participants included: INEEL, SNL, BNL. ($1,944) Provided critical technical and program management support services. (Antares, CSMI). ($473)	up technologies. In coordination with the Infrastructure Working Group, support activities, through a competitive solicitation, that are focused on reducing the cost and improving the use of natural gas fueling stations. Participants include: INEEL, SNL, BNL. ($1,966) Provide critical technical and program management support services (Antares, Sentech). ($246)	environmental factors. Participants include: AD Little, and ANL. ($300) Provide critical technical and program management support services (Antares, Sentech). ($150)
Total, Alternative Fuels	**$12,361**	**$13,980**	**$4,825**
TOTAL, FUELS UTILIZATION R&D	**$23,134**	**$25,908**	**$18,483**

TRANSPORTATION TECHNOLOGIES
TRANSPORTATION SECTOR
(Dollars in Thousands)

MATERIALS TECHNOLOGIES

I. Mission Supporting Goals and Objectives

Mission: The Materials Technologies subprogram supports the development of cost-effective materials and materials manufacturing processes necessary to successfully commercialize significantly more fuel-efficient, low-emission transportation vehicles. This sub-program is a critical enabler for concepts developed in other Transportation Sector subprograms.

Summary: The Materials Technologies subprogram has two closely coordinated activities: Propulsion Materials Technology and Lightweight Materials Technology. Each of these two activities has sub-activities focused on automobiles or trucks. The Materials Technologies subprogram also includes maintenance and usage of the Oak Ridge National Laboratory's world-class High Temperature Materials Laboratory (HTML), which has unique capabilities to support the transportation materials development effort. This facility also supports other materials efforts, and the training of technologists in cutting-edge materials characterization research.

Context: The technologies developed in this program help to increase the fuel-to-motion conversion efficiencies of and to lighten autos and trucks. This responds to the "corporate" Program Strategic Performance Goal and the overall Energy Efficiency performance goals by decreasing the demand for petroleum by transportation vehicles. The general effects of reducing vehicle mass are quantified on page 4-10 of the *National Energy Policy*.

The market for the technologies developed in this program is the North American market for autos and trucks of all classes, which accounts for 16 to 18 million vehicles per year.

The technical barriers to commercialization are mainly associated with designing, manufacturing, repairing, recycling and disposing of vehicles that are acceptable to consumers and to society at large. Assuring that advanced high-performance materials meet these needs at acceptable life-cycle costs is the current challenge.

GPRA: The projected benefits of the Transportation Materials subprogram alone are shown in the table below. These benefits derive only from the weight reductions that are projected to be achieved. The benefits due to enabling more efficient propulsion systems are not included in order to avoid double-counting, as they are accounted for by other Transportation subprograms.

Materials Technologies	2005	2010	2020
Petroleum Displaced (Millions Barrels per Day)	0.00	0.003	0.047
Total Primary Energy Displaced (Trillion Btu)	0	6	93
Energy Costs or Savings (Millions of $)	0	64	979
Carbon Equivalent Emissions Displaced (MMTCe)	0.00	0.11	1.81

Note: Program benefit projections are developed through an impact analysis process undertaken annually by EERE, based on assumptions for future energy markets derived from EIA's annual energy outlook. EERE's sectors analyze the impacts their programs will have on energy savings, energy cost savings, and carbon reductions if all program goals are met, and future energy markets develop as expected. A sample of program benefit estimates are externally reviewed by Arthur D. Little.

Management Strategy*:* Since its beginning in 1991, the R&D portfolio of the Automotive Lightweight Materials (ALM) activity has been planned and coordinated in conjunction with DOE national laboratories and in partnership with the major U.S.-based automakers (Chrysler group of the DaimlerChrysler Corporation, the Ford Motor Company and General Motors Corporation). The Argonne National Laboratory has played a lead role in automotive recycling; the Lawrence Berkeley National Laboratory has led efforts on nondestructive evaluation; the Pacific Northwest National Laboratory has lead the Northwest Alliance for Transportation Technology; and the Oak Ridge National Laboratory has performed as the overall field technical manager. Since about 1998, the planning and coordination has increased with Tier 1 and Tier 2 automotive suppliers such as Delphi, Budd, and Visteon, and with material supplier organizations such as the Aluminum Association, the American Iron and Steel Institute and the American Plastics Council. Planning and coordination with a similar effort sponsored by Natural Resources of Canada have increased since 1999, and a jointly funded project is now underway. The planning and coordination is continuous throughout the fiscal year, in order to determine appropriate funding for projects. Final decisions on projects remain with DOE program managers.

ALM's R&D activities are conducted in industry research centers, national laboratories, and universities, with the specific mix being determined by the nature of the project. The more fundamental work is done by the universities and national laboratories, while the more applied work is performed by industry. The specific performers have largely been determined by DOE and the entities supplying the cost-share, via solicitations of interest. The burden of proving out and implementing the technologies developed has invariably been on industry.

Formal cost-share by the automakers, their Tier 1 and Tier 2 suppliers and the material suppliers, has been about 50 percent of the overall efforts, or about a 1:1 match of the DOE funds. However, industry partners consistently claim additional, proprietary expenditures several times that of the formal figure. Of the DOE funds, about 50 percent has gone to the DOE national laboratories, 35 percent to industry researchers, and 15 percent to universities.

Mid-course milestones, go/no-go decision points, end-points and downselects are identified in every project and updated as the projects proceed. The projects are usually of two to five years' duration. The projects are usually terminated when the end-point objectives are reached as determined by the participants and the "stakeholder" entities supplying the cost-shares.

DOE's goals and planning for the High Strength/ Weight Reduction activity for heavy vehicles have been substantially augmented by workshops involving representatives from government, industry, and academia, which have resulted in the formulation of peer-group reviewed Multi-Year Program Plans (MYPPs). The MYPPs have identified the key technical thrust areas, technical barriers, potential market barriers, time frames for development, and estimated resources required to achieve the identified goals. Truck original equipment manufacturers (OEM), engine manufacturers, material suppliers, and key component manufacturers have been actively involved in the review, approval, and acceptance of the MYPPs, the subsequent research activities, and the evaluation and commercial implementation of the technical developments of the activity. The national laboratories (ORNL, PNNL, LANL, SNL, LLNL, and INEEL) are providing materials formulations, testing, and characterization support for the various projects, many selected through competitive solicitations, within the R&D program. The DOE program manager has the responsibility for making the final decisions in the selection of the projects within the programmatic portfolio.

The Automotive Propulsion Materials activity focuses its efforts on enabling materials technologies-- technologies that are critical in removing barriers to the power electronics, fuel cell, and compression ignition, direct injection (CIDI) engine combustion and emissions control research programs. Industry technical teams set materials requirements and help DOE establish priorities for each of these programs.

The Automotive Propulsion Materials activity is executed through the DOE national laboratories. Collaboration and cooperation across organizations is a crucial element of the management strategy. Scientists at the national laboratories are collaborating with industry to identify manufacturing barriers and to refine the necessary characteristics for meeting performance requirements. The individual automotive propulsion materials projects are evaluated by industry and academia as part of the annual program merit reviews and peer evaluations. As a result of these reviews, program priorities are re-evaluated and projects are either terminated, redirected, or continued. These program management decisions drive the funding allocations for the new fiscal year.

The Propulsion Systems Materials activity for heavy vehicles is designed primarily as an enabling and support function for the development and ultimate deployment of cost-competitive, highly energy efficient, low emission heavy duty engines. Materials play several key roles in this effort: substantial reduction of parasitic energy losses within the engine that arise from friction and wear processes; ensuring the

compatibility of new and improved fuels and fuel mixtures with the various components of the engine including the combustion chamber; formulation of specialized catalysts for the treatment of exhaust gas emissions and trapping of particulates from the combustion process; and the amelioration of corrosion and erosion processes within the engine. Because of commercial requirements for long life of components in heavy vehicles, essential aspects of the performance of the materials in this program are durability and reliability. In this program also, the workshop approach involving representatives from government, industry, and academia provides the basis for the formulation of peer-group reviewed Multi-Year Program Plans (MYPPs) that identify the key technical thrust areas, technical barriers, potential market barriers, time frames for development, and estimated resources required to achieve the identified goals. The heavy engine manufacturers have had a key role in this process, with substantial input from the truck OEMs, material suppliers, and key component manufacturers. ORNL is the lead laboratory in performing heavy vehicle propulsion materials R&D. Many of the projects are selected through competitive solicitations, but some support identification of engine material degradation, material replacement strategies, and improved performance approaches. The DOE program manager has responsibility for making the final decisions in the selection of the projects within the activity portfolio.

The HTML addresses materials formulations, performance, failure analyses, and characterizations, on micro- and macro-scales, as defined by peer-group reviewed proposals by industry to meet its needs with the use of state-of-the-art equipment located within the HTML user centers. Energy efficiency improvements and emissions reductions in transportation systems, as affected by specific materials and the state of the materials, are often evaluated and quantified, but the determination of the durability and reliability of such materials may be even more important in assessing the value of the material in meeting industry's requirements.

Projects conducted at the HTML generally involve shared responsibility between industry and HTML staff. Proprietary work is performed under a cost recovery system. Over 100 projects per year are conducted with time frames between three weeks and three months. Each project is a stand-alone activity. The HTML often provides the basis for materials optimization, which contributes to measurable improvement in the performance of vehicular systems.

Long Term Goals and Benefits

Lightweight Materials: There are two elements of this activity: 1)Automotive Lightweight Materials, which addresses lightweight materials for autos, and 2) High Strength Weight Reduction Materials which addresses lightweight materials for trucks.

Automotive Lightweight Materials: The major goal of the Automotive Lightweight Materials (ALM) activity is to develop and validate lightweight materials and processing technologies that could significantly reduce automobile weight without compromising vehicle cost, performance or safety. This will require the development of advanced technologies for primary fabrication, secondary processing, forming, joining, assembly, and recycling.

By 2000, developed and validated advanced material technology that:

- enables a 25 percent reduction in weight of the body and chassis
- exhibits the performance, reliability, and safety characteristics comparable to those of conventional vehicle materials

By 2004, develop and validate advanced material concepts that will:
- enable reduction in the weight of body and chassis components by 50 percent and overall vehicle weight by 40 percent
- exhibit the performance, reliability, and safety characteristics comparable to those of conventional vehicle materials
- be cost competitive with life-cycle costs of conventional vehicle materials

By 2011, develop and validate advanced material concepts that will:
- enable reduction in the weight of body and chassis components by 60 percent in a mid-size passenger car
- exhibit the performance, reliability, and safety characteristics comparable to those of conventional vehicle materials

High Strength/ Weight Reduction Materials (HS/WR): The major goal of the HS/WR materials activity is to reduce the parasitic energy losses in heavy vehicles, due to current weight of the vehicle, without reducing vehicle functionality, durability, reliability or safety, and to achieve this goal in a cost effective manner. This reduction in weight will be reflected in increased productivity of the heavy duty fleet, since a smaller number of trucks will be capable of carrying the same freight tonnage. Lightweight material usage and innovative design of components, in addition to the full range of material production, fabrication, joining, repair and recycling methodologies, are essential parts in the technological portfolio of the program.

