Vehicle Technologies
Funding Profile by Subprogram

(dollars in thousands)

	FY 2008 Current Appropriation[a]	FY 2009 Original Appropriation	FY 2009 Additional Appropriation	FY 2010 Request
Vehicle Technologies				
Hybrid Electric Systems	92,079	125,709	–	164,661
Advanced Combustion Engine R&D	43,443	40,800	–	57,600
Materials Technology	38,616	39,903	–	54,905
Fuels Technology	17,376	20,122	–	25,122
Technology Integration	16,845	46,704	–	31,014
Advanced Battery Manufacturing	–	–	2,000,000	–
Transportation Electrification	–	–	400,000	–
Alternative Fueled Vehicles	–	–	300,000	–
Total, Vehicle Technologies	208,359	273,238[b]	2,700,000	333,302[c]

Public Law Authorizations:

P.L. 95-91, "U.S. Department of Energy Organization Act" (1977)
P.L. 102-486, "Energy Policy Act" (1992)
P.L. 109-58, "Energy Policy Act of 2005" (2005)
P.L. 110-140, "Energy Independence and Security Act of 2007" (2007)

Mission

The mission of the Vehicle Technologies (VT) program is to develop more energy-efficient and environmentally friendly highway transportation technologies (for both cars and trucks) that will meet or exceed drivers' performance expectations and environmental requirements and that will enable America to use significantly less petroleum and reduce greenhouse gas (GHG) emissions.

Modifications were made to the budget structure of two subprograms to better reflect the Vehicle Technology program's activities in FY 2010.

Benefits

The VT program mission and activities contribute directly to the DOE and Secretarial goals of improving national energy and economic security by addressing the President's call for reducing dependence on oil imports by about 3.5 million barrels per day within 10 years and modernizing conservation technologies and practices.

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[a] SBIR/STTR funding was transferred to the Science Appropriation in FY 2008, which includes a reduction of $4,183,000 that was transferred to the SBIR program, and $501,000 that was transferred to the STTR program.
[b] Includes activities previously funded in the Hydrogen Program in years prior to FY 2009 (now the Fuel Cell Technologies Program): Technology Validation, Safety and Codes and Standards, and Education.
[c] Technology Validation, Safety and Codes and Standards, and Education have been transferred to the Fuel Cell Technologies Program from the Vehicle Technologies Program.

Vehicle Technologies focuses on highway vehicles (passenger and commercial vehicles), which account for 55 percent of total U.S. oil use ─ more than all U.S. domestic oil production. Cost-competitive, more energy-efficient and fuel diverse vehicles will enable individuals and businesses to accomplish their daily tasks while reducing consumption of gasoline and diesel fuels. This will reduce U.S. demand for petroleum, lower carbon emissions, and decrease energy expenditures. Due to the high use of oil by highway transportation, President Obama has stated, "Increasing fuel efficiency in our cars and trucks is one of the most important steps that we can take to break our cycle of dependence on foreign oil. It will also help spark the innovation needed to ensure that our auto industry keeps pace with competitors around the world."[a]

To achieve higher fuel efficiency and to lower GHG emissions, DOE strives to meet the following Presidential goals:

- Within 10 years save more oil than currently imported from the Middle East and Venezuela combined;
- Invest in developing advanced vehicles and put 1 million plug-in hybrid electric vehicles (PHEVs) on the road by 2015;
- Deploy the cheapest, cleanest, fastest energy source – energy efficiency; and
- Establish a National Low Carbon Fuel Standard.[b]

The VT Program funds and performs the advanced technology R&D needed to achieve these goals.

In the near to mid-term, transportation energy use can be reduced through improved vehicle energy efficiency from more efficient advanced combustion engines, hybrid-electric (HEV) and PHEV vehicle powertrains, and reducing vehicle weight. Other fuels, such as ethanol, natural gas, electricity with storage, and biodiesel, can also provide attractive means for reducing oil use through fuel displacement. These efficiency gains and fuel alternatives also provide other benefits, such as improving air quality, reducing CO_2 emissions, and enhancing energy security.

By 2030, the program's results could directly contribute a cumulative reduction of at least 0.7 billion bbls of oil, 0.3 gigatons of carbon, and consumer savings of nearly $40 billion. By mid-century the benefits could increase tenfold.

Climate Change:

The VT program contributes to reducing greenhouse gases (GHG, i.e., CO_2) by providing technology which, when commercialized, will make the Nation's highway vehicles more energy efficient and make it possible for those vehicles to be powered by renewable energy. Lightweight materials, advanced combustion, and hybrid drive-trains all improve vehicle efficiency. The use of alternative fuels with advanced combustion and advanced batteries to store electricity, which could come from renewable sources, could increase the displacement of fossil fuels.

As one simple example, a hybrid vehicle that combines advanced, more efficient combustion with lightweight materials and a hybrid drive-train could easily double the fuel efficiency – meaning half the GHG emissions – of a conventional vehicle. If all of these technologies were utilized, the car could achieve triple the fuel efficiency, and one-third the GHG emissions, of a conventional vehicle.

[a] Remarks on Jobs, Energy Independence, and Climate Change, President Barack Obama, Jan. 26, 2009 (http://www.whitehouse.gov/blog_post/Fromperiltoprogress/)

[b] Energy and the Environment Agenda, www.whitehouse.gov/agenda/energy and environment/ (as of April 13, 2009).

Energy Security:

By using advanced efficiency technologies and non-petroleum fuels, oil use can be substantially reduced, making the nation less vulnerable to oil supply disruptions or price spikes. Flexible-fuel vehicles (FFVs) allow the consumer to choose what type of fuel to use based on price and availability. Plug-in hybrid vehicles (PHEVs) will allow consumers to displace fuel use with electricity, based on price and convenience (and how "green" their electricity supply is). PHEVs with flex-fuel engines will provide "all of the above" flexibility in choosing energy sources.

Achievement of VT's goals is expected to displace 0.4 million barrels per day (mbpd) of imported oil in 2030 and 5.2 mbpd in 2050, based on energy-economy models. This displacement will yield energy security benefits by diversifying our energy base and increasing energy productivity which, in turn, lower GHG, provide clean, secure energy, and stimulate economic prosperity.

In the nearer term, program R&D is expected to contribute about half of the oil savings needed from highway transportation to achieve the President's 10 year oil reduction goal. This savings, about 1.8 million barrels per day, will be comprised of contributions from PHEVs, HEVs, other vehicle efficiency gains, and substitution of other energy sources for oil, e.g. ethanol, biodiesel, and electricity. The remaining portion of the savings will need to be met from oil reductions by other transportation methods and from other sectors such as industry, utilities and home heating.

Economic Impact:

Reduced petroleum use can be expected to lead to reduced oil imports, improving the Nation's balance of trade and position in the global economy. New technologies developed and manufactured within the U.S., and fuels produced domestically, will create jobs and economic growth. Finally, achieving the VT goals for reducing the cost of advanced vehicle technologies will save the consumer money that can stimulate other areas of the national economy.

The benefits tables below show the estimated security, economic and environmental benefits from 2015 through 2050 that would result from realization of the program's goals. These benefits are achieved by targeted Federal investments in technology research and development in partnership with auto manufacturers, commercial vehicle manufacturers, equipment suppliers, fuel and energy companies, other Federal agencies, State government agencies, universities, National Laboratories, and other stakeholders. These partnerships facilitate the technical coordination of activities and attract cost sharing to provide leveraged benefits for the American taxpayer.

The benefits table also reflects the increasing penetration of the program's technologies over time as performance and cost goals are met. Not included are any policies, regulatory mechanisms, or other incentives not already in existence that might be expected to support or accelerate the achievement of the program goals. The expected benefits reflect solely the achievement of the program's goals.

The goals are modeled in contrast to the "baseline" case, in which no DOE R&D exists. The baseline case is identical to those used for all DOE applied energy R&D programs.[a] Across all of DOE's applied energy R&D programs, the expected outcome benefits are being calculated using the same fundamental methodology. The metrics by which expected outcome benefits are measured are identical for all of

[a] The starting point for the baseline case is the Energy Information Administration's "reference case," as published in the AEO 2007. Program analysts across DOE examined the AEO to determine the extent to which their program goals are modeled (explicitly or implicitly). If program goals are modeled in the AEO, they are removed in the GPRA baseline. Further, some programs believe that the AEO's technology representation is too conservative, even in the absence of program goals, and thus in certain cases a modification is made to make the technology representation in the baseline case more optimistic than the AEO.

DOE's applied energy R&D programs.[a] This standardization of methodology and metrics has been undertaken as part of the DOE's efforts to respond to OMB's request to make all programs' outcomes comparable.

The difference between the baseline case and the program goal case results in economic, environmental, and security benefits. For example, achievement of program goals results in a reduction in cumulative net consumer expenditures of almost $40 billion dollars by 2030 and $1 trillion by 2050. The achievement the programs goals would also result in carbon emissions reductions of 0.3 gigatons by 2030 and 9.6 gigatons by 2050. The results are generated by modeling the program goals within two energy-economy models: NEMS-GPRA10 for benefits through 2030, and MARKAL-GPRA10 for benefits through 2050.[b] The full list of modeled benefits appears below.

The notion of a baseline has become more complicated this year as a result of the inclusion of EISA 2007 provisions into the baseline model. EISA 2007 was not included in the modeling for the FY 2009 budget request. EISA requires increased use of alternative fuels and sets higher fuel economy standards relative to current law. The technologies that VT is developing will help meet those requirements more economically. Therefore, in effect, both EISA and the baseline now incorporate many of the benefits expected to arise from the achievement of VT's R&D program targets. This causes the models to show a much smaller incremental "gain" from VT's R&D than in previous years. The estimated benefits in this request reflect gains expected from VT's R&D goals in addition to EISA requirements. For example, the NEMS estimated 2030 benefits are only about 16 to 17 percent of what they were when EISA, with its assumption of benefits from VT technologies, was not included: the consumer savings of $40 billion by 2030 attributable to the achievement of the goals of the VT program would be more than $240 billion if the benefits from VT assumed by EISA were included. However, the model does not estimate the extent to which VT's R&D program contributes towards cost-effectively implementing EISA – and hence does not provide a full accounting of the benefits of the program.

[a] The set of expected outcome metrics used this year differs in substantial ways to that of most years. In addition to the standardization across DOE's applied energy R&D programs, the list is expanded and more comprehensive. The list also maps to DOE strategic goals. The expected outcome metrics represent inherent societal benefits that stem from achievement of program goals.

[b] Documentation on the analysis and modeling can be found at http://www.eere.energy.gov/ba/pba/program_benefits.html.

Primary Metrics for FY 2010 Budget Request

(Incorporates Approximate Impacts of EISA 2007)

	Metric[1]	Model	Year			
			2015	2020	2030	2050
Energy Security	Oil Imports Reduction, cumulative[2] (Bil bbl)	NEMS	ns	ns	0.7	N/A
		MARKAL	0.2	0.6	2.8	23.4
	Natural Gas Imports Reduction, cumulative (Tcf)	NEMS	ns	ns	ns	N/A
		MARKAL	ns	ns	ns	8.4
	Reduction in Share of Highway Fuel Demand Derived from Crude Oil[3] (%)	NEMS	ns	ns	ns	N/A
		MARKAL	ns	ns	1%	5%
Environmental Impacts	CO_2 Emissions Reduction, cumulative (Mil mtCO_2)	NEMS	ns	ns	277	N/A
		MARKAL	99	317	1185	9558
	SO_2 Allowance Price Reduction[4] ($/ton)	NEMS	ns	ns	ns	N/A
		MARKAL	N/A	N/A	N/A	N/A
	NO_x Allowance Price Reduction ($/ton)	NEMS	ns	ns	ns	N/A
		MARKAL	N/A	N/A	N/A	N/A
	Hg Allowance Price Reduction (thousand $/lb)	NEMS	ns	ns	ns	N/A
		MARKAL	N/A	N/A	N/A	N/A
Economic Impacts	Consumer Savings, cumulative[5] (Bil $)	NEMS	ns	ns	40	N/A
		MARKAL	41	62	150	998
	Electric Power Industry Savings, cumulative (Bil $)	NEMS	ns	ns	ns	N/A
		MARKAL	ns	ns	ns	ns
	Household Energy Expenditures Reduction ($/household/yr)	NEMS	ns	ns	10	N/A
		MARKAL	ns	ns	26	1117

1. “Reductions” and “savings” are calculated as the difference between results from the baseline case (i.e. no DOE technology) and the technology case (i.e. all DOE technology R&D programs are successful).
2. All cumulative metrics are based on results beginning in 2010.
3. Metric includes oil-derived fuel use by light-duty vehicles, commercial light trucks and freight trucks; the metric excludes buses. Reported oil use is adjusted to exclude ethanol, biodiesel and CTL.
4. All monetary metrics are in 2006$.
5. Cumulative monetary metrics are in 2006$ that are discounted to 2010 using a 3% discount rate.

ns - Not significant
NA - Not yet available
N/A - Not applicable

Secondary Metrics for FY 2010 Budget Request

(Incorporates Approximate Impacts of EISA 2007)

	Metric[1]	Model	Year			
			2015	2020	2030	2050
Energy Security	Oil Imports Reduction, annual (Mbpd)	NEMS	ns	ns	0.4	N/A
		MARKAL	0.1	0.3	0.9	5.2
	Natural Gas Imports Reduction, annual (Tcf)	NEMS	ns	ns	ns	N/A
		MARKAL	ns	ns	ns	0.8
	MPG Improvement[2] (%)	NEMS	ns	ns	3%	N/A
		MARKAL	1%	1%	7%	95%
Environmental Impacts	CO_2 Intensity Reduction of US Economy (Kg CO2/$GDP)	NEMS	ns	ns	ns	N/A
		MARKAL	ns	ns	0.01	0.02
	CO_2 Intensity Reduction of US Power Sector[3] (Kg CO2/kWh)	NEMS	ns	ns	ns	N/A
		MARKAL	ns	ns	ns	ns
	CO_2 Intensity Reduction of US Transportation Sector[4] (Kg CO2/mile)	NEMS	0.00	0.00	0.02	N/A
		MARKAL	0.01	0.01	0.03	0.16
Economic Impacts	Consumer Savings, annual[5] (Bil $)	NEMS	ns	ns	15	N/A
		MARKAL	6	5	24	250
	Electric Power Industry Savings, annual (Bil $)	NEMS	ns	ns	ns	N/A
		MARKAL	ns	ns	ns	ns
	Energy Intensity of US Economy (energy/$GDP)	NEMS	ns	ns	0.05	N/A
		MARKAL	0.02	0.04	0.10	0.38
	Net Energy System Cost Reduction, cumulative (Bil $)	NEMS	N/A	N/A	N/A	N/A
		MARKAL	ns	ns	ns	712

1. "Reductions" and "savings" are calculated as the difference between results from the baseline case (i.e. no DOE technology) and the technology case (i.e. all DOE technology R&D programs are successful).
2. Change in light duty vehicles miles traveled per gallon of oil, where oil is only that derived from petroleum.
3. Emissions include all power sector emissions. Generation calculated as total net generation adjusted for estimated T&D losses.
4. Emissions calculated using highway fuel use and related carbon emission factor. Miles calculated as highway miles traveled, excluding buses.
5. All monetary metrics are in 2006$.

ns - Not significant
NA - Not yet available
N/A - Not applicable

The model used to estimate these benefits increases the market share of advanced-technology vehicles over time as their projected incremental cost relative to conventional vehicles declines, and as their efficiency relative to conventional vehicles increases. The energy savings (in the long-term benefits) are the net savings to the vehicle users, including both the value of fuel saved and the incremental expenditures made to purchase their advanced vehicles. Carbon emission reductions are based on the amount of carbon that the petroleum products saved which would have been released if used.