By 2004, identify and develop advanced materials technology that can:
- reduce the weight of an unloaded class 8 heavy vehicle from 23,000 pounds to 18,000 pounds through materials substitution and/or innovative design approaches

By 2007, develop and validate advanced lightweight materials technology that will:
- achieve the lightweighting goal above
-exhibit the performance, durability, reliability, safety, and cost effectiveness comparable to those of current heavy vehicles

Propulsion Materials: This activity also contains two elements, Automotive Propulsion Materials and Heavy Vehicle Propulsion Materials

Automotive Propulsion Materials: The activity supports development of cost effective materials technologies that will enhance fuel efficiency and reduce emissions of vehicles while maintaining safety, reliability, recyclability and economic competitiveness. To achieve this, the activity funds research and development work to remove materials-related technical barriers to the overarching development subprograms within the automotive and heavy duty vehicle programs. The activity therefore adopts the goals of the subprograms being supported. In the automotive area:

Compression Ignition, Direct Injection Engine (CIDI) Combustion and Emission Control: Develop advanced materials technology for application in high-fuel-economy, emissions-compliant passenger cars.

- By 2010, validate the capability of a CIDI engine-powered, high fuel economy vehicle to meet Tier 2, Bin 3 emissions (0.03 g/mile NOx and 0.01 g/mile particulate matter (PM) with a fuel economy penalty of less than 5 percent.

Fuel Cells for Transportation: Develop highly efficient, low or zero-emission, cost-competitive fuel cell power system technologies that operate on conventional and alternative fuels.

- By 2010, develop and validate fuel cell power system technologies (including fuel cell stack subsystem, fuel processor subsystem, and balance of plant components) that are 45 percent efficient at 25 percent power and capable of meeting a high volume manufactured cost of $45/kW.

Power Electronics: Develop power electronics and electric machinery technologies with increased component integration and flexibility, while improving reliability and ruggedness and achieving significant reductions in cost, volume and weight.

- By 2006, develop and validate power electronics and electric machinery technologies that cost $6/kW and $4/kW respectively, with efficiencies of 98 percent and 97 percent respectively.

:

Heavy Vehicle Propulsion Materials**:** The major goal of this activity is to identify and provide improved and new materials to enable cost effective, high energy efficiency, substantially lower emission producing heavy duty engines, and exhaust treatment materials and devices possessing high durability and reliability. Lightweight materials applications in heavy duty engines may also provide an opportunity to reduce weight-induced parasitic energy losses, provided that the same cost, durability and reliability requirements can be met.

By 2003, identify and verify the leading material degradation mechanisms in heavy duty engines produced by the use of substantial (>25 percent) exhaust gas recirculation (EGR) in heavy duty engines, to achieve EPA emission requirements

By 2005, develop and validate advanced materials technology that will:

-substantially reduce the erosion and corrosion in heavy duty engines as a result of the use of EGR

-exhibit the performance, durability, reliability, safety, and cost effectiveness comparable to those of current heavy duty engines

High Temperature Materials Laboratory (HTML)

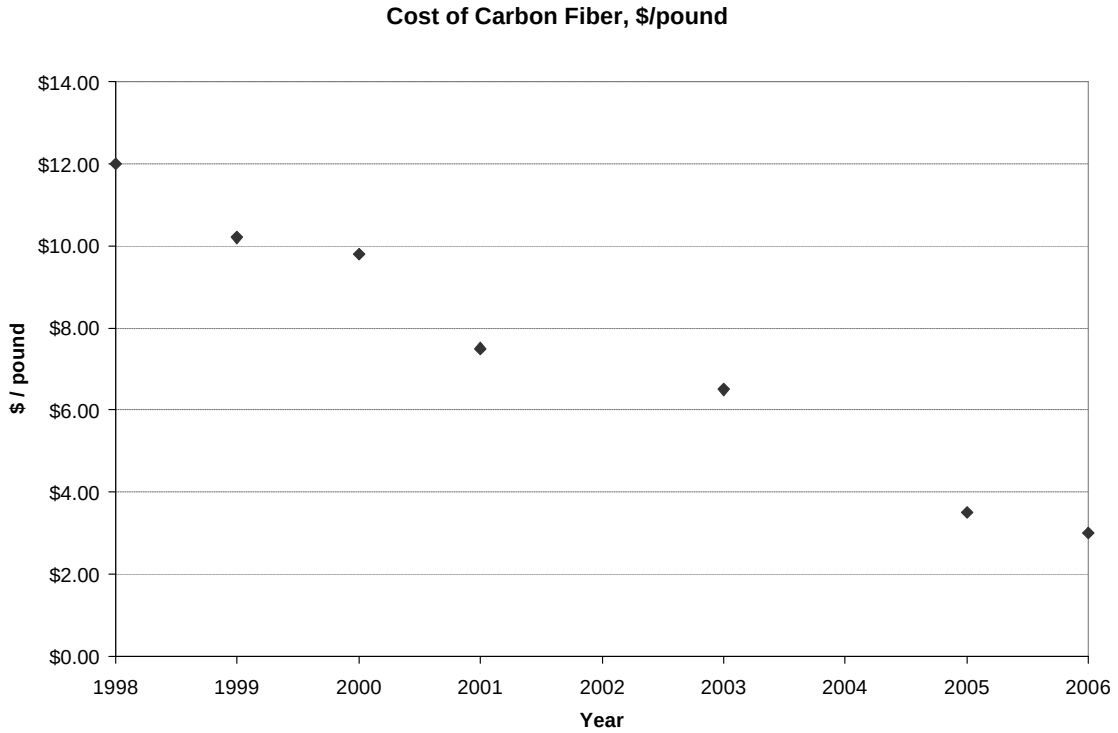
The HTML addresses materials formulations, performance, failure analyses, and characterizations, on micro- and macro-scales, as defined by peer-group reviewed proposals to meet industry's needs, using state-of-the-art equipment located within the HTML user centers. Energy efficiency improvements and emissions reductions in transportation systems, as affected by specific materials and state of the materials, are often evaluated and quantified, but the determination of the durability and reliability of such materials may even be more important in assessing the value of the material in meeting industry's requirements.

- By 2003, demonstrate sub-angstrom resolution with the Aberration Corrected Electron Microscope in characterizing exhaust emission catalysts.
- By 2003, complete a user project with industry using the new in-situ temperature and atmosphere control systems on the neutron beam line to study degradation mechanisms in engine alloys.

Program Strategic Performance Goal

ER1-16: Transportation Materials Technologies
Transportation Materials Technologies R&D activities will reduce the production cost of carbon fiber from $12 per pound in 1998, to $3 per pound in 2006.

Performance Indicator
The cost of carbon fiber is the indicator of performance for the materials activity.



The program target for FY 2003, which is an important milestone to achieving the overall goal, is projected to be achieved with funding at the FY 2003 level.

Annual Performance Results and Targets

FY 2001 Results	FY 2002 Target	FY 2003 Proposed Target
Completed explorations of four approaches to lower-cost precursors for carbon fibers; downselected and initiated further work on two most promising approaches.	Fabricate a sport utility vehicle chassis component using carbon fiber, in a low cost molding process that is suitable for high volume production.	Complete R&D on technology which, if implemented in high volume, could reduce the price of automotive-grade carbon fiber to less than $7/pound.

Significant Accomplishments and Program Shifts

Lightweight Materials:

FY 2001

- Completed planning of Focal Project 3, focused on a predominantly carbon-fiber-reinforced polymer-matrix composite, hybrid-material (i.e., some additional materials like steel and aluminum are used sparingly when necessary) "body-in-white."

FY 2002

- Complete development of creep resistant magnesium alloys and initiate tests of automotive components.

FY 2003

- Develop low cost extrusion process for fabrication of carbon foams.
- Achieve operational capability of aberration-corrected electron microscope at the HTML.
- Complete fabrication of lightweight stainless steel bus and validate weight savings.

Propulsion Materials:

The automotive propulsion materials activity supports 13 projects addressing key materials-related barriers to the Fuel Cell, CIDI Combustion and Emission Control, and Power Electronics subprograms. Each project supports aspects of the Mission Supporting Objectives.

FY 2001

- Demonstrated ceramic particulate filter system for engines that removes 90 percent of particulates with 90 percent filter regeneration efficiency.
- Achieved 50 percent reduction of friction in a variable displacement compressor/expander utilizing carbon/carbon composite and anodized aluminum contact pairs.

FY 2002

- Demonstrate ceramic particulate filter system for engines that removes 90 percent of particulates with 95 percent filter regeneration efficiency.
- Demonstrate an air-cooled power electronics module using carbon foam that can eliminate the need for a liquid cooling loop.

FY 2003

- Demonstrate ceramic particulate filter system for engines that removes 90 percent of particulates with 95 percent filter regeneration efficiency and meets the 5,000 hour durability requirement.
- Design, fabricate and operate a reciprocating press demonstrating continuous manufacturing techniques for low-cost, high-energy-product permanent magnets. The target is to achieve magnet power densities and thermal performance using low-cost bonded magnet materials. These developments will be measured against commercially available high quality ceramic magnets.

II. A. Funding Table: MATERIALS TECHNOLOGIES

Program Activity	FY 2001 Enacted (a)	FY 2002 Enacted	FY 2003 Request	$ Change	% Change
Propulsion Materials Technology	$8,848	$8,962	$7,000	$-1,962	-21.9%
Lightweight Materials Technology	$27,198	$25,731	$18,800	$-6,931	-26.9%
High Temperature Materials Laboratory	$5,501	$5,600	$4,000	$-1,600	-28.6%
Total, Materials Technologies	$41,547	$40,293	$29,800	$-10,493	-26.0%

(a) FY 2001 reduced by $676,000 for SBIR/STTR

II. B. Laboratory and Facility Funding Table: MATERIALS TECHNOLOGIES

	FY 2001 Enacted	FY 2002 Enacted	FY 2003 Request	$ Change	% Change
Argonne National Lab (East)	$1,657	$1,754	$1,375	$-379	-21.6%
Idaho National Engineering and Environmental Lab	$250	$225	$250	$25	11.1%
Lawrence Berkeley National Lab	$400	$400	$400	$0	0.0%
Lawrence Livermore National Lab	$475	$550	$385	$-165	-30.0%
Los Alamos National Laboratory	$117	$0	$100	$100	100.0%
National Renewable Energy Lab	$0	$0	$0	$0	0.0%
Oak Ridge National Lab	$24,465	$24,841	$18,669	$-6,172	-24.8%
Pacific Northwest National Lab	$4,950	$4,050	$3,565	$-485	-12.0%
Sandia National Laboratories	$395	$329	$670	$341	103.6%
All Other	$8,838	$8,144	$4,386	$-3,758	-46.1%
Total, Materials Technologies	$41,547	$40,293	$29,800	$-10,493	-26.0%

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Propulsion Materials Technology	**Automotive Propulsion Materials** Conducted R&D to remove materials-based barriers to the introduction of advanced propulsion systems. The R&D focused on: improved thermal management for power electronics and fuel cell systems; materials to reduce the size, and improve the performance, manufacturabilility and reliability of power electronics components and modules; advanced diesel engine materials and catalysts to enable reduction of NOx and particulates. Developed surface treatment technologies for advanced diesel engine components and fuel cell air compressors to lower weight, decrease wear, eliminate parts and increase efficiency. Demonstrated a ceramic particulate filter prototype on a diesel engine achieving 75 percent particulate removal efficiency, 95 percent filter regeneration efficiency, and 0.01 g/mile research target.	**Automotive Propulsion Materials** Develop in-cylinder application techniques for diesel engine aluminum block surface treatment technology, to improve durability in a light weight engine block. Develop low friction surface coatings for advanced fuel cell compressors. Optimize ceramic particulate filter system for diesel engines to remove 90 percent of particulates with 95 percent filter regeneration efficiency. Demonstrate full scale carbon foam heat sinks for power electronic modules. Develop an improved fuel cell thermal management system integrating use of carbon foam technology. Transfer polymeric dc buss capacitor technology to industry supplier(s). Characterize high dielectric polymer film materials. Characterize failure mechanisms of fuel cell membranes. Develop ceramic backing layers for prototype PEM fuel cell high	**Automotive Propulsion Materials** Validate aluminum block surface treatment technology by testing Ford engine that incorporates two treated components. Demonstrate dielectric plates (catalyst substrate) in a non-thermal plasma reactor assembly in actual diesel exhaust. Transfer carbon foam heat sink technology for power electronic modules to industry suppliers. Continue to transfer polymeric dc buss capacitor technology to industry supplier(s). Optimize high dielectric ceramic bus capacitor fabrication techniques. Participants include: ORNL, LLNL, SNL, ANL, Industrial Ceramic Solutions. ($1,000)

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Propulsion Materials Technology (Cont'd)	Initiated testing of carbon foam heat sinks in power electronics modules for improved thermal management. Identified optimum nanofluid composition for fuel cell thermal management system. Fabricated and tested new ceramic-based capacitors utilizing materials previously developed to achieve volume reduction and increased temperature operation for power electronics. Developed ceramic-based membranes and backing materials for higher temperature PEM fuel cell operation. Participants included: ORNL, LANL, SNL, ANL, Industrial Ceramic Solutions, University of Wisconsin. ($2,916)	temperature membranes. Characterize relationship between processing parameters and structure of NdFeB permanent magnets. Develop highly sensitive NOx sensor. Develop techniques to fabricate small orifices for diesel fuel injectors. Participants include: ORNL, LLNL, SNL, ANL, Industrial Ceramic Solutions. ($2,971)	

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Propulsion Materials Technology (Cont'd)	**Heavy Vehicle Propulsion Materials** In response to urgent national needs for higher efficiency, lower emission engines for heavy vehicles, SUVs, and vans, accelerated the development of identified materials and processes, such as intermetallic compounds in high temperature regions, amorphous metals and alloys, and metal-and ceramic-matrix composites. Conducted proof-of-principle tests of selected materials for advanced engine components applications. With the major diesel engine manufacturers, completed the manufacture and evaluation of prototype thick thermal barrier coatings, insulated cylinder heads, and the materials developed for low emissions exhaust gas aftertreatment devices.	**Heavy Vehicle Propulsion Materials** Distribute peer/industry-reviewed Multi-Year Program Plan for the Propulsion Systems Materials Program.. Materials needs have been identified, assessed for design/ manufacture of components for high efficiency, low emission, high durability, high reliability heavy vehicle engines. Develop catalyst and catalyst support systems for exhaust aftertreatment to significantly reduce engine emissions. Study prototype thick thermal barrier coatings for pistons. Complete evaluation of test results. Complete initial development, laboratory testing of "smart materials" in fuel injection applications. Plan proposed follow-on development project.	**Heavy Vehicle Propulsion Materials** Select and prioritize, based on peer/industry-reviewed Multi-Year Program Plan, potential projects on materials and/or manufacturing processes for components of high efficiency, low emission, high reliability, durable heavy vehicle engines. Characterize, and subject to performance tests, materials previously selected for various engine component applications. Explore new approaches for producing thick thermal barrier coatings for thermal control within the engine. Investigate laser surface microtexturing to increase surface bonding and enhance performance of components in shear applications. Evaluate electrodeposition, thermal and plasma spray, cold spray, chemical vapor deposition and physical vapor deposition coating methods.

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Propulsion Materials Technology (Cont'd)	Continued the development and qualification of "smart" materials for fuel injection applications. Designed and tested prototypes for specific heavy vehicle engines. Characterized fuel injector holes machined with the Femto-second laser as to size, profile, reproducibility, and durability. Determined if this new technology could meet the stringent requirements of advanced diesel engines and improved candidate engine components materials characteristics. Continued exploratory efforts to develop new particulate filter materials and designs and new NOx catalyst materials, by utilizing computer simulation.	Expand assessment of the Femto-second laser technology for processing of component materials. Develop cermet materials for fuel systems and low-cost continuous sintering processes for cermets, ceramics, metallurgical and intermetallic compounds for engine components. Refine component durability evaluations and part-life prediction models. Validate code predictions of cost, performance parameters. Apply refined models to current R&D portfolio. Continue development of high reliability non-destructive evaluation technology for diesel engine components, advanced testing/characterization of new engine materials.	Downselect from among materials currently being developed for low emissions exhaust gas aftertreatment devices. Conduct detailed characterization and structure/performance optimization. Rig test "smart materials" on fuel injector actuators that have passed stringent laboratory tests. Apply Femto-second laser to automotive glasses and industrial ceramics, to modify the surface and possibly improve in-service material behavior and component performance. Conduct, with industry partners, development and testing of advanced materials including intermetallic compounds, cermets, ceramics, and titanium alloys. Develop cost-effective manufacturing processes of components for high efficiency, low emission engines.

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Propulsion Materials Technology (Cont'd)	Developed computer simulations to evaluate radically new and promising concepts for joining dissimilar materials for enhanced performance, increased manufacturing yield, and lower cost. Continued the development and standardization of high yield sintering of diesel engine components, durability evaluations and formulation of reliable part-life prediction models to achieve industry target costs and confidence levels. Evaluated the effects of exhaust gas recirculation (EGR) on engine component reliability and identified materials solutions. Developed new concepts for precision machining at competitive costs for fuel system components and other engine parts. Developed low-cost materials processing and components fabrication for class 1-2 truck engines, and higher temperature alloys for turbocharger	Evaluate new formulations of NOx catalysts, plasma assisted catalysts, and catalyst systems, in the presence of exhaust gas recirculation (EGR). Assess materials EGR-related degradation of engine components. Collaborate with ASTM, SAE to develop domestic, international testing standards for advanced materials for higher efficiency diesel engines. With NIST, continue similar cooperation with International Energy Agency. Incorporate new Aberration Corrected Electron Microscope (ACEM) at the HTML in examination/characterization of heavy vehicle-related materials and components. Investigate breakthrough in titanium production for feasibility of cost-effective titanium alloy development for engine components.	Apply life-prediction models to selected diesel engine components and verify performance. Use advanced high reliability non-destructive evaluations of diesel engine components and microstructural characterization of new engine materials to achieve material/component optimization. Continue assessment of the degradation of engine components by re-circulated exhaust gases (EGR) to determine abatement strategies. In conjunction with industry, continue to evaluate the performance of NOx catalysts, plasma assisted catalysts, and catalyst systems in the presence of EGR to achieve compliance with mandatory emission standards. Design and test prototype radiators constructed of very high conductivity carbon foams for down-sizing and possible relocation of heavy vehicle cooling systems.

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Propulsion Materials Technology (Cont'd)	compressors to operate in the EGR environment. Continued collaboration with consensus standards organization (ASTM, SAE) to develop materials and testing standards for advanced diesel engines.		Extend advanced, high precision machining by a movable electric spark device to include intractable intermetallic compounds, precipitation hardenable alloys, ceramics, and cermets. Continue collaboration with NIST, ASTM, and SAE in the development of domestic and international testing standards for advanced materials for high efficiency diesel engines. Assist the International Energy Agency in expanding the materials portfolio of the High Temperature Materials Annex from ceramic powders only, to include all light-weighting materials to achieve greater vehicular efficiency. Identify and develop new methods for joining dissimilar materials to be subjected to high stress, high velocity environments in air handling components of high efficiency, low emissions heavy duty engines.

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Propulsion Materials Technology (Cont'd)	Participants included: Caterpillar, Cummins, Detroit Diesel Corporation, ORNL, ANL, NIST, North Carolina A&T, Southern Illinois Univ. ($5,912)	Participants include: Caterpillar, Cummins, Detroit Diesel Corp., ORNL, NIST, ANL, Ford, North Carolina A&T, Southern Illinois University, TBD. ($5,896)	Participants include: Caterpillar, Cummins, Detroit Diesel Corp., Ford, ORNL, NIST, ANL, North Carolina A&T, Southern Illinois University, TBD. ($5,850)
	Provided critical technical and program management support services. (CSMI). ($20)	Provide critical technical and program management support services. (Sentech, Antares). ($95)	Program critical technical and program management support services. (Sentech, Antares). ($150)
Total, Propulsion Materials Technology	**$8,848**	**$8,962**	**$7,000**
Lightweight Materials Technology	**Automotive Lightweight Materials** General planning and coordination continued with the United States Automotive Materials Partnership (USAMP), the Automotive Composites Consortium (ACC), the government/industry Materials Technical Team, the Auto/Steel Partnership (A/SP) and Natural Resources of Canada (NRCan).	**Automotive Lightweight Materials** Continue planning and coordination with the USAMP, ACC, A/SP and NRCan and planning with the APC, VRP, and others on new efforts in plastics and recycling.	**Automotive Lightweight Materials** Conclude all residual efforts on aluminum, steel, and metal-matrix composites. Continue efforts on other areas at reduced levels.

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Lightweight Materials Technology (Cont'd)	Conclude the two roadmapping efforts on plastics and recycling, begun in FY 2000, and the planning of new efforts to implement the recommendations begun in conjunction with the American Plastics Council (APC), the Vehicle Recycling Partnership (VRP), and other interested organizations. Metals: Shifted emphasis from development of aluminum alloys and low-cost aluminum alloy sheet to fabrication of aluminum components. Conducted proof-of-concept efforts with aluminum suppliers on aluminum tailor-welded blanks (Reynolds), warm forming of aluminum sheet (Alcoa), binder control technology for stamping aluminum sheet (Alcoa) and hydroforming of aluminum extrusions (Alcoa). Began two new follow-on projects on warm forming of aluminum sheet and binder control technology for stamping aluminum sheet, with the USAMP. Continued follow-on to the hydroforming of aluminum extrusions project. Concluded a	Metals: Continue the warm forming and stamping binder projects on fabrication of components from aluminum sheet, and the aluminum extrusion hydroforming project. Conclude the project on extending the lives of steel dies used for casting aluminum components and the difficult-to-cast aluminum alloy, thus ending all program efforts on aluminum casting. Complete three of six metal-joining projects. These include one on non-destructive evaluation (NDE) of spot welds of aluminum, one on plasma-arc welding of aluminum and magnesium and one on NDE of laser-welded light metals. Continue projects on extending the lives of electrodes used for spot welding aluminum, the fundamentals of	Metals: Continue research on titanium, creep resistant magnesium for structural applications, and joining dissimilar metals.