The following external factors could affect the ability of the VT program to achieve these long-term goals and benefits:

- Ethanol distribution infrastructure. Successful deployment of alternative fuel vehicles (AFV's) depends on development of adequate infrastructure for large-scale distribution of ethanol and ethanol blends.
- Electricity grid capacity. Successful deployment of PHEVs depends on adequate grid capacity during peak charging hours.
- Market Appeal. The interest of consumers in new vehicle fuel economy can be very dependent on the price of gasoline. Because gasoline prices have historically gone up and down, they have not provided a consistent signal to either buyers or manufacturers. Within the typical development period for a new car model (3 to 5 years), recent oil prices have risen from the $40s per barrel to over $140, then crash down into the $30s per barrel, and back into the $50s again. Consumer interest in alternative fuels and HEVs generally follows those roller-coaster price fluctuations.

Contribution to the Secretary's Priorities

The VT program contributes to several of the Secretary's priorities as enumerated below. The principal focus area is to create economic prosperity through the formation of green jobs and increased competitiveness by means of reduced energy demand from highway transportation and through the deployment of cost-effective low-carbon clean energy technologies by establishing low carbon fuel standards in transport.

Priority 1: Science and Discovery — Invest in science to achieve transformational discoveries.
VT works with the Office of Science and its National Laboratories for better scientific understanding and improved computational tools, for instance to develop and improve materials models using advanced computational resources. VT has also worked with the Office of Science to define basic research needs to improve fundamental electrochemistry understanding and to identify opportunities for improving battery energy storage using nanotechnology. Additionally, VT collaborates with industry and universities to improve the fundamental understanding of materials.

Priority 2: Clean Energy — Change the landscape of energy demand and supply

VT's mission directly advances this priority by providing technologies to decrease energy use in highway transportation. VT performs R&D to make PHEV technology both practical and cost effective, and validates the performance of state-of-the-art PHEV technology through vehicle testing. VT works with industry, universities, and the national labs to understand and improve the opportunities for PHEV vehicles including limitations and opportunities for vehicle-to-grid connectivity, electric range optimization, and recharging options. VT is also characterizing intermediate-blend alternative fuels for broader and faster petroleum displacement. VT also develops and demonstrates improved combustion efficiency for more effective utilization of alternative fuels.

Priority 3: Economic Prosperity — Create millions of green jobs and increase competitiveness.
VT is working to transform highway transportation efficiency through development of new combustion, battery, lightweight material, and energy-management technologies for both passenger vehicles and heavy commercial vehicles. Every area of activity includes industrial participation with the aim of translating R&D into products and jobs as quickly as possible. VT also supports universities in training the future engineering workforce that will continue to develop and utilize advanced highway transportation technologies.

Contribution to GPRA Unit Program Goal 1.1.02.00 (Vehicle Technologies)

The key program contribution to Strategic Theme 1, Energy Security, is the direct reduction of petroleum use. The VT Program supports an R&D portfolio focused on developing technologies that can enable dramatic improvements in the energy efficiency of passenger vehicles (e.g., cars, light trucks, and SUVs/crossovers) and commercial vehicles (heavy trucks, buses, etc.). In addition, R&D will focus on reducing the cost and overcoming technical barriers to volume manufacturing of advanced vehicle technologies.

The program's goals presented below demonstrate key technology pathways that contribute to achievement of reduced oil use.

- Hybrid Electric Systems subprogram (Power Electronics and Electric Motor R&D):
  - As an intermediate goal, by the end of 2010, develop an integrated electric propulsion system that costs no more than $19/kW peak and can deliver at least 55kW of power for 18 seconds and 30kW of continuous power with an inlet coolant temperature of 90^{o}C ($1,045 per system compared to the cost of $1,925 in 2004 with an inlet coolant temperature of 70^{o}C). Additionally, the propulsion system will have an operational lifetime of 15 years.
  - By 2015, meet the same life and performance requirements at a cost of $12/kW with an inlet coolant temperature of 105^{o}C.
- Hybrid Electric Systems subprogram (Energy Storage):
  - Reduce the production cost of a high power 25kW battery for use in passenger vehicles from $3,000 in 1998 to $500 by the end of 2010, enabling cost competitive market entry of hybrid vehicles; and
  - Reduce the production cost of a high energy and high power battery from $1,000/kWh in 2006 to $300/kWh by 2014, enabling cost competitive market entry of PHEVs.
- Hybrid Electric Systems subprogram (Vehicle and Systems Simulation and Testing): Demonstrate market readiness of PHEV technologies by 2015.
- Advanced Combustion R&D subprogram and Fuels Technology subprogram: Improve the efficiency of internal combustion engines from 30 percent (2002 baseline) to 45 percent by the end of 2010 for passenger vehicles, and from 40 percent (2002 baseline) to 50 percent validated in vehicle tests by 2014 for commercial vehicle applications, while utilizing an advanced fuel formulation that incorporates a non-petroleum based blending agent to reduce petroleum dependence and enhance combustion efficiency.
- By the end of 2010, develop material and manufacturing technologies which, if implemented in high volume, could cost-effectively reduce the weight of passenger vehicle body and chassis systems by 50 percent with safety, performance, and recyclability comparable to 2002 vehicles.

The proposed FY 2010 Budget investments complement funds provided by the Recovery Act that support ongoing vehicles R&D and will speed the transition of the highway vehicles market from current technology to one dominated by advanced technology high efficiency vehicles. To enable decision makers and the public to follow performance and plans, the program will post its progress in these planned activities at: http://www.energy.gov/recovery/index.htm.

Means and Strategies

"Means" include operational processes, resources, information, and the development of technologies, and "strategies" include program, policy, management and legislative initiatives and approaches. Various external factors, as listed below, may impact the ability to achieve the program's goals.

VT employs the following strategies to accomplish its goals:

The program supports a portfolio of activities that include both near-term and long-term R&D, early deployment and field validation of advanced technologies, and support for higher-education programs that "fill the pipeline" with young engineers motivated to improve America's energy efficiency.

The primary barriers and opportunities for improved vehicle efficiency are technological. Therefore, the principal strategy of the program is to support R&D of technologies that have the potential to achieve significant improvements in vehicle fuel efficiency or significant displacement of petroleum-based fuels with clean, cost-competitive alternative fuels that can be produced domestically.

The R&D strategy is subdivided into the pursuit of four technology pathways, each of which can improve vehicle efficiency relative to conventional technology, thus lowering vehicle oil use and GHG emissions:

- Improve hybrid electric vehicle component efficiency (up to 50 percent improvement in fuel economy);
- Improve PHEV components (up to 300 percent improvement in fuel economy);
- Improve combustion engines and fuel characteristics (up to 40 percent improvement in fuel economy and displacement of oil by non-petroleum fuels); and
- Reduce the weight of vehicles (up to 30 percent improvement in fuel economy).

These improvements can be combined to create integrated advanced technology vehicles capable of between 200 and 400 percent increased fuel economy per vehicle for passenger vehicles and 40 to 50 percent for commercial vehicles.

In addition to the main R&D pathways, the program strategy includes support of other activities to facilitate market adoption of new technologies, to train new engineers in advanced technologies, and to inform the program's own strategic planning.

VT employs the following means to achieve its goals:

The most important means is to engage in partnerships – with industry, with other Federal agencies, with State and local governments, and as opportunities arise, with foreign governments and international organizations.

The VT program has a long and successful history of working in partnership with industry to develop technology roadmaps, coordinate pre-competitive R&D, and determine which activities are the sole responsibility of industry and which may be appropriate for DOE support. The principal current collaborations are:

- **FreedomCAR and Fuel Partnership.** DOE (represented by the Vehicle Technologies and the Fuel Cell Technologies programs) participates in the FreedomCAR and Fuel Partnership with the U.S. Council for Automotive Research (USCAR), five energy companies, and two utilities. The Partnership is focused on precompetitive high-risk research necessary to provide a full range of affordable energy-efficient cars and passenger trucks, and their fueling infrastructure. The primary focus is supporting R&D of HEV and PHEV technologies, and combustion engines for the nearer term and fuel-cell hybrids for the long term.
- **21st Century Truck Partnership.** The 21st Century Truck Partnership (21CTP) is a cooperative effort between the commercial vehicle (truck and bus) industry and major Federal agencies to develop technologies that will make the Nation's commercial vehicles more efficient, clean, and safe. The 21CTP focus is on R&D to increase engine efficiency, improve performance of hybrid power-trains, reduce parasitic and idling losses, and validate and demonstrate efficient, clean, and safe technologies.

VT also participates in an effort to integrate and harmonize R&D pathways across DOE's energy research programs. VT's principal counterparts are the Biomass and Biorefinery Systems R&D, Building Technologies, and Fuel Cell Technologies programs within EERE, the Office of Electricity Delivery and Energy Reliability, and the Basic Energy Sciences Program within the Office of Science. Examples of collaborative activities with the Office of Science include development of nano-scale materials and structures that have potential for improving battery performance and exploring opportunities to study fundamental combustion processes.

The program also collaborates with the Environmental Protection Agency (EPA) to promote deployment of two specific technologies: (1) DOE's Technology Integration activity will leverage its Clean Cities partnerships to work with EPA's SmartWay Transport Partnership to promote the installation of more biodiesel and E85 ethanol refueling stations around the country; and (2) cooperate with EPA to promote the adoption of idling-reduction technologies and practices for trucks and buses.

The program also uses a variety of other means to achieve its goals, including the following:

- The program funds and facilitates demonstration and deployment of prototype/pre-prototype vehicles to identify and eliminate technology flaws prior to technology introduction and technology development opportunities that lead to further cost reductions and/or performance improvements.
- University-oriented activities create graduate education opportunities for working with new automotive technologies and encourage undergraduate engineering students to gain experience with hybrid and plug-in hybrid systems technology and advanced combustion engines.
- R&D and deployment activities fund market and economic analyses needed to properly inform the program's technology strategies and multi-year plans.
- The program's goals, activities, and progress are reviewed by industry partners in the FreedomCAR and Fuel Partnership, and the 21st Century Truck Partnership, by industry and academic experts, through technical and programmatic reviews, and by the National Academies of Science (NAS) through a formal biennial peer review process.

The following chart shows how broad, long-term Administration and Departmental goals cascade down to specific activities and measures of program performance.

Cascade from Goals to Performance Measures

Goals:	**Energy Security and Greenhouse-Gas Reductions**				
Strategies:	**More efficient use of petroleum fuels**			**Displacement by non-petroleum fuels**	
Technical Strategies:	More efficient engines	Lighter vehicles	Cost-competitive hybrid vehicles	Optimize combustion of alternative fuels / blends	Enable cost-competitive plug-in hybrid vehicles
Program Performance Measures:	Improve engine efficiency for gasoline, diesel, and advanced combustion regimes. Capture and use waste heat.	Reduce cost of advanced materials like carbon fiber.	Reduce cost of high-power batteries. Reduce cost of power electronics & motors.	Improve gasoline and diesel engine efficiency when using alt-fuel blends.	Reduce high-power/high-energy battery cost. Field demonstrations of PHEVs.

Validation and Verification

To validate and verify program performance, the VT Program will conduct internal and external reviews and audits. These programmatic activities are subject to continuing review by, for example, Congress, the Department's Inspector General, and the NAS. The VT Program also uses several program performance management methods to validate and verify its performance during the course of the program on an annual and ongoing basis, including: management standards; incorporation of goals; measurement and reporting from program contracts; peer reviewed roadmaps and activities; performance modeling and estimation; prototype testing; site visits; and annual program reviews.

Data Sources:	Program Reviews, Peer Reviews, Laboratory Tests, On-Road Tests, and Peer-Reviewed Model Baselines.
Baseline:	Cost of hybrid batteries in 1998 ($3,000 projected for volume production of a high power 25 kW battery), combustion efficiency in 2002 (30 percent for passenger vehicles and 40 percent for commercial vehicles), 2002 passenger vehicle weight (3450 pounds as the nominal weight for a mid-sized car), cost of plug-in hybrid high energy battery in 2006 ($1,000/kWh), and integrated electric propulsion system cost in 1998 ($1,900). (Note: cost values are not adjusted for inflation.)
Frequency:	Biennial Peer reviews will be conducted in alternate years for the FreedomCAR and Fuel Partnership and for the 21st Century Truck Partnership.
Data Storage:	EE Corporate Planning System
Evaluation:	In carrying out the program's mission, the VT Program uses several forms of evaluation to assess progress and to promote program improvement. These are conducted at both the program and the activity levels. The types of evaluations are:

- Continue to conduct and build upon the transparent oversight and performance management initiated by Congress and the Administration.
- Technology validation and operational field measurement, as appropriate;
- Peer review by independent outside experts of both the program and subprogram portfolios;
- Annual internal Technical Program Review of the VT Program;
- Specialized program evaluation studies to examine process, impacts, or market baseline and effects, as appropriate;
- Quarterly and annual assessment of program and management results based on Joule (the DOE quarterly performance progress review of budget targets), and PART (common government wide program/OMB reviews of management and results);
- Annual review of methods, and computation of the potential benefits for the Government Performance and Results Act (GPRA); and
- Biennial reviews of both the FreedomCAR and Fuel Partnership and the 21st Century Truck Partnership by an independent third party, such as the NAS/National Academy of Engineering, to evaluate progress and program direction. The reviews include evaluation of progress toward achieving the Partnership's technical goals and direction. Based on this evaluation, resource availability, and other factors, the FreedomCAR and Fuel partners and the 21CT partners will consider new opportunities, make adjustments to technology specific targets, and set goals as appropriate.