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Lightweight Materials Technology (Cont'd)	project on optimizing the casting of aluminum automotive components; continued another on extending the lives of steel dies used for casting aluminum components. Began a small project on casting of an especially attractive but difficult-to-cast aluminum alloy. Increased emphasis on joining technologies for aluminum and steel, including tools for non-destructive evaluation. Began new efforts on advanced design and manufacturing of magnesium alloys and developing alloys with enhanced properties. One approach for producing raw magnesium from ore at lower cost than at present was terminated and another started. Continued cost-efficient, optimized secondary processing and lower cost finishing technologies for both cast and powder-metallurgy aluminum metal matrix composites. Conducted assessments of three new approaches for reducing the cost of titanium. Initiated new projects on high-strength, high-ductility steels.	joining dissimilar aluminum alloys to each other and to steels and joining advanced high-strength, high-ductility steels to each other. Continue a major project on optimizing casting of magnesium alloys into mainly cool-section (body and chassis) structural components, one on casting of more creep-resistant magnesium alloys into hot-section powertrain components, and one on lower cost production of raw magnesium. Test product of the new approaches for producing titanium to see if R&D work on parts fabrication is justified. Conclude five of the nine projects on advanced high-strength, high-ductility steels.	

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Lightweight Materials Technology (Cont'd)	Composites: The transition from the focus of the previous five years, on manufacturing automotive structures from glass-fiber-reinforced (GFR) polymer-matrix composites (PMCs), to carbon-fiber-reinforced (CFR) PMCs, was completed. Focal Project 2, which used a pickup truck bed as its focal component, ended as Ford and General Motors began selling composite truck beds utilizing some of the technologies developed. Initial Focal Project 3 (FP3) planning ended, and development of preforming and molding processes for the CFRPMC structures began. The FP3 focal component is a CFRPMC-intensive, hybrid-material "body-in-white (BIW)." An initial project on a less safety-critical, much simpler shaped component (a skid plate for a sport utility vehicle), by an alternative to the preforming and molding method investigated in FP3, was launched. The large, fundamental project on the durability of PMCs in the	Composites: Continue efforts on processing technologies critical for successfully conducting FP3, focusing on development of high-volume processes for manufacturing automotive body and chassis components. Detailed design of an entire hybrid material BIW, along with cost, weight, and performance analyses, is being completed. Continue the FP3 preforming, molding and composite-metal joining projects, and the CFRPMC durability, crashworthiness and SUV skid plate projects. Conclude the thermoplastic molding project. Complete two carbon-fiber precursor projects, while continuing two others. Continue the microwave decomposition project.	Composites: FP3 efforts will continue at FY 2002 levels, including those on molding and advanced joining. A final cost, weight, and performance analysis of the hybrid BIW will be completed. Post-down-select carbon fiber precursor projects will also continue.

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Lightweight Materials Technology (Cont'd)	automotive environment, and one on crashworthiness of PMC structures, completed their shifts of focus from GFR to CFR PMCs. In recognition that the FP3 BIW will use some metals, a project on joining of PMCs to metals such as steels and aluminum was started. Continue projects aimed at lowering the cost of carbon fiber to below the $5 per pound (from $8+ per pound at present) threshold for high-volume automotive applications. Two of the four FY 1999-2001 carbon-fiber precursor projects were down-selected for continuation, and the project on microwave decomposition of the precursors continued. Initial efforts on warm forming of thermoplastic composites also continued. Other: Continued an aluminum scrap sorting effort, the project on recycling CFRPMCs and the projects on lower weight automotive window glass. Further cost studies were performed.	Other: Continue process development work on carbon fiber recovery and recycling, including re-use testing and evaluation of recovered fibers. Complete technical evaluation and testing of	Other: Continue the carbon fiber recovery and recycling efforts. Begin some new projects in the areas of plastics and recycling, identified in the FY 2002 planning with the APC and the VRP.

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Lightweight Materials Technology (Cont'd)		aluminum sorting technologies and process options, and the effort on lower weight automotive window glass. A unique device for testing materials at strain rates typical of automotive crashes is being installed, tested and put into use in conjunction with projects included in the *Metals* and *Composites* activities.	
	Participants included: Ames Lab, ANL, LBNL, LLNL, ORNL, PNNL, SNL, numerous companies and universities. ($18,418)	Participants include: Ames Lab, ANL, LBNL, LLNL, ORNL, PNNL, SNL, numerous companies and universities. ($15,660)	Participants include: Ames Lab, ANL, LBNL, LLNL, ORNL, PNNL, SNL, numerous companies and universities. ($9,600)

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Lightweight Materials Technology (Cont'd)	**Heavy Vehicle High Strength Weight Reduction Materials** Combined innovative design with the use of strong, lightweight and lightweighting materials to reduce the weight of heavy trucks. Lightweighting of pickups, vans, and sport utility vehicles also will be required to significantly reduce fuel consumption and exhaust emissions. Materials such as aluminum, magnesium, metal-matrix composites, high strength-low alloy steels, carbon-based materials and polymers are likely candidates for the required applications. Continued the multi-year development efforts selected from the competitive solicitation of FY 2000. Tested the dies and platens for larger size aluminum and magnesium casting facility. Operated the facility for qualifying,	**Heavy Vehicle High Strength Weight Reduction Materials** Continue competitively selected multi-year cost-shared R&D on cost-effective materials improvement, substitution in lightweight truck systems, increased reliability and durability of components, and lower life cycle costs. Assess materials substitution opportunities for lightweighting non-engine components to increase heavy vehicle energy efficiency. Having exceeded the goal ratio of 150 volumes of natural gas storage per unit volume of a low pressure (500 psi) storage vessel, initiate planning for an engine/gas storage system demonstration to evaluate system characteristics and performance. Plan to achieve a ratio of at least 180 volume. Prepare samples of the carbon storage material for detailed	**Heavy Vehicle High Strength Weight Reduction Materials** Prepare a competitive solicitation for multi-year, cost-shared R&D in high performance, lightweighting materials for the overall truck system to increase reliability of components and reduce life-cycle costs. Implement, on a trial basis, the proposed generic approach to identify, qualify and utilize cost-effective material substitutions in heavy vehicle components and structures. Perform in-lab tests of a full scale engine/natural gas carbon based storage system to characterize and evaluate system parameters, characteristics and performance. Achieve at least 180V/V at pressures between 500-700 psi. Identify, through high resolution electron microscopy, relationships between the density of local storage

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Lightweight Materials Technology (Cont'd)	certification, and acceptance. Cast a prototypic large truck component in initial tests and characterized the component. Modified equipment as needed and planned succeeding production-like casting tests. Evaluated parts with trucking industry partners. Continued the development of cost-effective energy-efficient monolithic carbon-based gas storage materials with unique, fully-reversible fuel retrieval capability. Evaluated the potential for using greatly reduced storage pressures, 0-500 vs. 3,600 psig in the case of natural gas, at comparable energy storage densities. Continued the development of the required design, materials selection, and manufacturing process for advanced lightweight frames for pickups and sport utility vehicles that meet cost/weight targets. Planned tests for component performance evaluation. Continued to coordinate this and other lightweighting activities for trucks	characterization/analysis to study alternatives for optimizing storage capacity. Study applicability to other energetic gases, hydrogen in particular. Continue industry cost-shared projects designed to achieve a 30-40 percent reduction in the weight of an SUV frame, while cost-effectively satisfying all component performance requirements. Assess manufacturability, durability, life-cycle costs, corrosion and crash worthiness; compare to current frame technology. Coordinate lightweighting activities with Northwest Alliance for Transportation Technologies, National Transportation Research Center. Continue development of advanced processing technologies for materials applications in heavy vehicles. Initiate construction of full size prototype stainless steel bus frame with bus manufacturer, to validate 50 percent reduction in weight based	sites and precursor processing parameters, to optimize the stored and retrievable volume of natural gas. Evaluate cost feasibility of applying this technology to the storage of other energetic gases, emphasizing hydrogen. Experimentally verify predictions. Laboratory test prototypic lightweight (30-40 percent weight reduction) SUV frames to determine compliance with industry performance requirements. Prepare for on-road vehicle tests and performance evaluations. Refine analyses of manufacturability, durability, life-cycle costs, corrosion, and crash-worthiness behavior of the innovative structures. Continue coordination of vehicular lightweighting strategies and materials R&D with the Northwest Alliance for Transportation Technologies and the National Transportation Research Center. Characterize advanced processing technologies for heavy vehicle

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Lightweight Materials Technology (Cont'd)	with the Northwest Alliance for Transportation Technologies and the National Transportation Research Center. Continued the application of Equal Channel Angular Extrusion (ECAE) to copper and copper alloys for the production of spot-welding electrode tips of substantially longer component life and, potentially, lower cost than conventional materials. Tested the powder consolidation potential of ECAE on intermetallic compounds, lightweight alloys, and candidate high-permeability magnetic alloys to characterize the applicability of the process to otherwise intractable materials. Confirmed the technical approach to reduce by about one-half the weight of transit buses through a novel space frame design using stainless steel and/or aluminum. Such a weight reduction could permit use of smaller engines with about a 45 percent reduction in both fuel use and exhaust emissions.	on modeling efforts. Evaluate manufacturability, cost, and performance parameters. Integrate heavy vehicle brake material and brake system energy loss activities in conjunction with Vehicle Systems Optimization activity. Issue competitive solicitation on cost-effective, high performance carbon composite heavy vehicle components. Announce awards and initiate projects.	materials applications. Evaluate near-net-shape casting and forming of new, lower cost, lightweight titanium alloys for high performance parts. Complete construction of full size prototype stainless steel bus frame of novel design, to verify calculated 50 percent weight reduction and predicted compliance with all industry required performance parameters. Validate manufacturability and projected cost reduction in excess of 12 percent. Based on positive results of feasibility studies, formulate R&D effort to utilize new, lower cost titanium alloys in high performance, light-weight forged, rolled or stamped heavy vehicle components. Road test thin-wall light-weight iron and steel castings with higher fatigue resistance for motor mount brackets. Establish feasibility of utilization of the new technology to other structural components of heavy trucks.