Verification: Run and document vehicle simulation tests, conduct bench tests, run laboratory tests on the engine and vehicle dynamometers, run wind tunnel tests, and conduct on-road and track tests to evaluate the technology. Conduct fleet tests and undertake target performance review.

Annual Performance Results and Targets[a]

FY 2005 Results	FY 2006 Results	FY 2007 Results	FY 2008 Targets	FY 2009 Targets	FY 2010 Targets
GPRA Unit Program Goal 1.1.02.00 (Vehicle Technologies)					
Hybrid Electric Systems/Advanced Power Electronics and Electric Motors R&D					
		Demonstrate in the laboratory a motor with a specific power of 1.0 kW/kg, power density of 3.0 kW/liter, projected cost of $9/kW peak, and efficiency of 90 percent. [MET]	Reduce the projected cost (modeled) of a combined inverter/motor to $22/kW peak for a specific power of 1.0 kW/kg, a power density of 2.0 kW/liter, and an inlet coolant temperature of 90^o C. [MET]	Reduce the projected cost (modeled) of a combined inverter/motor to $19/kW peak for a specific power of 1.0 kW/kg, a power density of 2.2 kW/liter~~,~~ and an inlet coolant temperature of 90^o C.	Demonstrate a combined inverter/motor with a specific power of 1.1 kW/kg, a power density of 2.6 kW/liter, and a cost of $19/kW peak at an inlet coolant temperature of 90^o C.
Hybrid Electric Systems /Energy Storage R&D					
Reduce high-power, 25 kW, light vehicle, lithium ion battery cost to $900 per battery system. [MET]	Reduce the projected cost at high volume of a high power, 25 kW, light vehicle, lithium ion battery to $750 per battery system. [MET]	Reduce high power, 25 kW, passenger vehicle, lithium ion battery cost to $700 per battery system for conventional hybrid vehicles. [MET]	Reduce modeled production cost of high-power, 25 kW passenger vehicle lithium-ion battery to $625. (Storage batteries are a key cost and performance component for hybrid vehicles, which offer improved fuel economy.) [MET]	Reduce modeled production cost of high-power, 25 kW passenger vehicle lithium-ion battery to $550. (Storage batteries are a key cost and performance component for hybrid vehicles, which offer improved fuel economy.)	Reduce modeled production cost of high-power, 25 kW passenger vehicle lithium-ion battery to $500. (Storage batteries are a key cost and performance component for hybrid vehicles, which offer improved fuel economy.)
Advanced Combustion Engine R&D; Fuels Technology					
Light vehicle combustion engines will reach 39 percent brake thermal efficiency and commercial heavy-duty vehicle combustion engines will be greater than 45 percent efficient while meeting EPA 2007 emission standards (1.2 g/hp-hr NO_x). [MET]	Achieve 41 percent brake thermal efficiency for light vehicle combustion engines and 50 percent brake thermal efficiency, while meeting EPA 2010 emission standards (0.2 g/hp-hr NOx), for heavy vehicle combustion engines. [MET]	In the laboratory, demonstrate passenger vehicle combustion engines with a 42 percent brake thermal efficiency. [MET]	Internal combustion laboratory demonstrated engine efficiency for light-duty vehicles of 43 percent. (Engine efficiency improvements can improve vehicle fuel economy.) [MET] Complete progress review of heavy-duty engine research and down-select from 4 to 2 the number of cooperative agreements for continued R&D, based on the best prospects of achieving the 2013 goal of 55 percent engine efficiency. [MET]	Internal combustion laboratory demonstrated engine efficiency for light-duty vehicles of 44 percent. (Engine efficiency improvements can improve vehicle fuel economy.)	Internal combustion laboratory demonstrated engine efficiency for light-duty vehicles of 45 percent. (Engine efficiency improvements can improve vehicle fuel economy.)

[a] The performance target for Technology Validation is shown in the Fuel Cell Technology budget as a result of the transfer of that activity in FY 2010.

FY 2005 Results	FY 2006 Results	FY 2007 Results	FY 2008 Targets	FY 2009 Targets	FY 2010 Targets
Materials Technology/Lightweight Materials Technology					
Complete R&D on technologies, which, if implemented in high volume, could reduce the price of automotive-grade carbon fiber to less than $4.50/pound. [MET]	Complete R&D on technologies, which, if implemented in high volume, could reduce the projected (i.e., modeled) bulk cost of automotive-grade carbon fiber to less than $3.00/pound. [NOT MET]	Reduce the modeled weight of a mid-sized passenger vehicle body and chassis components by 10 percent relative to baseline. [MET]	Reduce the modeled weight of a passenger vehicle body and chassis system by 25 percent relative to the 2002 baseline. [MET]	Reduce the modeled weight of a passenger vehicle body and chassis system by 40 percent relative to 2002 baseline.	Reduce the modeled weight of a passenger vehicle body and chassis system by 50 percent relative to 2002 baseline.
Contribute proportionately to EERE's corporate goal of reducing corporate and program adjusted uncosteds to a range of 20-25 percent by reducing program annual uncosteds by 10 percent in 2005 relative to the program uncosted baseline (2006) until the target range is met. [PARTIALLY MET]	Maintain total administrative overhead costs (defined as Program Direction and Program Support excluding earmarks) in relation to total program costs of less than 12 percent. [a] [MET]	Maintain total administrative overhead costs (defined as Program Direction and Program Support excluding earmarks) in relation to total program costs of less than 12 percent. [a] [MET]	Maintain administrative costs at less than 12 percent of total program costs. [a] [MET]	Maintain administrative costs at less than 12 percent of total program costs. [a]	Maintain administrative costs at less than 12 percent of total program costs. [a]

[a] Administrative costs are comprised of Program Direction and elements of Program Support (Technology Advancement and Outreach; and Planning, Analysis and Evaluation); baseline and targets under development.

Hybrid Electric Systems
Funding Schedule by Activity

	(dollars in thousands)		
	FY 2008	FY 2009	FY 2010 Request
Hybrid Electric Systems			
Vehicle and Systems Simulation and Testing	28,234	21,126	53,353
Technology Validation	—[a]	*14,789*	—[b]
Energy Storage R&D	48,348	69,425	77,437
Advanced Power Electronics and Electric Motors R&D	15,497	17,358	30,041
SBIR/STTR	—[c]	3,011	3,830
Total, Hybrid Electric Systems	92,079	125,709	164,661

Description

Modifications were made to the Hybrid Electric Systems subprogram budget structure to better reflect activities planned in FY 2010. The Technology Validation key activity is proposed to be moved back to the Fuel Cell Technologies Program as part of a reprioritization of fuel cell and hydrogen-related work.

This subprogram includes all of the VT efforts directly relating to the planning and modeling, development, and evaluation of advanced hybrid, electric, and plug-in hybrid drive systems. The Hybrid Electric Systems subprogram funds R&D on advanced vehicle technologies for both passenger and commercial vehicles that could achieve significant improvements in fuel economy without sacrificing safety, the environment, performance, or affordability. Primary emphasis is given to R&D on those technologies that support development of advanced HEVs and PHEVs. The subprogram also conducts simulation studies, component evaluations, and testing to establish needs, goals, and component/vehicle performance validation. This subprogram's funding contributes to the 21st Century Truck Partnership and the FreedomCAR and Fuel Partnership.

The subprogram focuses on the two basic building blocks of hybrid vehicles, and activities that tie the R&D efforts together and evaluate their progress.

- Energy Storage R&D addresses the first building block of a hybrid-electric vehicle: electricity storage. The needs of "regular" HEVs and PHEVs are similar, but not identical: PHEVs need to be able to store considerably more total energy in their batteries. Developing batteries that are rugged, long-lasting, affordable, lighter, hold a substantial charge, and work in all climates and seasons is still a major R&D challenge.
- Advanced Power Electronics and Electric Motors R&D addresses the second building block, which includes the electric and electronic devices that deliver the power stored in the battery to the vehicle's drive-train: power control circuits, charging circuits, electric motors, logic to synchronize

[a] Prior to FY 2009, Technology Validation was funded in the Hydrogen Technology (now Fuel Cell Technologies) Program.
[b] Technology Validation is transferred to the Fuel Cell Technologies Program from the Vehicle Technologies Program in FY 2010.
[c] SBIR/STTR funding was transferred to the Science Appropriation in FY 2008.

the power from the battery and motors with the main vehicle engine, and other related components. The power electronics for a PHEV will be considerably more complex than for a regular hybrid to accommodate additional charging modes and more complex control strategies.

- Vehicle and Systems Simulation and Testing ties all of the hardware R&D together. System-level simulations help specify the necessary performance characteristics of the hardware and predict the overall vehicle efficiency and performance for a given configuration. Both simulation and testing activities can be used to evaluate the development and progress of individual components, and predict how well they will integrate with other components being developed. Tests and simulations also evaluate how well the program is approaching its whole-vehicle goals and provides technical inputs to mathematical models of projected oil reduction and economic benefits. Closed-track and on-road evaluations of advanced technology vehicles are utilized to identify potential limits to market penetration and petroleum reduction to inform R&D activities.

The Technology Validation activity has included validation of both fuel cell vehicle (FCV) technology and hydrogen infrastructure through the Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project. The project is both a "Learning Demonstration" to manage the hydrogen and fuel cell component and materials research, and a validation of the technology under real-world operating conditions against time-phased performance-based targets. The project is 50/50 cost-shared between government and industry, including automobile manufacturers, energy companies, suppliers, universities, and state governments. Extensive data have been collected on vehicles operating on-road and during dynamometer testing. Validation of the hydrogen infrastructure included verification of hydrogen production cost and fueling time while gaining experience in the safe operation of stations. In FY 2010 the Technology Validation activity is transferred from the VT Program to the Fuel Cell Technologies Program as part of a reprioritization of fuel cell and hydrogen-related work.

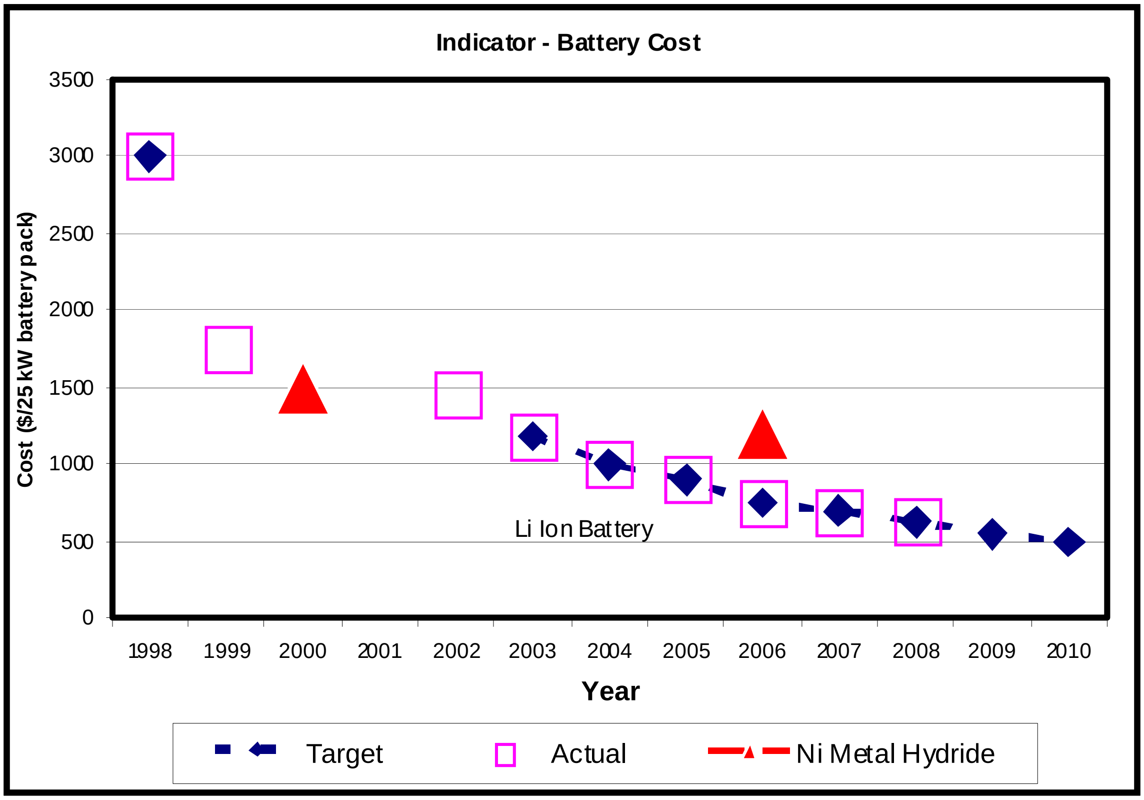
Benefits

The Hybrid Electric Systems subprogram supports VT Program goals by addressing the utilization of electric energy storage, electric drives, and energy recovery in new, more efficient vehicle designs.

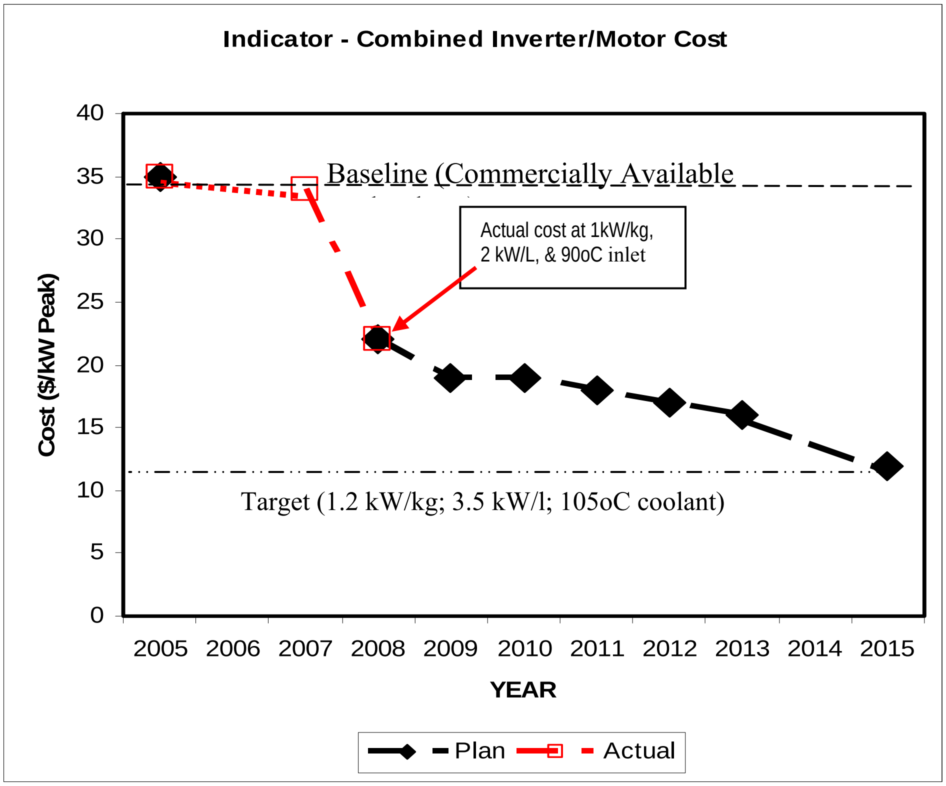
The following are representative goals of the Hybrid Electric Systems subprogram that can contribute to meeting national energy security, environmental, and economic objectives:

- Power Electronics and Electric Motor R&D:
  - As an intermediate goal, by the end of 2010, develop an integrated electric propulsion system that costs no more than $19/kW peak and can deliver at least 55kW of power for 18 seconds and 30kW of continuous power with an inlet coolant temperature of 90^{o}C ($1,045 per system compared to the cost of $1,925 in 2004 with an inlet coolant temperature of 70^{o}C). Additionally, the propulsion system will have an operational lifetime of 15 years.
  - By 2015, meet the same life and performance requirements at a cost of $12/kW with an inlet coolant temperature of 105^{o}C.
- Energy Storage:
  - Reduce the production cost of a high power 25kW battery for use in passenger vehicles from $3,000 in 1998 to $500 by the end of 2010, enabling cost competitive market entry of hybrid vehicles; and
  - Reduce the production cost of a high energy and high power battery from $1,000/kWh in 2006 to $300/kWh by 2014, enabling cost competitive market entry of PHEVs.
- Vehicle and Systems Simulation and Testing: Demonstrate market readiness of PHEV technologies by 2015.

Progress for energy storage and electric propulsion system is indicated by cost per 25kW battery system and combined inverter/motor cost estimated for a production level of 100,000 systems per year. Actual and projected progress for the battery cost and integrated inverter/ motor cost indicators are shown graphically below:



Note: 1998 value is baseline.



Note: 2005 and 2007 Actual data are cost for commercially available systems.

Additionally, in FY 2010 the subprogram will continue to accelerate the development of low-cost, high-energy batteries and corresponding improvements to electric drive systems (motors, power electronics, and electric controls) needed for cost-effective PHEVs. PHEVs (i.e., those that can be plugged into and recharged from an electric outlet) offer the potential for significant additional fuel savings benefits, particularly for commuter and local driving, for either combustion or fuel cell powered hybrid passenger vehicles.

Detailed Justification

(dollars in thousands)

	FY 2008	FY 2009	FY 2010
Vehicle and Systems Simulation and Testing	**28,234**	**21,126**	**53,353**

The Vehicle and Systems Simulation and Testing (VSST) activity integrates the modeling, systems analysis, and testing efforts that support the VT Program. The significant increase in funding for FY 2010 will support expanded heavy vehicle systems modeling and development of technologies to reduce commercial vehicles' "parasitic" losses such as aerodynamics and friction. It will also support significantly increased testing of both commercial vehicles and passenger vehicles. The additional funds will increase the number of PHEVs evaluated in the PHEV Technology Acceleration & Demonstration Activity. Additional advanced electric-drive vehicles, including hybrid electric vehicles and battery electric vehicles, will also be baseline tested and evaluated in cooperation with manufacturers, utilities and other industry partners. A portion of the increase will also be used to expand the laboratory and field evaluation of advanced prototype and pre-production electric drive vehicles with dual energy storage systems and other advanced energy storage devices, electric motors, and power electronics. VSST will also expand the evaluation of advanced HEVs and PHEVs in medium and heavy duty uses such as school buses, urban delivery vehicles, and transit buses.

The VSST activity uses a systems approach to define technical targets and requirements, guide technology development, and validate performance of VT Program-sponsored technologies for passenger and commercial vehicles. The activity develops and validates models and simulation tools to predict the performance, component interaction, fuel economy, and emissions of advanced vehicles. With industry input, these models are used to:

- Develop performance targets for the complete range of vehicle platforms and their components;
- Develop advanced control strategies to optimize the interaction between components and the overall performance and efficiency of advanced HEV, PHEV, and fuel cell vehicles; and
- Develop advanced vehicle performance and characteristics data that is then used to predict market potential and petroleum displacement, which can help guide office-wide research.

The modeling and validation effort is supported by laboratory and field testing to benchmark and validate the performance of passenger and commercial vehicles that feature one or more advanced technologies. Benchmarking performance and capabilities of advanced technologies supports development of industry and DOE technology targets. Testing results also are used in component, system, and vehicle models, as well as in hardware-in-the-loop testing that operates selected pieces of hardware linked to a real-time simulation of the rest of the vehicle.

This activity will also research heavy vehicle systems to develop advanced heavy vehicle systems models, as well as R&D on technologies that will reduce non-engine parasitic energy losses from aerodynamic drag, friction and wear, under-hood thermal conditions, and accessory loads.

In FY 2010, the subprogram will continue simulation studies of advanced control strategies and components for PHEVs, as well as the validation of advanced PHEV technology components in the laboratory and on the road. Test data will be used to enhance vehicle and systems modeling capabilities, to validate the accuracy of the component models, and to measure progress towards meeting performance targets. The program also will complete a series of detailed component models linked to the overall vehicle systems integration model ensuring the use of the most accurate component data. This effort, which builds upon an existing cooperative research and development agreement (CRADA) with industry, is developing a centralized vehicle modeling tool that will standardize vehicle modeling across manufacturers and component suppliers, thus reducing component and vehicle developments costs and bringing technologies to market faster. This model also increases accuracy of results and allows simulations that support R&D in all other VT subprograms.

The VSST activity will utilize the PHEV Mobile Automotive Technology Testbed (MATT) and hardware-in-the-loop techniques to emulate vehicle systems to determine systems interactions (e.g., energy storage requirements for different cumulative electric range control strategies and power electronics components and configurations). In FY 2010 VSST will incorporate more advanced energy storage systems and dual battery systems, and continue evaluations of advanced combustion technologies developed by other VT R&D subprograms and the use of engine emission models for analyzing the impact of emission control equipment on the fuel economy of all vehicle classes. VSST will validate, in a systems environment, performance targets for deliverables from the power electronics and energy storage technology R&D activities, and examine overall vehicle impacts associated with integration of other advanced vehicle technologies.

The activity also will conduct laboratory and closed track baseline testing and real-world monitored fleet evaluations of advanced original equipment manufacturer (OEM) PHEVs and complete tests of vehicles retrofitted with components developed through VT R&D activities. Test results will help identify component and system performance and reliability weaknesses to be addressed through future R&D activities. Data from these tests will expand the currently limited PHEV knowledge base and help accelerate market introduction of these fuel saving vehicles. Efforts focus on infrastructure/vehicle interface evaluations and potential impacts on the electricity grid.

VSST will work with industry partners to test the enhanced capabilities of the heavy vehicle systems model to incorporate on-road tests and proprietary industry data and the completed integration of turbulence and other computational fluid dynamics (CFD) models. In FY 2010, additional vehicle testing data from VSST activities, as well as other independent testing sources, will be utilized to validate medium duty vocations in the heavy vehicle model. In FY 2010, VSST will complete the second year of a three year effort focused on on-road and wind tunnel evaluation of the most promising tractor/trailer aerodynamic drag reduction devices being developed through a competitively awarded contract with industry partners. The funds will support CRADAs and National Laboratory projects to reduce drive-train friction and wear, and to develop and evaluate under-hood thermal management approaches that will improve vehicle efficiencies while increasing component reliability and life. The VSST will also work directly with industry partners to accelerate the development and validation of advanced medium and heavy hybrid vehicles.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

	FY 2008	FY 2009	FY 2010
Technology Validation	**–**	**14,789**	**–**

In FY 2010 the Technology Validation activity is transferred from the VT Program to the Fuel Cell Technologies Program as part of a reprioritization of fuel cell and hydrogen-related work.

In past budgets, this funding was requested as two budget items: validation of fuel cell vehicles and validation of hydrogen infrastructure, although the work was performed as an integrated project. In FY 2007 the split is $25.0 million for fuel cell vehicles and $14.566 million for infrastructure. In FY 2008 funding was requested as a single budget item, and the comparable split is $18.65 million for fuel cell vehicles and $11.224 million for infrastructure. In FY 2009 the anticipated split is $11.0 million for fuel cell vehicles and $4.0 million for infrastructure.

	(dollars in thousands)		
	FY 2008	FY 2009	FY 2010
Energy Storage R&D	**48,348**	**69,425**	**77,437**

The Energy Storage activity supports long-term research, applied research, and technology development of advanced batteries. Low-cost, abuse-tolerant batteries with higher energy, higher power, excellent low-temperature operation, and longer lifetimes are needed for the development of the next-generation of HEVs, PHEVs, and pure electric vehicles (EVs). Lithium-based batteries offer the potential to meet all three applications.

The program's long-term research is focused on developing advanced materials for the next generation of energy storage technologies. This research effort is being conducted at universities and National Laboratories. Applied research conducted at seven National Laboratories (ANL, BNL, INL, LBNL, NREL, ORNL, and SNL) is focused on the development and validation of low-cost, abuse-tolerant, and long-life lithium-ion (Li-ion) batteries for vehicle applications. Nearer-term technology development is conducted in cooperation with industry through the United States Advanced Battery Consortium (USABC). All USABC subcontracts to develop advanced batteries are awarded under a competitive process and are at least 50 percent cost-shared by developers.

The Energy Storage activity coordinates with other DOE programs working in advanced battery technologies to maximize returns on DOE's technology investments in this area. Close cooperation with the Office of Basic Energy Sciences (BES) provides valuable technical and programmatic support. The activity also coordinates with the Energy Storage Program in the Office of Electricity Delivery and Energy Reliability (OE) on the development of batteries and components that might serve both transportation and stationary applications. Interagency coordination on advanced battery development is conducted through the government-sponsored Interagency Advanced Power Group (IAPG) comprised of representatives from DOE, NASA, the Army, the Navy, and the Air Force.

In FY 2010, the Energy Storage long-term activity will continue to examine innovative materials and electrochemical couples with the potential for significant improvements over existing technologies for use in both hybrid and plug-in hybrid electric vehicles. These efforts are being coordinated with the Office of Science.

This supports the R&D aimed at reducing the detrimental effects of the volume change during cycling of metallic and intermetallic alloys (1,000 to 4,000 mAh/g) as a replacement for carbon/graphite materials (372 mAh/g) used in present-day lithium batteries. Efforts are underway to accelerate the development of solid polymer electrolytes with significantly higher stiffness and improved ionic conductivity at room temperature that show promise in retarding dendrite formation in cells with lithium metal anodes (3,800 mAh/g). Dendrites are metallic particles that form on the surface of an electrode during cycling and eventually cause an internal short circuit resulting in battery failure. Emphasis will be placed on block copolymers, with one block providing conduction and other block offering stiffness, and protective single-ion conducting ceramic glasses to isolate the lithium metal from the electrolyte.

In addition to new high-voltage electrolytes, research efforts will also be devoted to the development of redox shuttle additives to prevent overcharging, additives that form a good interface between the electrode and the electrolyte for improved life and fast charge capability, and electrolyte formulations and additives for low-temperature operation.

The activity will continue to develop advanced diagnostic techniques to investigate and better understand life- and performance-limiting processes in lithium-based batteries in transportation applications. The program will develop and apply electrochemical models to understand failure mechanisms, thermal runaway mechanisms in lithium batteries, and to design new functional materials.

In coordination with BES and OE, the VT energy storage activity will participate in integrated activities to support development of nanoscale materials and architectures for electrical energy storage. Nanomaterials can exhibit superior performance over conventional battery materials in terms of high pulse discharge and recharge power, and improved performance at low temperatures. However, the behavior of these materials is not well understood and is thought to be more than just a length-scale effect. New diagnostic tools and techniques could be required to investigate these materials.

In FY 2010, Energy Storage applied research will focus on the investigation of cell behavior of higher energy Li-ion cells. Historically, this activity focused on the development and enhancement of high power Li-ion chemistries. Since high-power Li-ion ion batteries are poised to enter the hybrid vehicle market, the emphasis in FY 2010 will focus on the development of electrochemistries that are required to achieve the higher energy density for the 40-mile all electric range (AER) PHEV application. Li-ion cell chemistries based on existing materials do not provide a sufficiently high energy density to meet the weight and volume constraints when providing sufficient energy for the 40-mile AER application. The primary goal of this activity is to develop and engineer higher-energy electrodes utilizing high capacity cathode and anode materials. Optimal cell chemistries will be developed around the most promising higher energy density materials and evaluated.