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Lightweight Materials Technology (Cont'd)	Identified and developed new, cost-effective joining methods of high reliability and durability for similar and dissimilar lightweight materials.		Test and characterize rods of composition-modified magnesium-rare earth alloys formed by the Equal Channel Angular Extrusion process. Establish increase in plastic elongation (expected to be greater than 300 percent). Fabricate industry-designed prototype component for heavy vehicle performance tests, which has a potential 25 percent reduction in weight over comparable aluminum components.
	Participants included: American Trucking Associations, PACCAR, Freightliner, ALCOA, Cummins, Caterpillar, Detroit Diesel Corporation, ORNL, ANL, INEEL, PNNL, WVU, MIT, Tenn. Tooling and Engineering. ($8,663)	Participants include: American Trucking Associations, PACCAR, Freightliner, ALCOA, Cummins, Caterpillar, Detroit Diesel Corp., Ford, Daimler Chrysler, Autokinetics, General Motors, ANL, LANL, INEEL, PNNL, MIT, Tenn. Tooling and Engineering, ORNL, Delphi. ($9,720)	Participants include: American Trucking Associations, PACCAR, Freightliner, ALCOA, Cummins, Caterpillar, Detroit Diesel Corp., Ford, Daimler Chrysler, Autokinetics, General Motors, ANL, LANL, INEEL, PNNL, MIT, Tenn. Tooling and Engineering, ORNL. ($8,950)
	Provide critical technical and program management support services. (Antares, CSMI). ($117)	Provide critical technical and program management support services. (Antares, Sentech). ($351)	Provide critical technical and program management support services. (Antares, Sentech). ($250)

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
Total, Lightweight Materials Technology	**$27,198**	**$25,731**	**$18,800**
High Temperature Materials Laboratory	**High Temperature Materials Laboratory** Continued to maintain world class, state-of-the-art technical and scientific level diagnostic and characterization capabilities for advanced materials, by continuously developing advanced analytical techniques and periodically acquiring the most modern equipment to support development of new and improved materials for application in surface transportation vehicles. The HTML supports the material characterization requirements of DOE's Office of Energy Efficiency and Renewable Energy (EERE). Utilized the expertise and facilities of the HTML to characterize the	**High Temperature Materials Laboratory** Maintain world class, state-of-the-art technical, scientific level diagnostic/characterization capabilities for advanced materials. Develop advanced analytical techniques. Support the material characterization requirements of DOE's Office of Energy Efficiency and Renewable Energy (EERE). Determine, as needed, microstructural, compositional, crystallographic conditions of structural metals, alloys, ceramics, novel materials under development for truck applications both from within DOE, and from other stakeholders through HTML's user centers.	**High Temperature Materials Laboratory** Maintain world class, state-of-the-art characterization capabilities for advanced materials. Develop cutting-edge analytical techniques in support identifying innovative materials for use in surface transportation applications. Conduct projects involving microstructural, compositional, crystallographic conditions of metals, alloys, ceramics, and novel materials under development for vehicle applications, generated by both DOE and outside stakeholders, and which benefit from HTML's user centers.

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
High Temperature Materials Laboratory (Cont'd)	materials and fabrication methods selected in the component development programs of EERE. Specific to the Transportation Sector activities, examined and characterized exhaust gas catalysts to determine functional mechanisms, degradation phenomena, compositions of products, and level of impurities and contaminants. Determined, as needed, microstructural, compositional, and crystallographic conditions of structural metals, alloys, ceramics, and novel materials under development for truck applications both from within DOE, and from outside the DOE Transportation program through the HTML's user centers. Supported development, examination, and evaluation of new truck brake materials, characterization of minute exhaust particles from both diesel and spark ignition engines, and evaluation of new materials for reduction of	Develop protocols for obtaining, preparing prototypic nanosize samples for atomic-level characterization and analysis using the Aberration Corrected Electron Microscope (ACEM). Prepare test articles to scope application of ACEM to key materials issuer. Characterize fine exhaust particles from both spark ignition and diesel engines.	

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
High Temperature Materials Laboratory (Cont'd)	friction and wear phenomena in various truck engine and power train components.		
	Capital Equipment	**Capital Equipment**	**Capital Equipment**
	Introduced the new, high resolution Aberration Corrected Electron Microscope (ACEM) into routine service within the HTML. Tested the methodology developed for remote operation of an electron microscope in the DOE 2000 Materials Micro Characterization Collaboratory, using the new high resolution microscope. Used new equipment to obtain microstructural images and data on thin films of materials that were previously unobtainable. Continued, through the user centers and cooperative efforts with industry, to enhance the scientific database on an expanding range of materials and help prepare the next generation of U.S. technologists and scientists for the increasingly sophisticated techniques needed to	No activity.	No activity.

III. Performance Summary of Program Activities: MATERIALS TECHNOLOGIES

Program Activity	FY 2001	FY 2002	FY 2003
High Temperature Materials Laboratory (Cont'd)	develop cost-effective materials that meet more stringent performance demands, including enhanced engine energy efficiency, significantly reduced exhaust gas emissions, and substantially improved engine component durability and reliability.		
	Maintained support of 16 scientific staff for the user programs and to manage the sophisticated experimentation in support of the transportation developments described above. ($5,501)	Maintain support of 16 scientific staff for the user programs and managing the sophisticated experimentation in support of transportation developments. ($5,600)	Support 12 scientific staff for the user programs and managing the sophisticated experimentation in support of transportation developments. ($4,000)
Total, High Temperature Materials Laboratory	**$5,501**	**$5,600**	**$4,000**
TOTAL, MATERIALS TECHN-OLOGIES	**$41,547**	**$40,293**	**$29,800**

TRANSPORTATION TECHNOLOGIES
TRANSPORTATION SECTOR
(Dollars in Thousands)

TECHNOLOGY DEPLOYMENT

I. Mission Supporting Goals and Objectives

***Mission*:** Transportation Technologies deployment activities accelerate the adoption and use of alternative fuel and advanced technology vehicles to help meet national energy and environmental goals.

Summary: The Department's deployment efforts logically follow and complement successful technology development by industry and government. As identified in the National Energy Policy, consumer education and demonstration activities are critical to accelerating the use of energy technologies. For the period 2003-2007, the program will promote both alternative fuel vehicles (AFVs) and advanced technology (high fuel economy) vehicles. To help build consumer confidence in these technologies and encourage private sector investment in supporting infrastructure, the program will:

- forge new partnerships and nurture existing partnerships with fleet owners, fuel providers, vehicle manufacturers, and State and local governments;
- provide current, accurate, reliable information on all types of alternative fuels and vehicles;
- pursue rigorous, structured programs to test and evaluate cars and trucks that use alternative fuels and advanced technologies;
- implement the alternative fuel requirements of the Energy Policy Act;
- promote consumer acceptance of advanced technology cars and trucks with significantly improved fuel economy; and
- work with industry and universities to sponsor advanced vehicle competitions that push the technology envelope and expose numerous people, particularly future vehicle engineers, to these technologies.

These deployment activities will help ensure that advanced transportation technologies developed by government and industry will achieve sufficient market share to provide significant energy and environmental benefits.

Context: The Deployment subprogram supports the use of new transportation technologies that will enable dramatic changes necessary to deal with rising dependence on oil imports and the increasing impact of transportation on air quality. A transportation system that uses a more diverse

fuel supply, and less oil overall, will increase competition and provide greater resiliency in the face of external disruptions. The Administration's National Energy Policy (May 2001) describes the need for a Federal role to promote the use of alternative fuels: "...alternative fuels not only reduce dependence on petroleum transportation fuels. They reduce or entirely eliminate harmful emissions as well....The Federal Government has promoted development of alternative fuels for many years and this program has helped to reduce U.S. reliance on oil-based fuels." (Page 6-8) This approach is also endorsed by the President's Committee of Advisors on Science and Technology, in its November 1997 recommendations: "Government investment in R&D is crucial, but needs to be supplemented by standards, incentives, information, and education programs." (page 3-9).

While oil prices are above their low point of a few years ago, in real terms petroleum products are still inexpensive enough so that market conditions are not conducive to widespread use of, and investment in, alternative fuels and fuel-efficient vehicles. In addition, specific EPACT authorities are not adequate to address many of the technical and market barriers to increased use of these vehicles even though it would be in the national long-term interest. Until market and/or policy conditions change, Federal deployment programs will lay foundations for future use by focusing on proven niche markets where alternative fuel vehicles and advanced vehicles can successfully compete.

Significant, but modest, market progress has been made. Since 1992, the number of alternative fuel vehicle models available to buyers has grown from 2 to 20; the number of alternative-fuel-capable heavy-duty engine models available has risen from 1 to 30; the number of natural gas refueling stations has increased from 500 to 1,250; the number of alternative fuel vehicles on the road has risen from 250,000 to 450,000. More than 2,000 natural gas transit buses are ordered each year, representing over 40 percent of the market.

Despite this progress, significant market constraints have contributed to the slow adoption of alternative fuel and advanced technology vehicles including: uncertainty over Energy Policy Act regulations; lack of codes and standards; changing regulatory environment affecting conventional fuels, such as energy deregulation in the natural gas and electric utility markets. Other market barriers are also impeding the growth of these fuels and technologies, including: powers of incumbency by entrenched conventional fuel infrastructure; fragmented industry; lack of information and access to information; high transaction costs; and lack of capital to finance investments in infrastructure. The projected benefits of the Technology Deployment sub-program are shown in the table below:

GPRA:

	2005	2010	2020
Petroleum Displaced (Million Barrels per Day)	0.11	0.14	0.29
Total Primary Energy Displaced (Trillion Btu)	0	0	0
Energy Costs or Savings (Millions of $)	90	389	1,287
Carbon Equivalent Emissions Displaced (MMTCe)	1.7	2.1	3.6

Note: Program benefit projections are developed through an impact analysis process undertaken annually by EERE, based on assumptions for future energy markets derived from EIA's annual energy outlook. EERE's sectors analyze the impacts their programs will have on energy savings, energy cost savings, and carbon reductions if all program goals are met, and future energy markets develop as expected. A sample of program benefit estimates are externally reviewed by Arthur D. Little.

Management Strategy: Deployment activities are highly leveraged and conducted in close cooperation with stakeholders, including the auto and fuels industry, State and local governments, and energy and environmental organizations. Funding for projects is determined competitively in accordance with DOE and Federal acquisition regulations. Non-Federal cost-share is 50 percent minimum in most projects, and as much as 5:1 for grant activities and university partnerships.

Stakeholder input and on-going program evaluation are top priorities. Annually, DOE holds workshops in each DOE region, often followed by local workshops in selected communities. For example, an annual Clean Cities strategic planning session is held with key stakeholder groups and representatives. The Clean Cities annual conference showcases the year's successes and provides a venue for networking and vehicle sales. Clean Cities staff conducts an annual performance assessment of each participating Clean City. Reports assess the growth in alternative fuel vehicles and stations, major accomplishments, changes in market development strategies, and barriers to progress. Every five years, participating Clean Cities go through a renewal of their memorandum of understanding to update and validate local commitments. The Clean Cities program reports to Congress every two years.

Regulatory programs are conducted in accordance with DOE and Federal regulations, in close coordination with the Office of General Counsel and the Office of Policy. In addition to formal notice and comment rulemaking, DOE conducts numerous workshops and stakeholder sessions to improve communication and understanding among covered fleets. DOE analytical work in support of the regulatory program is conducted by DOE national laboratories with professional peer review; draft and final reports are often published in the Federal Register. These reports are often cited by industry, government agencies, and other researchers. DOE developed models are in use worldwide by industry and government analysts of alternative fuels and advanced technology vehicles.

The program is managed at DOE headquarters, however, the involvement of EERE regional office staff is critical to program success.

***Long Term Goals and Benefits*:** The Department's efforts to encourage the deployment of alternative fuel and advanced technology vehicles are linked with and support State and local government initiatives. The Federal investment, together with these complementary efforts, will result in significant changes in the transportation market over the next five years. By 2007, AFVs and advanced technology vehicles will have achieved significant commercial success as increasing awareness of the benefits of fuel diversity and fuel-efficient vehicles spurs demand. This subprogram also supports other activities for which GPRA benefit metrics are estimated. Successful program implementation will result in increased penetration of alternative fuel vehicles and advanced technology vehicles in selected niche markets, laying a foundation for mass market use of many advanced vehicles by 2010. Critical mid-term milestones include:

By 2007, the Clean Cities program will have helped 75 percent of the coalitions become self-sustaining facilitating a growth rate of at least 15 percent annually in alternative fuel vehicle use in Clean Cities.

By 2007, education and outreach programs will have responded to 300,000 phone calls; provided information through the Internet to more than 1 million users; and published tens of thousands of documents.

By 2007, student vehicle competitions will yield four hundred highly trained automotive engineers

By 2007, the test and evaluation program will have conducted performance and reliability testing of thirty additional near market-ready advanced technology vehicles, and provided this information to consumers, fleets, and industry through web-sites and reports.

By 2007, Federal agencies will have added at least 50,000 new alternative-fuel vehicles and improved fleet fuel economy, resulting in continued reduction in petroleum consumption by Federal fleets.

Program Strategic Performance Goals

ER1-17: Transportation Technology Assistance
The Clean Cities program will increase the number of alternative fuel vehicles in the Clean Cities from 110,000 in 2001, to 250,000 in 2007 and to 400,000 in 2010; helping to create successful niche markets that will yield nationwide 1,000,000 alternative fuel vehicles, consuming 1 billion gallons of alternative fuel in 2010.

Performance Indicator
The number of alternative fuel vehicles in Clean Cities is the indicator of performance for the technology assistance activity.

Annual Performance Results and Targets

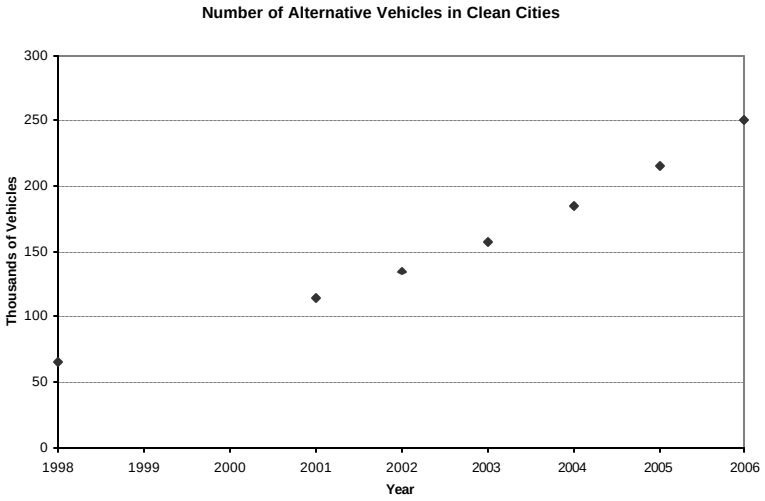
FY 2001 Results	FY 2002 Target	FY 2003 Proposed Target
Supported the annual acquisition of 10,000 alternative fuel vehicles in the Federal Fleet. (ER1-3)	Achieve 135,000 alternative fuel vehicles in operation in Clean Cities.	Achieve 157,000 alternative fuel vehicles in operation in Clean Cities.

Significant Accomplishments and Program Shifts

FY 2001

- Supported the annual acquisition on 10,000 alternative fuel vehicles in the Federal Fleet.
- Funded 54 projects in 25 States with $3.8 million, through the State Energy Program, leveraging over $20 million of non-Federal funds
- Developed data collection protocols and initiated testing program for light-duty hybrid electric vehicles and neighborhood electric vehicles.
- FutureTruck competition winner achieved 40 percent improvement in fuel economy for large SUV

FY 2002



The program target for FY 2003, which is an important milestone to achieving the overall goal, is projected to be achieved with funding at the FY 2003 level.

- Support the annual acquisition on 12,000 alternative fuel vehicles in the Federal Fleet.
- Fund 40-55 Clean Cities projects at $4.5 million through the State Energy Program
- Complete baseline performance testing of two light duty hybrid-electric vehicles and eight neighborhood electric vehicles.
- Initiate testing of one additional urban electric vehicle and one hybrid electric transit bus.
- Conduct 3rd year FutureTruck competition with new automotive partner

FY 2003

- Focus consumer education efforts for advanced technology vehicles in support of the National Energy Policy
- Strengthen the Clean Cities program emphasis on niche markets
- Fund 35-45 Clean Cities projects at $3.5 million through the State Energy Program
- Reform alternative fuel regulatory programs consistent with the National Energy Policy
- Expand testing of hybrid vehicles and complete baseline performance testing of two urban electric vehicles

II. A. Funding Table: TECHNOLOGY DEPLOYMENT

Program Activity	FY 2001 Enacted (a)	FY 2002 Enacted	FY 2003 Request	$ Change	% Change
Clean Cities	$9,768	$11,560	$9,000	$-2,560	-22.15%
Testing and Evaluation	$2,887	$1,800	$3,000	+1,200	66.67%
EPACT Replacement Fuels Program	$1,281	$1,000	$2,000	+1,000	100%
Advanced Vehicle Competitions	$840	$800	$1,000	$200	25%
Total, Technology Deployment	$14,776	$15,160	$15,000	$-160	-1.06%

(a) FY 2001 reduced by $241,000 for SBIR/STTR

II. B. Laboratory and Facility Funding Table: TECHNOLOGY DEPLOYMENT

	FY 2001 Enacted	FY 2002 Enacted	FY 2003 Request	$ Change	% Change
Argonne National Lab	$1,070	$975	$975	$0	0.0%
Idaho National Engineering & Environmental Lab	$900	$450	$500	$50	11.1%
National Renewable Energy Lab	$4,100	$3,850	$3,850	$0	0.0%
Oak Ridge National Lab	$800	$950	$950	$0	0.0%
All Other	$7,906	$8,935	$8,725	$-210	-2.4%
Total, Technology Deployment	$14,776	$15,160	$15,000	$-160	-1.1%

III. Performance Summary of Program Activities: TECHNOLOGY DEPLOYMENT

Program Activity	FY 2001	FY 2002	FY 2003
Clean Cities	**Core Program** Strengthened efforts to deploy additional alternative fuel vehicles and expand alternative fuel refueling stations through industry and other partnerships, with a concentration on niche markets such as taxis, airport shuttles, transit buses, school buses, delivery fleets, and welfare-to-work shuttles. Promoted 100 percent AFV use in specific niche markets in more than ten additional cities, including ten airport related projects. Offered simple, direct rebates to stimulate activity in Clean Cities niche market programs. Developed performance metrics for coalitions and strategies for strengthening lower performing coalitions. (NREL, Other)	**Core Program** In support of EPACT Section 505, continue to focus alternative fuel efforts in selected niche markets, with particular attention on medium and heavy-duty vehicles. Discontinue rebate activity. Help local coalitions identify non-Federal sources of support to create self-sustaining local programs. Facilitate, through DOE regional offices, local coalition market development, training, and grants management. Continue use of technical assistance teams to help address technical niche market issues raised by local Clean Cities coalitions. (NREL, Other)	**Core Program** In support of Energy Policy Act of 1992 (EPACT) Section 505, continue to focus alternative fuel efforts in selected niche markets, and strengthen focus on medium and heavy-duty vehicles. Help local coalitions identify non-Federal sources of support to create self-sustaining local programs. Facilitate, through DOE regional offices, local coalition market development, training, and grants management. Continue limited use of technical assistance teams to help address technical niche market issues raised by local Clean Cities coalitions. (NREL, Other)
	Tools and Training Promoted use of alternative fuel and fuel efficient advanced technology vehicles through Clean Cities networks. Updated tools with latest technical information. Integrated	**Tools and Training** In support of EPACT Section 505, continue efforts to provide targeted niche market assistance and training to a limited number of coalitions. Continue support for the Alternative	**Tools and Training** In support of EPACT Section 505, continue efforts to provide targeted niche market assistance and training to a limited number of coalitions. Continue support for

III. Performance Summary of Program Activities: TECHNOLOGY DEPLOYMENT (Cont'd)

Program Activity	FY 2001	FY 2002	FY 2003
Clean Cities (Cont'd)	advanced technology (fuel efficient) vehicles into publications and web-sites. Expanded access to tools through workshops, print media, and the Internet. Ensured local coordinators have tools to build effective coalitions. (NREL)	Fuels Data Center, hotline, and other information dissemination activities. Provide training to coalitions to enable development of stronger organizational coalitions. (NREL)	the Alternative Fuels Data Center, hotline, and other information dissemination activities. Provide training to coalitions to enable development of stronger organizational coalitions. (NREL)
	Competitive Grants Issued State grants and other public/private partnership grants to competitively fund projects that support infrastructure development and vehicle use in niche markets. Provided grants of $3.8 million for 54 Special Project State Energy Grants. Of that, $0.20 million was for Energy Smart School bus projects. (States)	**Competitive Grants** In support of EPACT Sections 302 and 409, issue State grants and other public/private partnership grants to competitively fund projects that support infrastructure development and vehicle use in niche markets. Provide $4.5 million for 40-55 Special Project State Energy Grants. Of that, at least $0.50 million will be for Energy Smart School bus projects. (States)	**Competitive Grants** In support of EPACT Sections 302 and 409, issue State grants and other public/private partnership grants to competitively fund projects that support infrastructure development, vehicle use in niche markets, and technology demonstration. Provide $3.5 million for 35-45 Special Project State Energy Grants. Of that, about $0.50 million will be for Energy Smart School bus projects. (States)
	Education and Outreach Provided technical information on near-term advanced technologies, including fuel cells. Sponsored 7th annual Clean Cities conference to	**Education and Outreach** In support of EPACT Section 405, sponsor 8th Annual Clean Cities Conference to showcase commercially available AFVs and	**Education and Outreach** In support of the National Energy Policy recommendation to expand consumer education and EPACT Section 405, sponsor 9th Annual

III. Performance Summary of Program Activities: TECHNOLOGY DEPLOYMENT (Cont'd)

Program Activity	FY 2001	FY 2002	FY 2003
Clean Cities (Cont'd)	showcase commercially available AFVs and advanced technology vehicles. Expanded use of improved Fuel Economy Guide and web-site www.fueleconomy.gov. Initiated efforts to build a stronger alliance with industry and other groups to promote fuel efficient advanced technology vehicles. (ANL, NREL, ORNL, GPO)	advanced technology vehicles. Publish case studies of successful alternative fuel niche market applications. Update and expand the improved Fuel Economy Guide and web-site www.fueleconomy.gov. Continue building alliances to promote fuel efficient advanced technology vehicles. Promote the use of fuel saving anti-idling devices for heavy truck fleets. (ANL, NREL, ORNL, GPO)	Clean Cities Conference to showcase commercially available AFVs and advanced technology vehicles. Publish case studies of successful alternative fuel niche market applications. Update and expand the Fuel Economy Guide and web-site www.fueleconomy.gov. Continue building alliances to promote fuel efficient advanced technology vehicles. (ANL, NREL, ORNL, GPO
	International Coordination: Conducted reverse trade missions with selected international partners to showcase U.S. alternative fuel successes. Responded to international requests for information on Clean Cities and invited international partners to the Clean Cities Conference. (NREL, Other)	International Coordination: Continue one reverse trade mission to showcase U.S. alternative fuel successes. Facilitate training program on natural gas vehicles in India, consistent with National Energy Policy. (NREL, Other)	International Coordination: Continue to showcase U.S. alternative fuel successes. (NREL, Other)
	Provided critical technical and program management support services. (QSS) ($390)	Provide critical technical and program management support services. (QSS) ($400)	Provide critical technical and program management support services. (QSS) ($390)