The applied research activity also supports the development of other energy storage devices, such as ultra-capacitors, that might be used for micro hybrids (start/stop power only) and fuel cell HEVs. Ultra-capacitors still have relatively low specific energy (less than 3 Wh/kg), which limits their capacity to serve as the main energy-storage devices in hybrid vehicles, but they offer the possibility of improved vehicle performance in a battery-plus-ultra-capacitor hybrid configuration. This configuration will be evaluated and optimized for lower cost and durability in a PHEV platform when the ultra-capacitor is sized for power assist and the battery is sized for energy. Ultra-capacitor development focuses on the use of low-cost, high-capacity carbon electrodes and improved electrolytes, which will allow the capacitors to operate at a higher voltage to improve their specific energy.

In FY 2010, the Energy Storage technology development will continue to support cost-shared subcontracts through the USABC with multiple battery suppliers to drive down the cost of Li-ion batteries. The program will continue to develop full-sized Li-ion modules using low-cost, thermally stable, high-performance anode and cathode materials. The emphasis is on driving down the cost and extending the life of higher energy Li-ion batteries for PHEVs.

The FY 2010 request reflects a new emphasis on accelerating the development of batteries for PHEVs. The dual use of batteries in PHEV applications for electric drive range during charge-depleting mode and for engine power assist during charge-sustaining mode challenges the design of the battery and the methodology to evaluate its performance and life. As a result, materials with higher energy capacity than currently being used are preferred. Also, as the battery becomes larger, abuse-tolerance (susceptibility to damage or failure from vibration or impact, over-charging, fire, etc.)

becomes a primary concern requiring higher stability between the electrodes and the electrolyte, and adequate/active thermal management at the module and system level. This activity will continue to validate requirements and refine standardized testing procedures to evaluate performance and life of PHEV batteries, as well as continue to identify areas for additional R&D and address the specific needs of PHEVs. VT will continue to solicit proposals and award additional subcontracts to battery suppliers for development of batteries for plug-in hybrid application. The goal is to reduce the cost of the PHEV battery to $300/kWh by 2014. In FY 2010, VT will continue to support the development of a Li-ion materials supply base in order to strengthen the U.S. based manufacturing of Li-ion batteries. The additional funding will support new contracts with industry to: (1) develop high energy batteries for PHEVs with a 20 to 40 mile all-electric range; (2) develop more cost-effective manufacturing processes for high-volume production of Li-ion batteries; or, (3) improve the quality of the materials and cell components from domestic suppliers, and enhance manufacturing efficiencies to reduce the component's or material's cost. Detailed studies of recycling and reuse of lithium batteries continue. In addition, these funds may be used to support peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

	FY 2008	FY 2009	FY 2010
Advanced Power Electronics and Electric Motors R&D	**15,497**	**17,358**	**30,041**

The Advanced Power Electronics and Electric Motors activity supports long-term R&D on power electronics, electric motors and other electric propulsion components, as well as the thermal control subsystems necessary for the development and ultimate adoption of fuel cell, electric and PHEVs. Supporting R&D on capacitors, magnets and wide band-gap materials (such as silicon carbide [SiC]) for advanced power electronics technologies also is included to enable the higher operating temperatures that are necessary to reduce systems cost and to meet PHEV and fuel cell HEV performance and reliability requirements.

The power electronics module conditions the flow of electrical power from the energy-storage device (battery, fuel cell, and ultra-capacitor) to the electric motor. This module also provides functionality that enables lower-cost and more efficient motors, while protecting them from harmful voltage and current conditions, and helps to reduce the overall size of the battery. The objective of the R&D efforts is to develop advanced, low cost technologies compatible with the high-volume manufacturing of motors, inverters, and DC/DC converters for advanced vehicle applications.

In FY 2010, a new solicitation will be issued to fund industry R&D efforts to develop power electronics and electric motors associated with increased vehicle electrification. Electrification of light-duty vehicles has great potential to reduce dependence on oil imports, and advance power electronics and electric motors are critical components for the successful deployment of advanced vehicles. These awards will enable substantial reductions in cost, weight, and volume, while ensuring a domestic supply chain. Emphasis will be placed on R&D for advanced packaging, enhanced reliability, and improved manufacturability. Awards will also accelerate the technology transfer from research organizations to domestic manufacturers and suppliers.

The activity also supports R&D of inverters and motors (permanent magnet (PM) and non-PM), DC-to-DC converters, SiC components, low-cost permanent magnet materials, high temperature capacitors, advanced thermal systems, and motor control systems to meet future passenger vehicle hybrid systems

	(dollars in thousands)		
	FY 2008	FY 2009	FY 2010

requirements. Existing work in these areas will be expanded to address the more stringent performance requirements for PHEVs, including utilizing the power electronics to provide plug-in capability by integrating the battery charging function into the traction drive, thereby reducing electric propulsion system cost. Activities focusing on advanced materials will be enhanced to enable the production of prototype devices to accelerate the process of transferring research results to device manufacturers. Joint efforts with other programs and agencies in wide bandgap materials will be emphasized and enhanced to enable earlier use of advanced devices and components.

The power electronics and electric motors activity coordinates with other DOE programs doing relevant work in advanced technologies in order to maximize the return on DOE's technology investments in this area. Interagency coordination on advanced power electronics and motors development is conducted through the government-sponsored IAPG.

The synergies of technologies for advanced vehicles, including PHEVs, HEVs, and EVs, will be achieved by maintaining close collaboration among researchers, device manufacturers, and users of the technologies. The developed technologies will be tested at National Laboratories for validation of performance and conformance to specifications. Crosscutting technologies also will be evaluated for potential application for advanced vehicle applications. In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

SBIR/STTR	**0**	**3,011**	**3,830**

In FY 2008, $1,836,000 and $220,000 were transferred to the SBIR and STTR programs respectively. The FY 2009 and 2010 amounts shown are estimated requirements for the continuation of the SBIR and STTR program.

Total, Hybrid Electric Systems	**92,079**	**125,709**	**164,661**

Explanation of Funding Changes

	FY 2010 vs. FY 2009 ($000)
Vehicle and Systems Simulation and Testing	
The additional funds will be used to increase the number of PHEVs built by vehicle manufacturers and evaluated in the PHEV Technology Acceleration & Demonstration Activity. Additional advanced electric-drive vehicles, including hybrid electric vehicles and battery electric vehicles, will also be baseline tested and evaluated in cooperation with manufacturers, utilities and other industry partners. A portion of these funds will also be used to expand the laboratory and field evaluation of advanced prototype and pre-production electric drive vehicles with dual energy storage systems and other advanced energy storage devices, electric motors, and power electronics. Funds will be utilized to expand the evaluation of advanced HEVs and PHEVs in medium and heavy duty uses such as school buses, urban delivery vehicles, transit buses, and other applications.	+32,227
Technology Validation	
Funding for this activity is transferred from the VT Program to the Fuel Cell Technologies Program as part of a reprioritization of fuel cell and hydrogen-related work.	-14,789
Energy Storage R&D	
Near and mid-term activities continue to focus on the development and validation of low-cost, abuse-tolerant, and long-life Li-ion batteries for vehicle applications. The activity also expands the work on high-energy/high-power batteries for PHEVs, while the long-term activities will continue to examine innovative materials and electrochemical couples that offer the potential for significant improvements over existing technologies for use in both HEVs and PHEVs. These efforts are being coordinated with the Office of Science to assure best utilization of the research efforts. Additional activities will include R&D focused on reducing the cost to domestically synthesize and produce advanced materials in support of battery manufacturers.	+ 8,012
Advanced Power Electronics and Electric Motors R&D	
The additional funds will be used to expand the laboratory R&D in the areas of reliability packaging, and materials. Efforts to improve understanding of reliability issues will be accelerated with increased coordination with component manufacturers and OEMs. Emphasis on advanced packaging materials and techniques will be accelerated as part of R&D of advanced power electronics technologies. New projects to transition and scale-up prototype advanced DC bus capacitors will begin. These new efforts will speed the transition of these new technologies to industry, which will allow for smaller and lower cost power electronics. Also, research to replace expensive rare earth magnetic materials used in electric motors will be expanded. Joint focus and efforts with other programs and agencies in wide bandgap materials, capacitors and	

	FY 2010 vs. FY 2009 ($000)
magnets will be emphasized and enhanced to enable earlier use of advanced devices and components. These funds will also be used to initiate a new solicitation for industry contracts to develop advanced power electronics and electric machines to meet the challenges associated with increased vehicle electrification. The new awards will enable substantial reductions in cost, weight, and volume, while ensuring a domestic supply chain. Emphasis will be placed on R&D projects to develop advanced packaging, improve reliability, and manufacturability. Awards will also accelerate the technology transfer from research organizations to domestic manufacturers.	+12,683
SBIR/STTR	
Changes in the SBIR/STTR funding are a direct result of changes in the funding of program activities and projected allocation among activities.	+819
Total Funding Change, Hybrid Electric Systems	**+38,952**

Advanced Combustion Engine R&D
Funding Schedule by Activity

	(dollars in thousands)		
	FY 2008	FY 2009	FY 2010
Advanced Combustion Engine R&D			
Combustion and Emission Control	38,906	35,089	47,239
Solid State Energy Conversion	4,537	4,568	8,748
SBIR/STTR	— [a]	1,143	1,613
Total, Advanced Combustion Engine R&D	43,443	40,800	57,600

Description

The Advanced Combustion Engine R&D subprogram focuses on removing critical technical barriers to commercialization of higher efficiency, advanced internal combustion engines for passenger and commercial vehicles. The goals are to improve the fuel efficiency of internal combustion engines for passenger vehicle applications from 30 percent in 2002 to 45 percent by 2010, and for commercial vehicles from 40 percent in 2002 to 55 percent by 2017, while meeting cost, durability, and emissions constraints. Research will be conducted in collaboration with industry and industry partnerships, National Laboratories, and universities followed by demonstrations on vehicle platforms. The Advanced Combustion Engine R&D subprogram includes Combustion and Emission Control R&D and Solid State Energy Conversion activities.

The most promising method to reduce petroleum consumption in the mid-term (10 to 20 years) – or until fuel-cell HEVs dominate the market – is to develop high-efficiency internal combustion engines and enable their introduction in conventional vehicles, HEVs and PHEVs. Improvements in engine efficiency alone have the potential of increasing fuel economy by 40 to 50 percent. Accelerated research on advanced combustion regimes, including homogeneous charge compression ignition (HCCI) and other modes of low-temperature combustion and lean-burn gasoline operation, is aimed at realizing this potential.

Benefits

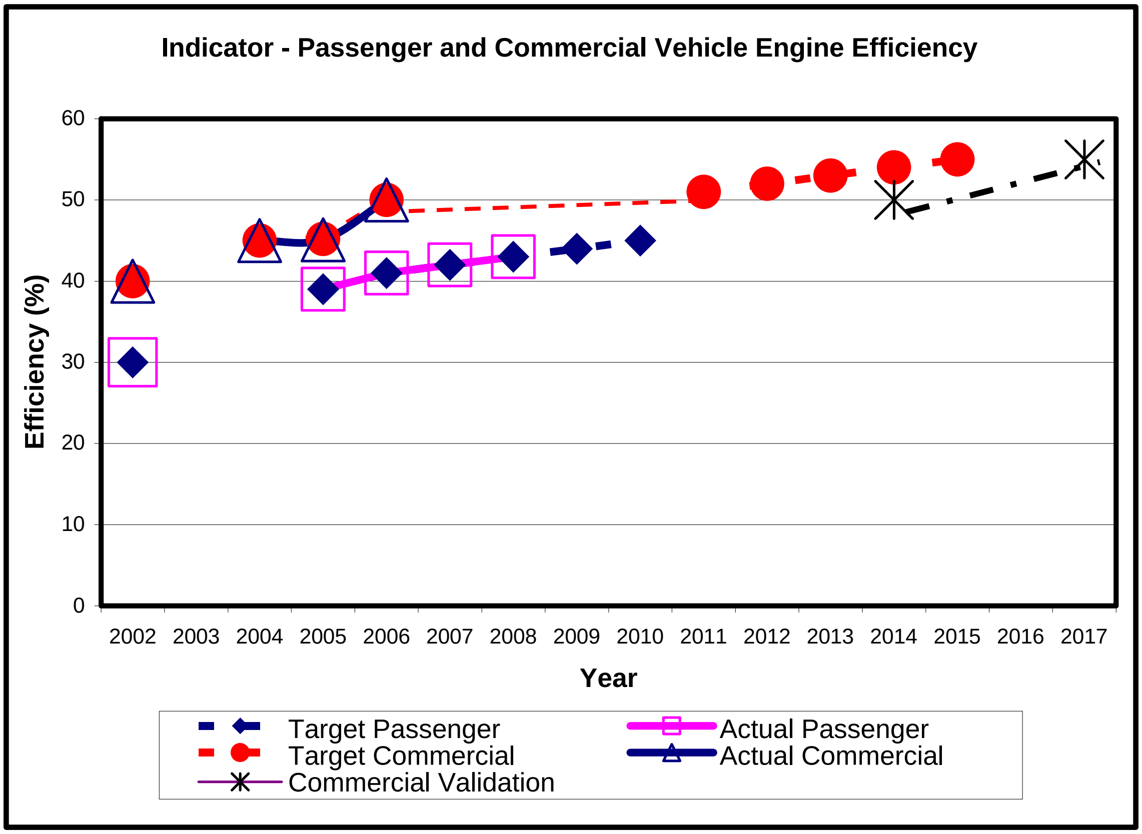
The Advanced Combustion Engine R&D subprogram and Fuel Technology subprogram contribute to the VT Program goals by dramatically improving the efficiency of internal combustion engines and will identify fuel properties that improve the system efficiency or can displace petroleum based fuels. Improved efficiency and petroleum displacement can directly reduce petroleum consumption.

The following are representative goals of the Advanced Combustion R&D subprogram that can contribute to meeting national energy security, environmental, and economic objectives:

- Passenger vehicles: Improve the efficiency of internal combustion engines from 30 percent (2002 baseline) to 45 percent by 2010; and
- Commercial vehicles: Improve the efficiency of internal combustion engines from 40 percent (2002 baseline) to 50 percent (20 percent improvement in fuel economy) by 2014 and further improve engine efficiency to 55 percent by 2017 with demonstrations on commercial vehicle platforms utilizing advanced fuel formulations that incorporate a non-petroleum based blending agent to reduce petroleum dependence and enhance combustion efficiency.