III. Performance Summary of Program Activities: TECHNOLOGY DEPLOYMENT (Cont'd)

Program Activity	FY 2001	FY 2002	FY 2003
Total, Clean Cities	**$9,768**	**$11,560**	**$9,000**
Testing and Evaluation	**Vehicle Evaluation** Conducted testing and evaluation of selected first generation light-duty hybrid-electric vehicles. Completed development of hybrid-electric transit bus testing and evaluation procedures. Worked in partnership with industry to identify critical performance attributes and help medium and heavy-duty vehicle manufacturers design new advanced technology models to address customer requirements. (INEEL, NREL, ANL, FTA)	**Vehicle Evaluation** In support of EPACT sections 502, and 601, conduct baseline performance testing and accelerated reliability testing of selected light-duty hybrid-electric vehicle models. Conduct baseline performance testing of one additional urban electric vehicle. Complete baseline performance testing of eight neighborhood electric vehicles. Discontinue development of hybrid-electric medium and heavy-duty vehicle testing procedures. Complete collecting data from advanced technology transit bus demonstration project. (INEEL, NREL, ANL, FTA, APTA)	**Vehicle Evaluation** In support of EPACT sections 502, and 601,conduct baseline performance testing and accelerated reliability testing of selected light-duty hybrid-electric vehicle models. Complete fleet demonstration/reliability testing of two urban electric vehicles. Initiate testing of additional urban electric vehicles and at least four neighborhood electric vehicles. Complete evaluation of data from advanced technology transit bus demonstration projects and issue final reports. Initiate procedures development for and testing of one medium duty hybrid electric delivery truck. Conduct testing and evaluation of idling reduction technologies to support public information activities. (INEEL, NREL, ANL, FTA, APTA)

III. Performance Summary of Program Activities: TECHNOLOGY DEPLOYMENT (Cont'd)

Program Activity	FY 2001	FY 2002	FY 2003
Testing and Evaluation (Cont'd)	**Federal Fleets** Strengthened the joint DOE/GSA AFV USER program to promote development of alternative fuel refueling infrastructure. Facilitated evaluation and use of advanced technology vehicles by Federal agencies. Helped Federal agencies acquire 10,000 AFVs and use more alternative fuel, as required by Executive Order 13149. (INEEL, NREL, GSA, DOI)	**Federal Fleets** In support of EPACT Sections 303 and 502, assist Federal agencies in acquiring 12,000 AFVs and increase the amount of alternative fuel consumed by Federal alternative fuel vehicles. (INEEL, NREL, GSA, DOI)	**Federal Fleets** In support of EPACT Sections 303 and 502, assist Federal agencies in acquiring 15,000 AFVs and increase the amount of alternative fuel consumed by Federal alternative fuel vehicles. Expand the joint DOE/GSA AFV USER program to further increase availability of re-fueling infrastructure for Federal vehicles. (INEEL, NREL, GSA, DOI)
	Infrastructure Testing Worked with industry partners to identify key infrastructure projects that address technical barriers to expanded use of natural gas, propane, ethanol, and electricity. Initiated interagency effort to work with fuel industry to address deficiencies in tracking sales of alternative fuels. (EPACT Section 502) (INEEL, Other)	**Infrastructure Testing** In support of EPACT Sections 303 and 502, continue leading interagency effort to assist industry in developing procedures for accurately tracking sales of alternative fuels. (INEEL, Other)	**Infrastructure Testing** In support of EPACT Sections 303 and 502, continue leading interagency effort to assist industry in developing procedures for accurately tracking sales of alternative fuels. (INEEL, Other)
Total, Testing and Evaluation	**$2,887**	**$1,800**	**$3,000**

III. Performance Summary of Program Activities: TECHNOLOGY DEPLOYMENT (Cont'd)

Program Activity	FY 2001	FY 2002	FY 2003
EPACT Replacement Fuels Program	**Analysis and Modeling** Updated models with results from regulatory data collection. Incorporated changes due to EPA fuel quality regulations. Expanded modeling of hybrid vehicles. Integrated medium and heavy duty vehicles into alternative fuel models. (ANL, ORNL)	**Analysis and Modeling** In support of EPACT Sections 502, 504, and 506, use updated models to develop improved estimates for penetration of alternative fuels into medium and heavy-duty markets. (ANL, ORNL)	**Analysis and Modeling** In support of Energy Policy Act of 1992 (EPACT) Sections 502, 504, and 506, use updated models to develop improved estimates for penetration of alternative fuels into medium and heavy-duty markets. (ANL, ORNL)
	Regulatory Support Expanded efforts to improve compliance of EPACT State and fuel provider fleet programs, and supported implementation through voluntary and credit based approaches. Improvements to regulatory fleet programs included expanded database development, improved processing of exemption requests, and expanded outreach to covered fleets. Reviewed and processed petitions to designate new alternative fuels under EPACT. Initiated evaluation of the EPACT replacement fuel goals. (NREL,	**Regulatory Support** In support of EPACT Sections 501, 502, 504, 506, 507, 508, and 509, continue EPACT compliance efforts for State and fuel provider fleet programs. Review and process petitions to designate new alternative fuels under EPACT. Complete evaluation of EPACT replacement fuel goals and submit for stakeholder and Congressional review. (NREL, ANL, ORNL)	**Regulatory Support** In support of EPACT Sections 501, 502, 504, 506, 507, 508, and 509, continue EPACT compliance efforts for State and fuel provider fleet programs. Implement program improvements to EPACT fleet programs. Increase automated compliance efforts. Initiate voluntary alternative fuel use promotion to State fleets and increase outreach to fuel provider fleets. Complete alternative fuel petition process improvements. Review and process petitions to designate new alternative fuels

III. Performance Summary of Program Activities: TECHNOLOGY DEPLOYMENT (Cont'd)

Program Activity	FY 2001	FY 2002	FY 2003
EPACT Replacement Fuels Program (Cont'd)	ANL, ORNL) Provided critical technical and program management support services (QSS) ($141)	Provide critical technical and program management support services (QSS) ($100)	under EPACT. (NREL, ANL, ORNL) Provide critical technical and program management support services (QSS) ($100)
Total, EPACT Replacement Fuels Program	**$1,281**	**$1,000**	**$2,000**
Advanced Vehicle Competitions	**Advanced Vehicle Competitions** Supported Future Truck student participants using advanced power plants, alternative and reformulated fuels, and advanced lightweight and propulsion materials technologies in competition vehicles to improve fuel economy and reduce emissions. Fuels and vehicle industry partners, suppliers, and professional societies, as well as State and other Federal agencies provided matching funds. Participants included: ASEE, ANL, GM.	**Advanced Vehicle Competitions** Conduct third year of Future Truck Challenge with a new automotive partner. (ASEE, ANL, Ford).	**Advanced Vehicle Competitions** Conduct fourth year of Future Truck Challenge, increasing use of fuel cell propulsion systems in student designed vehicles. Initiate planning for new vehicle competition. (ASEE, ANL, Ford).

III. Performance Summary of Program Activities: TECHNOLOGY DEPLOYMENT (Cont'd)

Program Activity	FY 2001	FY 2002	FY 2003
Total, Advanced Vehicle Competitions	**$840**	**$800**	**$1,000**
TOTAL, TECHNOLOGY DEPLOYMENT	**$14,776**	**$15,160**	**$15,000**

TRANSPORTATION TECHNOLOGIES
TRANSPORTATION SECTOR
(Dollars in Thousands)

COOPERATIVE PROGRAMS WITH STATES

I. Mission Supporting Goals and Objectives

Mission: The Cooperative Programs with States pursues collaborative applied research, development, and demonstration (RD&D) that accelerate the use of clean energy technologies. Collaborating with states can provide opportunities to leverage funding for RD&D that might not otherwise receive adequate support at either the Federal or the State level.

Summary: In the transportation sector, the Office of Energy Efficiency and Renewable Energy and the States will pursue the work in the following areas: fuel cell vehicles and their associated refueling infrastructure, alternative fuel vehicles and their associated refueling infrastructure and advanced, highly fuel-efficient internal combustion vehicles. Other areas of collaboration with states include materials, motors, controllers and sensors that can improve vehicle component performance and reduce costs.

Management Strategy: DOE pursues this mission by entering into cooperative agreements with State energy offices, organizations that represent State energy offices, state energy research entities, and organizations that represent state energy research entities. These organizations are encourages to enter teaming arrangements with industry, DOE national laboratories, institutions of higher education, non-profit organizations, and Native American organizations.

II. A. Funding Table: COOPERATIVE PROGRAMS WITH STATES

Program Activity	FY 2001 Enacted (a)	FY 2002 Enacted	FY 2003 Request	$ Change	% Change
Cooperative Program with States	$ 1,964	$ 2,000	$ 0	$ -2,000	-100.0%
Total, Cooperative Program with States	$1,964	$ 2,000	$ 0	$ -2,000	-100.0%

a/Reflects transfer of $32,000 to SBIR/STTR program

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

	FY 2001 Enacted	FY 2001 Enacted	FY 2003 Request	$ Change	% Change
All Other	$ 1,964	$ 2,000	$ 0	$ -2,000	-100.0%
Total, Cooperative Program with States	$ 1,964	$ 2,000	$ 0	$ -2,000	-100.0%

III. Performance Summary: COOPERATIVE PROGRAMS WITH STATES

Program Activity	FY 2001	FY 2002	FY 2003
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 be fuel cell vehicles and refueling infrastructure; alternative fuel vehicles and refueling infrastructure; and advanced highly fuel efficient vehicles. Other areas for collaboration with the states could include materials, motors, controllers, sensors, etc. Existing state fleets would provide an excellent test bed for vehicles with PEM fuel cell, alternative fuel, or advanced fuel efficient propulsion units. Similarly, establishing refueling infrastructure at centralized fleet sites also would provide excellent test beds. Projects will be designed to provide important feedback to manufacturers, researchers, and operators as the technology matures. ($1,964)	Funding will be awarded through the Golden Field Office and applied to ongoing research, development, and demonstration projects that are crosscutting in nature. Such projects will impact States and will be conducted is concert with the transportation, buildings, and industry sectors. This program will support research, development, and demonstration activities that explore and exploit synergies among these varying research fields. ($2,000)	No Activities. ($0)
TOTAL, COOPERATIVE PROGRAMS WITH STATES	**$1,964**	**$2,000**	**$0**

TRANSPORTATION TECHNOLOGIES
TRANSPORTATION SECTOR
(Dollars in Thousands)

ENERGY EFFICIENCY SCIENCE INITIATIVE

I. Mission Supporting Goals and Objectives

Mission: The Energy Efficiency Science Initiative (EESI) seeks to identify and fund "bridging" research and development (R&D) that falls between fundamental exploratory science and pre-commercial applied R&D.

Summary: By stimulating R&D that maximizes synergies among different research fields, technologies, investigator communities, and end-use applications, this initiative expands EERE's R&D activities among energy efficiency technologies. It also cuts across traditional energy end-use sectors by emphasizing distributed power generation applications for industrial and buildings systems, transportation, and stationary power.