[a] SBIR/STTR funding was transferred to the Science Appropriation in FY 2008.

Progress is indicated by efficiency of passenger and commercial vehicle internal combustion engines and is shown graphically below.



Note: 2002 value is baseline.

Detailed Justification

	(dollars in thousands)		
	FY 2008	FY 2009	FY 2010
Combustion and Emission Control	**38,906**	**35,089**	**47,239**

Combustion and Emission Control research supports the VT Program goal of enabling energy-efficient, clean vehicles powered by advanced internal combustion engines using clean, petroleum- and non-petroleum-based fuels and hydrogen**.** This activity develops technologies for advanced engines with the goal of improving thermal efficiency by optimizing combustion, fuel injection, air handling, emission control, and waste heat recovery systems, along with reducing friction and pumping losses, while ensuring that no new toxic air emissions are generated. The activity will be closely coordinated with VT's Fuels Technology subprogram as different fuel characteristics and reduced property variability may be needed to meet the goals.

This activity focuses on developing cost-competitive technologies for passenger and commercial vehicle engines operating in advanced combustion regimes, including HCCI and other modes of low-temperature combustion (LTC), which will increase efficiency beyond current advanced diesel levels and further reduce engine-out emissions of NO_x and particulate matter (PM) to near-zero levels.

Although advanced diesel engine technology has demonstrated Tier 2 emissions performance, the current energy consumption, cost, and durability of the emission control system will limit the rate of market penetration. To address this issue, in parallel with advanced combustion regime development, innovative emission control strategies will be pursued through National Laboratory and university projects designed to reduce cost and increase performance and durability of NO_x reduction and PM oxidation systems. Project areas include development of low-cost base metal catalysts (to replace expensive platinum group metals), lighter and more compact multifunctional components, and new control strategies.

By overcoming these challenges, more efficient lean-burn combustion engines can be cost-competitive with current gasoline engines in passenger vehicles, and further improve the efficiency and reduce the cost of engines used in commercial vehicles.

In FY 2010, the Combustion and Emission Control activity will continue emphasis on R&D of advanced combustion engines that can achieve the program's efficiency goals for passenger and commercial vehicles, while maintaining cost and durability levels and achieving near-zero regulated emissions. This activity will continue to fund cooperative agreements awarded in FY 2007 and FY 2009 for passenger vehicle low temperature combustion technologies and advanced power-train systems targeting a 25 to 40 percent improvement in vehicle fuel economy. FY 2010 funding will complete previous competitively-awarded cooperative agreements for improving heavy-duty engine efficiency through the utilization of advanced combustion regimes (HCCI, LTC and mixed-mode and utilization of waste heat recovery). The activity will continue to fund awards from the FY 2009 solicitation to work in partnership with the commercial vehicle industry on incorporating advanced engine technologies capable of demonstrating 50 percent thermal efficiency and a 20 percent fuel economy improvement in a Class 8 truck by 2014. A parallel path will be followed to demonstrate the feasibility of achieving 55 percent engine efficiency in a laboratory while meeting prevailing emissions standards. The selected participants will develop a complete engine system incorporating technologies for heavy-duty diesel engines, such as optimized combustion, fuel injection, emissions control, and waste heat recovery systems while reducing parasitic losses, friction and pumping losses, to meet these engine system goals.

Examples of specific activities to be conducted for passenger and commercial vehicles include the development of multi-mode combustion processes which combine the various forms of HCCI, partial HCCI, traditional diffusion combustion, and lean-burn combustion with gasoline and ethanol. Components needed to enable the advanced combustion system described above will include advanced ultra high pressure fuel injection and charge air systems, high flow exhaust gas recirculation systems and waste heat recovery. Advanced injectors must be capable of tightly packed multiple injection events within a given engine cycle. Advanced charging air systems will allow for precision control of air flow and charge temperature. Efforts also will be undertaken to develop and integrate innovative control strategies for NO_x and PM emissions to meet the durability requirement of 435,000 miles for commercial vehicles and 120,000 for passenger vehicles, while both meeting emission standards and anticipating changes in emission control strategies and regulations due to changing engine-out emissions constituents. The activity will also investigate the use of these advanced technologies for off-highway and locomotive applications.

The activity will conduct optical laser diagnostics of in-cylinder combustion processes for advanced combustion regimes such as HCCI, other modes of LTC, and mixed-mode regimes. Through simulation and experimentation, it will also conduct R&D on advanced thermodynamic strategies that will enable engines to approach 60 percent thermal efficiency. The activity also will utilize laser-based, optical diagnostics to conduct in-cylinder engine research focused on overcoming barriers to the development of high-efficiency, hydrogen-fueled IC engine technology in coordination with the Fuel Cell Technologies Program. Development of detailed chemical kinetic models of advanced combustion regimes and emissions processes will continue, including fuel composition effects, that will aid the development of advanced, high-efficiency combustion engines using LTC and mixed-mode combustion regimes. The activity will utilize x-rays from the Advanced Photon Source to study fuel-injection spray characteristics near the injection nozzle.

Cost-shared cooperative agreements awarded in FY 2009 to automotive suppliers and universities will continue to develop innovative component technologies such as variable valve timing, variable compression ratio, and NO_x and PM sensors that enable cost-effective implementation of advanced combustion engines with high efficiency and near-zero emissions of NO_x and PM.

Also in FY 2010, the fifth full year of the Advanced Collaborative Emissions Study (ACES) will continue to generate and characterize emissions from 2010 emissions compliant commercial vehicle diesel engines and from Selective Catalytic Reduction (SCR) Urea after-treatment devices. DOE is responsible for the generation, characterization and collection of samples for ACES. These characterized engine emissions have been routed to expose animals (rats and mice) beginning last year and will continue through FY 2011 for chronic bioassays of tissue samples from these animal exposures supported by the other ACES sponsors.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

Solid State Energy Conversion	**4,537**	**4,568**	**8,748**

The Solid State Energy Conversion activity develops technologies to convert waste heat from engines and other sources to electrical energy to improve overall thermal efficiency and reduce emissions. This activity will focus on the R&D of thermoelectrics and other solid state systems that recover energy from waste heat.

In FY 2010, the activity will continue to fund cost-shared cooperative agreements awarded in FY 2009 to develop and fabricate high efficiency thermoelectric generators and thermoelectric air conditioning for passenger vehicles. Thermoelectric generators could directly convert a nominal 1kW of electric power from engine waste heat for passenger vehicle and up to 5kW for commercial vehicles. These improvements could increase vehicle fuel economy by up to 10 percent. These agreement(s) will develop thermoelectric devices that can operate as coolers/heaters to replace current R134-a gas air conditioners in passenger and commercial vehicles.

The program will release a completive solicitation in FY 2010 for research in advanced thermoelectric materials and scale-up for demonstration in vehicle applications. This activity will also continue

	(dollars in thousands)		
	FY 2008	FY 2009	FY 2010

investigating the use of segmented or nano-modified bulk materials and high-efficiency materials that have shown potential for greater than 30 percent efficiency in laboratory evaluations. In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

SBIR/STTR	**0**	**1,143**	**1,613**

In FY 2008, $1,025,000 and $123,000 were transferred to the SBIR and STTR programs respectively. The FY 2009 and 2010 amounts shown are estimated requirements for the continuation of the SBIR and STTR program.

Total, Advanced Combustion Engine R&D	**43,443**	**40,800**	**57,600**

Explanation of Funding Changes

	FY 2010 vs. FY 2009 ($000)
Combustion and Emission Control	
The Combustion and Emission Control activity will continue emphasis on the RD&D of advanced combustion engines that can achieve the program's efficiency goals for passenger and commercial vehicles while maintaining cost and durability levels, and achieving near-zero regulated emissions. The most promising method to reduce petroleum consumption in the mid-term (10 to 20 years) is to improve the efficiency of advanced internal combustion engines and enable their rapid introduction in conventional vehicles, HEVs and PHEVs. The health impacts research will continue to evaluate the relative toxicity and consequent human health implications of emissions from new combustion technologies, new fuels derived from unconventional feedstocks, and new blending agents.	
FY 2010 funding for combustion engine R&D is increased to place greater emphasis on engine systems R&D. This will allow several awards that will be selected from the competitive solicitation issued in 2009 to develop a complete engine system capable of demonstrating 50 percent engine efficiency and a 20 percent improvement in fuel economy by 2014 for commercial vehicles, and a 25 to 40 percent improvement in fuel economy for passenger vehicles. This selection will be focused on the highest risk technologies with industry absorbing more of the moderate risk R&D activities.	+12,150

	FY 2010 vs. FY 2009 ($000)
Solid-State Energy Conversion (formerly Waste Heat Recovery)	
The Solid State Energy Conversion activity develops thermoelectrics and other solid state systems that recover energy from waste heat and also can operate as coolers/heaters. The increase in funding will allow continuation of cooperative agreements awarded in FY 2009 to develop first-generation thermoelectric devices that can operate as coolers/heaters to replace current R134-a gas air conditioners. The increase will also fund competitively selected awards on an FY 2010 solicitation focused on demonstrating thermoelectric devices in vehicle applications and on research of the next generation of advanced thermoelectric materials.	+4,180
SBIR/STTR	
Changes in the SBIR/STTR funding are a direct result of changes in the funding of program activities and projected allocation among activities.	+470
Total Funding Change, Advanced Combustion Engine R&D	**+16,800**

Materials Technology
Funding Schedule by Activity

(dollars in thousands)

	FY 2008	FY 2009	FY 2010
Materials Technology			
Propulsion Materials Technology	9,654	10,742	13,666
Lightweight Materials Technology	22,383	22,374	34,039
High Temperature Materials Laboratory	6,579	5,670	5,662
SBIR/STTR	— [a]	1,117	1,538
Total, Materials Technology	38,616	39,903	54,905

Description

The Materials Technologies subprogram supports the development of cost-effective materials and materials manufacturing processes that can contribute to fuel-efficient passenger and commercial vehicles. This subprogram contributes to concepts developed throughout the VT Program. The subprogram consists of three activities: Propulsion Materials Technology, Lightweight Materials Technology, and the High Temperature Materials Laboratory (HTML).

Benefits

The Materials Technology subprogram contributes to the VT Program goal by developing higher performing, more cost-effective materials that will make lighter vehicle structures and more efficient power systems. Lighter vehicles require less energy to operate and thus reduce fuel consumption. Likewise, better propulsion materials can enable more efficient power systems that will contribute to a vehicle's reduced energy consumption.

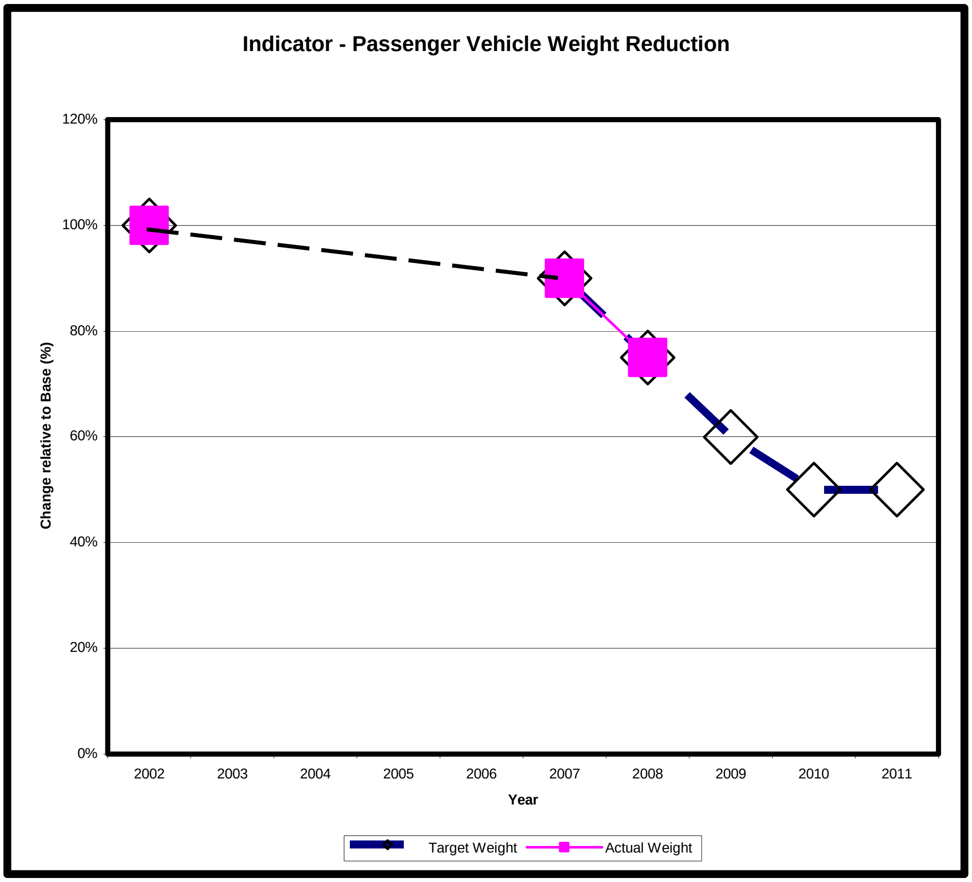
The following representative goal of the Materials Technology subprogram can contribute to meeting national energy security, environmental, and economic objectives:

- By 2010, develop material and manufacturing technologies which, if implemented in high volume, could cost-effectively reduce the weight of passenger vehicle body and chassis systems by 50 percent with safety, performance, and recyclability comparable to model-year 2002 vehicles.

This is a broader goal than the previous subprogram goal of reducing the projected mass-production price of carbon-fiber materials to $3 per pound. The broader goal encompasses both further progress in carbon-fiber composites and advances in a variety of other lightweight automotive materials.

Progress is indicated by the change in vehicle weight (percent relative to baseline) as determined from materials development progress and the corresponding modeled change in vehicle weight. Annual progress is shown graphically below.

[a] SBIR/STTR funding was transferred to the Science Appropriation in FY 2008.



Note: 2002 value is baseline

Detailed Justification

	(dollars in thousands)		
	FY 2008	FY 2009	FY 2010
Propulsion Materials Technology	**9,654**	**10,742**	**13,666**

The Propulsion Materials Technology key activity will conduct R&D on improved materials that will enable development of highly efficient propulsion systems for advanced passenger cars and commercial vehicles operating on a combination of conventional and non-petroleum fuels. Improved propulsion materials are critical for the performance and cost targets of advanced technologies being developed by the VT Program.

In FY 2010, Propulsion Materials will conduct targeted materials research that complements the efforts of three VT teams: 1) Advanced Combustion Engines; 2) Fuels; and 3) Hybrid Electric Systems supporting the efficiency and petroleum displacement goals. In support of the Advanced Combustion Engines team, Propulsion Materials will use specialized characterization and processing techniques to develop materials for in-cylinder thermal management, friction reduction, improved dynamic response, increased power to weight ratios, and robust catalysts for emissions control.

Propulsion materials will quantify potential efficiency improvements by evaluating prototype components in research engines. Technology transfer tasks will communicate these results to industry to accelerate deployment of beneficial technologies.

Implications of utilizing new fuel formulations in internal combustion engines on the durability of fuel systems and engine components will be evaluated in concert with Fuels Technology research. Propulsion materials will develop new materials and processing techniques that mitigate fuel-materials interaction issues. The program will also develop improved thermoelectric materials that are durable, efficient, and operate in temperature ranges of interest for various applications.

Support for hybrid- and electric-drive systems will be expanded by addressing materials requirements for high efficiency components including improved materials for high efficiency electric motors, high-temperature power electronics, high performance electrical connections, and characterization and evaluation of battery component materials. Additional efforts will support the long-term sustainability of advanced batteries through the development of materials recycling and recovery techniques.

Activities will include collaborative, pre-competitive R&D with support to automotive suppliers. States and other automotive manufacturing organizations to develop promising new technologies for energy efficient, performance-specific, factory-ready materials, processes, and designs. In addition, these funds may support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

Lightweight Materials Technology	**22,383**	**22,374**	**34,039**

This activity supports R&D on advanced concepts to reduce the weight of vehicles, accomplished primarily by substitution of lower density or stronger materials for current materials. Materials include magnesium, aluminum, advanced high-strength steels, titanium as well as polymer- and metal-matrix composites reinforced with fibers and particulates including *in-situ*-grown. Since cost-effectiveness is the major materials challenge, this element supports research, development and validation of materials needed to meet the FreedomCAR goal of 50 percent body and chassis weight reduction, as well as designing and manufacturing components and structures from these materials. The objective is to lower the potential costs and cost uncertainties of advanced materials to approach the FY 2010 goal of cost neutrality.

In FY 2010 increased funding will focus on new development and demonstrations at pilot-scale of technologies for reducing the effective costs of automotive aluminum, magnesium, carbon-fiber and carbon-fiber composites and components and structures made from these materials.

High Temperature Materials Laboratory (HTML)	**6,579**	**5,670**	**5,662**

FY 2010 funding will provide continued support of the HTML and the HTML user program, with increased emphasis on industrial user needs. The HTML facility is an advanced materials characterization R&D industrial user center located at the Oak Ridge National Laboratory. The HTML strives to maintain world-class, state-of-the-art advanced materials characterization (i.e., the determination of the composition and structure of materials which determine their properties and functionality) capabilities not available elsewhere and makes them available to U.S. industries (at

	(dollars in thousands)		
	FY 2008	FY 2009	FY 2010

nominal or no cost, especially small businesses), and academia for use in solving complex materials problems. It develops cutting-edge analytical techniques to identify innovative materials for use in transportation applications.

Activities include the investigation and determination of the composition, structure, physical and chemical properties and performance characteristics of metals, alloys, ceramics, composites, and even novel nano-phase materials under development for vehicle applications. Experience has shown that technologies needed to enhance vehicle fuel and energy efficiency are often limited by the performance and cost of the materials needed to manufacture these technologies. Past increases in funding enabled the acquisition of new analytical capabilities at the HTML, including instruments and tools to characterize the properties and performance of new high efficiency thermoelectric materials (e.g., Seebeck Coefficient); deployment of an intense neutron flux diffractometer, VULCAN, enabling research on chemical reactions occurring in the solid state and rapidly occurring changes in materials subjected to stresses; and a special purpose scanning transmission electron microscope (STEM) modified for in-situ characterization of catalysts, advanced battery, and thermoelectric materials. These enhanced capabilities are now paying dividends by helping companies solve materials problems occurring from recent changes in fuel composition, such as the addition of ethanol to gasoline and the removal of sulfur from diesel fuel. The HTML user program also provides funding for some pre-competitive non-proprietary research projects submitted by academia and U.S. companies for the advancement of high efficiency vehicle transportation technologies in alignment with the goals of the FreedomCAR and 21st Century Truck partnerships. Typically, 100 projects are completed each year, with results published in peer reviewed journals, industry presentations, and trade press.

SBIR/STTR	**0**	**1,117**	**1,538**

In FY 2008, $911,000 and $109,000 were transferred to the SBIR and STTR programs respectively. The FY 2009 and 2010 amounts shown are estimated requirements for the continuation of the SBIR and STTR program.

Total, Materials Technology	**38,616**	**39,903**	**54,905**

Explanation of Funding Changes

	FY 2010 vs. FY 2009 ($000)
Propulsion Materials Technology	
The additional funds will be used to expand laboratory R&D in the areas of biofuels materials compatibility and high efficiency electric motor magnetic materials. The biofuels efforts will expand and accelerate efforts to mitigate interactions identified between biofuels and engine materials that impact the reliability of those systems. These efforts will be coordinated with OEMs, component suppliers, and other programs to ensure efficient technology transfer. A magnetic materials effort will be initiated to develop non-rare earth magnets for high efficiency electric motors. This work represents a critical issue for competitive production of domestic hybrid electric vehicles and will be conducted in concert with other programs, agencies, and industry partners to accelerate the market penetration of devices using these materials.	+2,924
Lightweight Materials Technology	
The increase will fund new development and demonstrations at pilot-scale of technologies for reducing the effective costs of automotive aluminum, magnesium, carbon-fiber and carbon-fiber composites and components and structures made from these materials.	+11,665
High Temperature Materials Laboratory	
No significant change.	-8
SBIR/STTR	
Changes in the SBIR/STTR funding are a direct result of changes in the funding of program activities and projected allocation among activities.	+421
Total Funding Change, Materials Technology	**+15,002**

Fuels Technology
Funding Schedule by Activity

(dollars in thousands)

	FY 2008	FY 2009	FY 2010
Fuels Technology			
Advanced Petroleum Based Fuels (APBF)	6,466	5,808	6,780
Non-Petroleum Based Fuels and Lubricants (NPBFL)	10,910	13,751	17,639
SBIR/STTR	— [a]	563	703
Total, Fuels Technology	17,376	20,122	25,122

Description

The Fuels Technology subprogram supports R&D that will provide vehicle users with cost-competitive fuel options that enable high fuel economy with low emissions, and contribute to petroleum displacement. Tightening emissions standards present a challenge to advanced engine technologies which, even now, are more sensitive to variations in fuel composition than earlier engines. Different fuels meeting the same specifications can have widely varying impact on engine performance and emissions. This trend is likely to be accentuated as technology advances and emissions standards become progressively more stringent. Future refinery feedstocks may increasingly be from non-conventional sources including, but not limited to, oil sands, shale oil, and tar sands. The impact of changes in refinery feedstocks on finished fuels is an area of relatively new concern to engine manufacturers, regulators and users. Balance of refinery feedstocks also has to be considered to ensure that the slate of refining products matches end-use needs and is efficiently accommodated. In the nearer term, this subprogram addresses technology barriers associated with increased use of biomass-based fuels as blendstocks with conventional fuels.

Benefits

This subprogram supports the mission of the VT Program to develop more energy-efficient and environmentally-friendly highway transportation vehicles that enable America to use less petroleum. It consists of two activities, Advanced Petroleum-Based Fuels (APBF) and Non-Petroleum-Based Fuels and Lubricants (NPBFL). These activities have been coordinated with, and are supportive of, EPA's fuels and emissions related activities.

The APBF and NPBFL activities are undertaken: (1) to enable advanced combustion regime engines and emission control systems to be more efficient while meeting future emission standards; and (2) to reduce reliance on petroleum-based fuels through direct fuel substitution by non-petroleum-based fuels. To differentiate these two activities, an advanced petroleum-based fuel is envisioned as consisting primarily of highly-refined, petroleum-derived base fuel comprising a likely-future mix of refinery feedstocks, possibly blended with performance-enhancing non-petroleum components derived from renewable resources such as biomass, or from non-petroleum or non-conventional fossil resources such as natural gas or coal. In contrast, a non-petroleum-based fuel consists of components derived primarily from non-crude-oil sources, such as agricultural products or other biomass. The APBF activity represents the

[a] SBIR/STTR funding was transferred to the Science Appropriation in FY 2008.

harmonization of the fuel requirements of advanced engine and vehicle manufacturers with the product specifications of future refineries. The additional benefit of NPBFL is that it will provide non-petroleum-based blendstock specifications to enable both high fuel economy and direct displacement of petroleum fuels.

Detailed Justification

	(dollars in thousands)		
	FY 2008	FY 2009	FY 2010
Advanced Petroleum Based Fuels (APBF)	**6,466**	**5,808**	**6,780**

The APBF activity develops petroleum-based fuels and lubricants that will enable extremely high efficiency engines for passenger and commercial vehicle applications. This effort employs the expertise and shared funding of the Federal government, energy companies, emission control manufacturers, and engine and vehicle manufacturers. The main goal is to identify and exploit fuel properties that can enable engines to operate in the highest-efficiency mode while meeting future emissions standards and to expand the operating conditions in which maximum efficiency is achievable. These activities are undertaken in close coordination with the Advanced Combustion Engine R&D subprogram.

In FY 2010, APBF will continue to study the effects of physical and chemical property variation in petroleum-based fuels on the performance and emissions of advanced combustion engines, in cooperation with the Advanced Combustion Engine subprogram.

Also in FY 2010, APBF will continue to monitor data in the open literature and within the VT technology portfolio resulting from use of fuels developed under the Fuels for Advanced Combustion Engines (FACE) activity to determine whether FACE fuels matrices require parametric revision based on FY 2009 data.

Also in FY 2010, APBF will initiate analysis of the flexibility of the U.S. petroleum fuel production, distribution, and retailing infrastructure with respect to changes in physical and chemical properties of gasoline and diesel fuel for transportation use and other petroleum-based products and fuels. This activity will begin with a broad literature review and research survey that includes input from the industries impacted. Affected industry participants and relevant issues will be identified through a series of technical workshops. In addition, these funds will support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

Non-Petroleum Based Fuels and Lubricants (NPBFL)	**10,910**	**13,751**	**17,639**

The NPBFL activity formulates and evaluates non-petroleum-based fuels and lubricants that can be used as neat (pure) alternative fuels or as blendstocks in transportation fuels. With a primary focus on biomass-based renewable and synthetic fuels, specific areas being investigated include fuel quality and stability; detailed chemical composition and its relationship to fuel bulk properties; the effect of physical and chemical properties on engine performance and emissions; and safety associated with storage, handling, and toxicity.

In FY 2010, the activity will continue studies of the effects of physical and chemical property variation in synthetic and renewable fuels on the performance and emissions of advanced combustion engines, in cooperation with the Advanced Combustion Engine subprogram. The activity also will continue to monitor data in the open literature and within the VT technology portfolio on testing with FACE fuel formulations to determine whether the non-petroleum-containing FACE fuels within the matrices require parametric revision based on FY 2008 data.

In addition, the activity will:

- Complete work on ethanol-optimized engines aimed at minimizing the ethanol MPG efficiency penalty for second generation flexible-fuel vehicles (FFVs), so project partners can accelerate market introduction of improved engine & vehicle systems for renewable fuels.
- Continue testing intermediate ethanol blends (between 10 percent and 50 percent) to determine impact on emissions, fuel-system materials, control systems, operability, and durability of emission-control systems for automotive and non-road engines, and related fueling station components (in cooperation with EPA, the automotive industry, the non-road engine industry, and fuel providers). This work will help identify critical technical and safety issues that must be addressed before ethanol based fuels can be introduced in significant volumes to broader engine and vehicle markets; and
- Continue monitoring fuel quality and utilization for biomass-derived diesel fuels.
- Expand studies of the next generation of biomass-derived transportation fuels. Such fuels are more compatible with existing fuel production, distribution, and fueling infrastructure than the current generation of fuels (e.g., starch-derived ethanol and ester-type biodiesels). They enable a more-efficient use of current biomass feedstock resources and expand the potential resource base beyond starches and food oils. They are also more familiar from the perspective of consumers and therefore less likely to fail due to a lack of customer acceptance or poor compatibility with existing vehicles. Finally, many potential next generation biofuels have a vastly-better GHG profile than the current generation of biofuels. A comprehensive R&D and testing program will be developed to fully evaluate these fuels in cooperation with industry and other stakeholders.

In addition, these funds will support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

	FY 2008	FY 2009	FY 2010
SBIR/STTR	**0**	**563**	**703**

In FY 2008, $411,000 and $49,000 were transferred to the SBIR and STTR programs respectively. The FY 2009 and 2010 amounts shown are estimated requirements for the continuation of the SBIR and STTR program.