Context: This initiative expands on existing cooperative efforts with the Office of Fossil Energy in areas such as natural gas-fueled turbine and fuel cell technologies, combined heat, power and cooling applications, hydrogen production, and carbon emission sequestration. This effort also involves coordination with the Office of Science in pursuing follow-on research in areas critical to energy efficiency and clean energy development, such as basic biosciences, plant genetics, photo emission, heat transfer, new materials, catalysts, and computational science. The awards are generally small, and universities, small businesses, national labs (not as the lead), and industry (as appropriate) are all eligible to participate in this initiative.

Management Strategy: In FY 2002, this program completed its third year. Projects funded to date have been performed in collaboration with academia in partnership with the National Laboratories, as well as with the Office of Fossil Energy through the National Energy Technology Laboratory (NETL). Due to the need to accommodate higher priority activities, no additional funds will be requested in FY2003.

II. A. Funding Table: ENERGY EFFICIENCY SCIENCE INITIATIVE

Program Activity	FY 2001 Enacted (a)	FY 2002 Enacted (b)	FY 2003 Request	$ Change	% Change
Energy Efficiency Science Initiative	$ 3,828	$ 4,000	$ 0	$ -4,000	-100.0%
Total, Energy Efficiency Science Initiative	$ 3,828	$ 4,000	$ 0	$ -4,000	-100.0%

a/Reflects a transfer of $63,000 to SBIR/STTR program
b/Does not reflect FY 2002 Interior and Related Agencies Appropriation (P.L. 107-63) language directing that 50 percent of Energy Efficiency Science Initiative funds for FY 2002 ($2,000,000) and beyond shall be made available to the DOE Fossil Energy Research and Development account.

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

	FY 2001 Appropriation	FY 2002 Request	FY 2003 Request	$ Change	% Change
All Other	$ 3,828	$ 4,000	$ 0	$ -4,000	-100.0%
Total, Energy Efficiency Science Initiative	$ 3,828	$ 4,000	$ 0	$ -4,000	-100.0%

III. Performance Summary: ENERGY EFFICIENCY SCIENCE INITIATIVE

Program Activity	FY 2001	FY 2002	FY 2003
Energy Efficiency Science Initiative	**Energy Efficiency Science Initiative** As part of the continuing initiative to support R&D to bridge the gap between fundamental exploratory science and pre-commercial applied R&D, EERE conducted a follow-on strategic visioning workshop (e-vision 2001). This workshop built on the tremendous technology possibilities identified during e-vision 2000, and will broaden the understanding of the proposed options for the Nation's energy future. In succeeding years, it is expected that the e-vision workshops will be conducted biennially. Up to 5 research projects were awarded as a follow-on to recommendations from e-vision 2000. Additionally, funded approximately 10 to 20 cooperative agreements with research and development teams, which are being led by universities and include industrial, national laboratory and other partners. The cooperative agreements focus on industrial sector fundamental strategic R&D, as contained in the visions and roadmaps for the nine Industries of the	**Energy Efficiency Science Initiative** In collaboration with the DOE Office of Fossil Energy, a single award solicitation will be issued to address technology gaps between exploratory science and pre-commercial applied R&D. ($4,000)	**Energy Efficiency Science Initiative** No Activities ($0)

Program Activity	FY 2001	FY 2002	FY 2003
	Future. ($3,828)		
TOTAL, ENERGY EFFICIENCY SCIENCE INITIATIVE	**$3,828**	**$4,000**	**$0**

TRANSPORTATION TECHNOLOGIES
TRANSPORTATION SECTOR
(Dollars in Thousands)

MANAGEMENT AND PLANNING

I. Mission Supporting Goals and Objectives

Mission: To provide the skilled workforce and quality analysis/assessment needed to manage and support a national program to reduce transportation oil use and greenhouse gases.

Summary: Effective management requires efficient organizational design, adequate human resources, sufficient and high quality information and excellent communication both within the organization and with outside parties. Moreover, understanding the potential for increasing the penetration of energy-efficient and clean energy technologies in the transportation sector and for achieving the correct program balance, requires a solid analytical foundation. The Management and Planning function provides this foundation by carrying out the evaluation, planning, analysis and program direction functions necessary to effectively guide and support all transportation technology programs.

Management Strategy: Management and Planning provides fully integrated program direction to plan, manage, and oversee the research, development, and technology deployment efforts within the transportation program. Management and Planning also provides the information, guidance, and direction necessary for the staff to implement the National Academy of Public Administration (NAPA) Implementation Plan, the EERE Strategic Management System, and EERE Strategic Plan.

The Management and Planning function includes Analysis, Technology Assessment, and Program Direction. The analysis function is accomplished by collecting and analyzing technology and market data, using computer models to estimate the impact of fuel economy gains on energy use, oil use, and carbon emissions. The analysis function also produces the annual *Transportation Energy Data Book*, which is used by program managers and by individuals in many federal and state agencies as a desk-top reference for statistics and information that characterize transportation activity, and which provide data on other factors that influence transportation energy use.

The technology assessment activity measures impacts, benefits, and costs of advanced transportation vehicle and fuel technologies. A system of models has been created that: (1) estimates the market shares of new sales of light duty vehicles that have alternative fuel and advanced vehicle technologies; and (2) calculates the alternative fuel use, petroleum use reductions and changes in criteria pollutant and greenhouse gas emissions.

These models are continually improved and updated to account for new technology developments and to be consistent with projections prepared by the Energy Information Administration. The models are also used to estimate the benefits and likely consequences of individual technology programs during budget formulation and program planning activities accomplished by the Transportation Sector staff.

Program Direction includes R&D feasibility studies; R&D option development and trade off analyses; technical, economic and market evaluations of R&D; and management of Transportation Sector subprograms and activities; and contract audit costs. These activities provide important benefits directly to the R&D programs.

II. A. Funding Table: MANAGEMENT AND PLANNING

Program Activity	FY 2001 Enacted	FY 2002 Enacted	FY 2003 Request	$ Change	% Change
Technology Assessment and Analysis	$1,700	$1,700	$2,000	$300	17.65%
Program Direction	$7,452	$8,532	$8,101	$-431	-5.05%
Total, Management and Planning	$9,152	$10,232	$10,101	$-131	-1.28%

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

	FY 2001 Enacted	FY 2002 Enacted	FY 2003 Request	$ Change	% Change
Argonne National Lab	$940	$940	$1,000	$60	6.4%
National Renewable Energy Lab	$250	$250	$250	$0	0.0%
Oak Ridge National Lab	$460	$460	$500	$40	8.7%
All Other	$7,502	$8,582	$8,351	$-231	-2.7%
Total, Management and Planning	$9,152	$10,232	$10,101	$-131	-1.3%

III. Performance Summary: MANAGEMENT AND PLANNING

Program Activity	FY 2001	FY 2002	FY 2003
Technology Assessment and Analysis	**Technology Assessment and Analysis** Expanded the quality metrics methodology to deal in greater detail with the deployment of advanced technologies in niche markets and out to the year 2030. Improved the methodology for estimating oil savings, energy reductions, greenhouse gas reductions, employment changes, Gross Domestic Product changes, and criteria emission impacts resulting from the introduction of advanced vehicle and fuel technologies into the market place. Published and distributed Edition 21 of the *Transportation Energy Data Book*, including information on advanced vehicle sales and prices. Expanded the effort to estimate the costs of advanced vehicle technologies such as hybrid vehicles, fuel cell vehicles and electric vehicles. (ANL, ORNL, NREL) ($1,650) Provide critical technical support services. (Antares) ($50)	**Technology Assessment and Analysis** Expand the quality metrics methodology to deal in greater detail with the deployment of advanced technologies in fleet applications to the year 2030. Publish and distribute Edition 22 of the *Transportation Energy Data Book*, and include information on hybrid vehicle sales and prices. (ANL, ORNL, NREL) ($1,650) Provide critical technical support services. (Antares) ($50)	**Technology Assessment and Analysis** Improve the quality metrics methodology to deal in greater detail with the deployment of advanced technologies in fleet applications to the year 2030. Publish and distribute Edition 23 of the Transportation Energy Data Book and include information on hybrid vehicle sales and prices. Develop the analytic capability to estimate the best pathways to making the U.S. transportation sector sustainable with respect to domestic fuels used and greenhouse gases emitted. (ANL, ORNL, NREL) ($1,950) Provide critical technical support services. (TBD) ($50)

Program Activity	FY 2001	FY 2002	FY 2003
Total, Technology Assessment and Analysis	**$1,700**	**$1,700**	**$2,000**
Program Direction	The following is a breakdown of the funding by Object Class: 11.9 Personnel compensation $ 5,532 12.1 Civilian personnel benefits $ 1,385 21.0 Travel and transportation of persons $ 510 25.0 Other contractual services $ 25 Provided funds for salaries, benefits, and travel (including normal increases in both salaries and benefits) to support usage of 67 FTEs needed to conduct and monitor research, development, and other activities associated with various transportation technologies, at Headquarters (66) and in the field (1) (Budgeted Headquarters 62, field 1 and total 63). Total obligational authority of $7,460,000 for Program Direction includes $1,158,000 from FY 2000 unobligated carryover funds in Program Direction.	The following is a breakdown of the funding by Object Class: 11.9 Personnel compensation $ 5,754 12.1 Civilian personnel benefits $ 1,440 21.0 Travel and transportation of persons $ 530 25.0 Other contractual services $ 808 The request provides funds for salaries, benefits, and travel (including normal increases in both salaries and benefits) to support 63 FTEs needed to conduct and monitor research, development, and other activities associated with various transportation technologies, at Headquarters (62) and in the field (1). ($7,724)	The following is a breakdown of the funding by Object Class: 11.9 Personnel compensation $ 5,196 12.1 Civilian personnel benefits $ 1,295 21.0 Travel and transportation of persons $ 510 25.0 Other contractual services $ 1,100 The request provides funds for salaries, benefits, and travel (including normal increases in both salaries and benefits) to support 62 FTEs needed to conduct and monitor research, development, and other activities associated with various transportation technologies, at Headquarters (61) and in the field (1). This is a reduction of 1 FTE. ($7,001)

Program Activity	FY 2001	FY 2002	FY 2003
Program Direction (Cont'd)	Also supported a systematic analysis of critical staffing needs within the context of current and projected R&D program missions, and developed a comprehensive plan focusing on building and sustaining a talented and diverse workforce of R&D Technical Managers. ($6,302)		
Management Support Services	TRANSFER FROM: Vehicle Technologies R&D, Fuels Utilization R&D, Materials Technologies, Technology Deployment, and Management and Planning		
	Includes activities such as improving effectiveness, efficiency, and general administrative services. These activities are critical to the planning, formulation, and execution of the Energy Conservation programs. ($1,150)	Includes activities such as improving effectiveness, efficiency, and general administrative services. These activities are critical to the planning, formulation, and execution of the Energy Conservation programs. ($808)	Includes activities such as improving effectiveness, efficiency, and general administrative services. These activities are critical to the planning, formulation, and execution of the Energy Conservation programs. ($1,100)
Total, Program Direction	**$7,452**	**$8,532**	**$8,101**
TOTAL, MANAGE-MENT AND PLANNING	**$9,152**	**$10,232**	**$10,101**