	FY 2008	FY 2009	FY 2010
Total, Fuels Technology	**17,376**	**20,122**	**25,122**

Explanation of Funding Changes

	FY 2010 vs. FY 2009 ($000)
Advanced Petroleum Based Fuels (APBF)	
The increased funding will allow initiation of a petroleum product infrastructure flexibility analysis.	+972
Non-Petroleum Based Fuels (NPBF)	
In FY 2010, NPBF will continue studies of the effects of physical and chemical property variation in synthetic and renewable fuels on the performance and emissions of advanced combustion engines, in cooperation with the Advanced Combustion Engine subprogram. The increase in this area reflects increased emphasis on the evaluation of intermediate blends of ethanol and renewed efforts to optimize the performance of engines and vehicle systems that use non-petroleum-based alternative fuels. The increase will also initiate evaluation of the next generation of biomass-derived fuels for diesel and gasoline vehicles.	+3,888
SBIR/STTR	
Changes in the SBIR/STTR funding are a direct result of changes in the funding of program activities and projected allocation among activities.	+140
Total Funding Change, Fuels Technology	**+5,000**

Technology Integration
Funding Schedule by Activity
(Non-Comparable, or as-Appropriated, Structure)

(dollars in thousands)

	FY 2008	FY 2009	FY 2010
Technology Integration			
Graduate Automotive Technology Education (GATE)	496	950	1,000
Advanced Vehicle Competitions	1,387	1,750	2,000
Education	—	4,200[a]	—[b]
Safety and Code and Standards	—	12,238[c]	—[d]
Legislative and Rulemaking	1,986	1,804	2,004
Vehicle Technologies Deployment	12,481	25,000	25,510
Biennial Peer Reviews	495	500	500
SBIR/STTR	—[e]	262	0
Total, Technology Integration	16,845	46,704	31,014

[a] In FY 2009, the Education activity was transferred from the Hydrogen Technology Program (now the Fuel Cell Technologies Program) to the VT Program.
[b] In FY 2010, the Education activity is transferred from the VT Program to the Fuel Cell Technologies Program as part of a reprioritization of fuel cell and hydrogen-related R&D.
[c] In FY 2009, the Safety and Codes & Standards activity was transferred from the Hydrogen Technology Program (now the Fuel Cell Technologies Program) to the VT Program.
[d] In FY 2010, the Safety and Codes & Standards activity is transferred from the VT Program to the Fuel Cell Technologies Program as part of a reprioritization of fuel cell and hydrogen-related R&D.
[e] SBIR/STTR funding was transferred to the Science Appropriation in FY 2008.

Technology Integration
Funding Schedule by Activity
(Comparable Structure to the FY 2010 Request)

(dollars in thousands)

	FY 2008	FY 2009	FY 2010
Technology Integration			
Graduate Automotive Technology Education (GATE)	496	950	1,000
Advanced Vehicle Competitions	1,387	1,750	2,000
Education	—	*4,200*[a]	—
Safety and Code and Standards	—	*12,238*[b]	—
Legislative and Rulemaking	1,986	1,804	2,004
Vehicle Technologies Deployment	12,481	25,000	25,510
Biennial Peer Reviews	495	500	500
SBIR/STTR	—[c]	0	0
Total, Technology Integration	16,845	30,004	31,014

Description

Modifications were made to the budget structure to better reflect the Technology Integration subprogram's activities in FY 2010. The two tables above show a non-comparable and comparable funding profile for the subprogram. The non-comparable table presents the FY 2010 funding in the new budget structure only and FY 2008 and FY 2009 funding is shown as appropriated. The comparable table shows the FY 2008 and FY 2009 funding in the new budget structure to assist in comparing year-to-year funding trends.

The Technology Integration subprogram accelerates the adoption and use of alternative fuel and advanced technology vehicles, including fuel cell vehicles, to help meet national energy and environmental goals and accelerate dissemination of advanced vehicle technologies through demonstrations and education. These efforts follow successful research by industry and government and help to accelerate the commercialization and/or widespread adoption of technologies that are developed in other VT program areas. Deployment activities linked to R&D also provide early market feedback to emerging R&D.

Subprogram functions include both regulatory and voluntary components. The regulatory elements include legislative, rulemaking, and compliance activities associated with alternative fuel requirements identified by EPAct 1992 and 2005. Voluntary efforts include demonstration of advanced technology vehicles to verify market readiness, and public information, education, outreach and technical assistance efforts. The VT Program works with public/private partnerships between DOE and local coalitions of key stakeholders across the country (such as Clean Cities) to implement strategies and projects that

[a] In FY 2009, the Education activity was transferred from the Hydrogen Technology Program (now the Fuel Cell Technologies Program) to the VT Program.
[b] In FY 2009, the Safety and Codes & Standards activity was transferred from the Hydrogen Technology Program (now the Fuel Cell Technologies Program) to the VT Program.
[c] SBIR/STTR funding was transferred to the Science Appropriation in FY 2008.

displace petroleum. In addition, the annual DOE/EPA Fuel Economy Guide publication and related data dissemination efforts (required by law) are produced, along with the website www.fueleconomy.gov.

The Education activity aids in overcoming institutional barriers to widespread use of advanced vehicle technologies and alternative fuels. Activities such as the Advanced Vehicle Competitions and GATE encourage the interest of university student engineers and engage their participation in advanced technology development. This helps address the need for more highly trained engineers in hybrid and fuel cell technologies to overcome barriers in the market place. The GATE effort also supports a pipeline into the auto industry of new engineers familiar with the most advanced technologies. In addition, unlike other more familiar alternative fuels and technologies, low awareness and false perceptions about safety risks of hydrogen threaten the success of demonstration projects and future commercialization. Education can overcome these significant challenges by training critical needs personnel, making available objective and technically-accurate information to decision-makers at the state and local levels, and building public confidence in the safe use of hydrogen and fuel cells, as well as other alternative fuels and advanced vehicle technologies.

Wide acceptance of hydrogen and other alternative fuel technologies depends on meeting safety standards in which the public has confidence. The Safety and Codes & Standards activity supports the establishment of a global technical regulation for hydrogen and fuel cell vehicles and infrastructure needed to allow the technologies to compete in a global market. To do this, the Safety and Codes & Standards activity funds research to provide the technical data on hydrogen technologies (such as fuel cells and hydrogen production, storage, and distribution systems) and other alternative fuels necessary to support and inform the codes and standards development process. Work includes fundamental studies to determine the flammability, explosive, reactive, and dispersion properties of hydrogen and other alternative fuels, and testing of components, subsystems, and systems to check design practices and verify failure-mode prediction analysis. The technical data obtained from these activities is provided to the appropriate codes and standards developing organizations (e.g., International Code Council, National Fire Protection Association) to write and publish applicable codes and standards. The subprogram will also support the development of passive and active safety systems based on new sensor technologies, and will fund comprehensive safety analysis of hydrogen components and systems.

The Legislative and Rulemaking activity implements a variety of statutory responsibilities placed on DOE by EPAct 2005 and other legislation. The main responsibilities include oversight and regulation of the requirements for States and alternative-fuel providers to operate AFV vehicle fleets.

Benefits

The Technology Integration subprogram contributes directly to the VT Program's climate benefits by accelerating the movement of advanced technologies into widespread usage. The university-based activities contribute to a "green" workforce that will incorporate energy efficiency thinking into their entire careers, and the deployment activity directly accelerates the movement of advanced-technology vehicles into the marketplace. Applied R&D benefits are not parsed to individual subprograms because of the interdependency of the research, development and technologies within the program. The VT Program continually assesses and draws from feedback, new information and advances among science, research, technologies and key market elements to accelerate the benefits of technology development and adoption.

Detailed Justification

	(dollars in thousands)		
	FY 2008	FY 2009	FY 2010
Graduate Automotive Technology Education (GATE)	**496**	**950**	**1,000**

In FY 2010, this activity will fund GATE Centers of Excellence (competitively selected) to develop new curricula and provide research fellowships for approximately 30 students for research in advanced automotive technologies. In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

Advanced Vehicle Competitions	**1,387**	**1,750**	**2,000**

In FY 2010, the Advanced Vehicle Competitions activity will conduct the second year of EcoCAR: the NeXt Challenge. Seventeen universities from North America are competing in EcoCAR to integrate advanced vehicle technologies (including fuel cells and PHEVs) and appropriate fuels to develop an approach that minimizes use of petroleum fuel. Many students who graduate from these vehicle competitions and from the GATE Program go on to jobs in the auto industry where they bring an unprecedented appreciation and understanding of advanced automotive efficiency technologies. In FY 2010 the program will also initiate planning for a follow-on advanced vehicle competition. In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

Education	**—**	***4,200***	**—**

In FY 2010, the Education activity is transferred from the VT Program to the Fuel Cell Technologies Program as part of a reprioritization of fuel cell and hydrogen-related work. In FY 2009, the Education activity is collaborating with Safety and Codes and Standards (also transferred to the Fuel Cell Technologies Program in FY 2010) to provide training for first responders and code officials to facilitate the approval and implementation of hydrogen and alternative fuel vehicle and refueling projects. Key target groups include fire-fighters and fire department training coordinators, law enforcement personnel, and emergency medical technicians, as well as code officials, fire marshals, city planners, and other hydrogen users.

Safety and Codes & Standards	—	**12,238**	—

In FY 2010 the Safety and Codes & Standards activity is transferred from the Vehicle Technologies Program to the Fuel Cell Technologies Program as part of a reprioritization of fuel cell and hydrogen-related work. The activity provides the underlying research to enable the development of technically sound codes and standards for the safe use of alternative fuels (including hydrogen) in all applications. The effort also supports the development of a global technical regulation (GTR) for hydrogen fuel cell vehicles. Global consistency in standards will ensure that different technologies need not be developed for each region of the world. The drafting and adoption of alternative fuel codes and standards is supported through the development of alternative fuel characterization and behavior data and through limited direct support of Standards Development Organizations (SDOs) and Codes Development Organizations (CDOs). Alternative fuel release data and incident scenario analysis supports a quantitative risk assessment approach for codes and standards development activities focused on enabling technology readiness. DOE collaborates with DOT, EPA, NIST and other government agencies to ensure that vehicle and fuel standards development proceeds in agreement with existing regulatory authorities. The cooperating agencies maximize available resources and expertise in areas such as alternative fuel vehicle dispensing measurement (NIST), vehicle safety (DOT National Highway Traffic Safety Administration) and international standards development (DOT, EPA).

	FY 2008	FY 2009	FY 2010
Legislative and Rulemaking	**1,986**	**1,804**	**2,004**

The Legislative and Rulemaking activity consists of implementation of the State and Alternative Fuel Provider Regulatory Program 10 CFR Part 490, alternative fuel designations, the Private and Local Government Fleet Regulatory Program, and the implementation of other EPAct 2005 requirements including reports and rulemaking, analyses of the impacts from other regulatory and pending legislative activities, and the implementation of legislative changes to the EPAct fleet activities as they occur. The fleet programs require selected covered fleets to procure passenger AFVs annually. DOE also reviews and processes petitions to designate new alternative fuels under EPAct. In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

	FY 2008	FY 2009	FY 2010
Vehicle Technologies Deployment	**12,481**	**25,000**	**25,510**

The Vehicle Technology Deployment activity promotes the adoption and use of petroleum reduction technologies and practices by working with Clean Cities coalitions and their stakeholders, industry partners, fuel providers, and end-users. Technology focus areas include: AFVs, alternative fuel infrastructure development, idling reduction for commercial trucks and buses, expanded use of non-petroleum and renewable fuel blends, hybrid vehicles, driving practices for improved efficiency, and engine/vehicle technologies that maximize fuel economy. Working in conjunction with technology experts at the National Laboratories, activities include outreach, training, and technical assistance related to each technology focus area. Critical tools and information will be provided via the Internet, telephone hotline, publications, and direct interaction with experts. The program also will continue efforts to provide technical assistance for early adopters of technologies and provide training and workshops to coalitions, public safety officials, and stakeholders related to infrastructure development and targeted niche market opportunities (transit, refuse trucks, school bus, delivery trucks, municipal fleets, etc.).

In support of the National Energy Policy, Section 405 of EPAct 1992, and Sections 721, 1001, and 1004 of EPAct 2005 that direct DOE to expand consumer education, to promote technology transfer, and to address implementation barriers, the program will identify and support opportunities to showcase the technology focus areas and continue to build national and regional alliances to promote petroleum reduction strategies and will support further expansion of ethanol infrastructure deployment. Public awareness of these technologies will be enhanced by high visibility demonstration projects at national parks and other public locations whenever possible. Efforts to support the development and promote the use of the (legislatively mandated) Fuel Economy Guide and associated www.fueleconomy.gov website also will continue. In addition, these funds may be used to support efforts such as technology transfer/technology exchange meetings and forums with industry stakeholders, peer reviews, data collection and dissemination, and technical, market feasibility, economic, and other analyses.

	(dollars in thousands)		
	FY 2008	FY 2009	FY 2010
Biennial Peer Reviews	**495**	**500**	**500**

Funding is used to conduct biennial reviews of the FreedomCAR and Fuel Partnership and the 21st Century Truck Partnership by an independent third party, such as the National Academy of Sciences/National Academy of Engineering, to evaluate progress and program direction. Reviews will include evaluation of progress toward achieving the technical and program goals supporting each partnership, as well as an assessment of the appropriateness of Federal investment in each of the activities. The FreedomCAR and Fuel Partnership review to be held in FY 2010 will address relevant elements of the VT Program. Based on evaluations, resource availability, and other factors, the partners will consider new opportunities, make adjustments to technology specific targets, and set goals as appropriate.

SBIR/STTR	**—**	**262**	**0**

In FY 2008, no funding was transferred to the SBIR and STTR programs respectively. The FY 2009 and 2010 amounts shown are estimated requirements for the continuation of the SBIR and STTR program.

Total, Technology Integration	**16,845**	**46,704**	**31,014**

Explanation of Funding Changes

	FY 2010 vs. FY 2009 ($000)
Graduate Automotive Technology Education	
No significant change.	+50
Advanced Vehicle Competitions	
Funding for EcoCAR: the NeXt Challenge was increased in FY 2010 to sustain the activity at planned levels.	+250
Education	
This activity is transferred from the VT Program to the Fuel Cell Technologies Program as part of a reprioritization of fuel cell and hydrogen-related work.	-4,200
Safety and Codes and Standards	
This activity is transferred from the VT Program to the Fuel Cell Technologies Program as part of a reprioritization of fuel cell and hydrogen-related work.	-12,238
Legislative and Rulemaking	
Increased funding will maintain effort at levels consistent with the needs of EPAct and EISA.	+200

	FY 2010 vs. FY 2009 ($000)
Vehicle Technology Deployment	
Increased funding will be used to expand efforts in consumer awareness, education, and outreach to be performed in cooperation with the private sector.	+510
Biennial Peer Reviews	
No change.	0
SBIR/STTR	
Changes in the SBIR/STTR funding are a direct result of changes in the funding of program activities and projected allocation among activities.	-262
Total Funding Change, Technology Integration	**-15,690**