Vehicle Technologies

Funding Profile by Subprogram

(dollars in thousands)

	FY 2010 Current Approp[a]	FY 2012 Request
Vehicle Technologies		
Batteries and Electric Drive Technology	98,566	188,000
Vehicle and Systems Simulation & Testing	43,732	58,000
Advanced Combustion Engine R&D	55,987	49,000
Materials Technology	49,303	38,000
Fuels Technology	23,421	18,503
Outreach, Deployment & Analysis	33,214	236,500
Total, Vehicle Technologies	304,223	588,003

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

Mission

The mission of the Vehicle Technologies Program (VTP) is to develop and promote energy-efficient and environmentally friendly transportation technologies that will enable America to use significantly less petroleum and reduce greenhouse gas (GHG) emissions while meeting or exceeding drivers' performance expectations and environmental requirements.

Benefits

The VTP mission and activities are planned and executed in a manner congruent with explicit and implicit national priorities, strategies, and goals. These activities will generate benefits in both the near- and long-term from technologies that address high priority issues of energy security, climate change, and economic impact. VTP's activities primarily focus on highway vehicles (passenger and commercial), which account for 55 percent of total U.S. oil use, more than all U.S. domestic oil production.[b] More energy-efficient, fuel-diverse, and cost-competitive vehicles will enable individuals and businesses to accomplish their daily tasks while reducing consumption of petroleum, lowering greenhouse gas (GHG) emissions, and decreasing energy expenditures. The President has announced and is proposing in the 2012 Budget a major new initiative to make the U.S. the first country to put 1 million electric vehicles on the road by 2015[c]. This initiative supports advanced technology vehicle manufacturing and adoption through new consumer rebates, investments in battery and electric vehicle R&D – including a new Energy Innovation Hub within the Office of Science -, and competitive programs to encourage

[a] SBIR/STTR funding transferred in FY 2010 was $6,377,000 for the SBIR program and $765,000 for the STTR program.
[b] Tables 1.13, 1.14, and figure 1.8 in the 29th edition of the Transportation Energy Data Book, 2010. See http://cta.ornl.gov/data/index/shtml.
[c] Remarks by the President in the State of Union Address, President Barrack Obama, United States Capital, January 25, 2011. http://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state-union-address

communities that invest in electric vehicle infrastructure. Within EERE this initiative includes funding for battery and electric vehicle R&D and a new $200 million competitive program to help communities become early adopters of electric vehicles through regulatory streamlining, infrastructure investments, vehicle fleet conversions, and other investments. 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]

The FY 2012 activities focus on meeting the President's 2015 electrification goal, and addressing key programmatic goals through 2020 and beyond. VTP's combined activities are intended to increase electrification and fuel efficiency thereby lowering GHG emissions, and, specifically, to meet the following goals:

- Invest in developing and deploying electric vehicle technologies enabling 1 million electric drive vehicles on the road by 2015.
- By 2020 save 1.8 million barrels per day of petroleum for highway use.
- Develop and deploy advanced battery manufacturing capacity to support 500,000 plug-in hybrid electric vehicles (PHEVs) a year by 2015.
- Develop technologies enabling the improvement of the fuel economy of new vehicles to achieve an average corporate average fuel economy (CAFE) standard of 37.8 miles per gallon (mpg) for cars and 28.8 mpg for light trucks by 2016.

These goals are supported by DOE's R&D investments in technology for vehicle energy efficiency and petroleum displacement, as well as by the American Recovery and Reinvestment Act (Recovery Act) efforts to establish manufacturing for advanced vehicles and batteries, demonstration of advanced vehicles, and improved fuels infrastructure and utilization.

The FY 2012 request supports these new efforts to encourage advanced technology vehicle manufacturing and adoption in the U.S., investments in R&D, and a program to help communities across the country become early adopters of electric vehicles. The vehicle technologies developed and manufactured with the support of annual appropriations and Recovery Act funding will help to improve the U.S. vehicle fleet fuel economy to meet strict new CAFE requirements. In addition, the Program targets are designed to take vehicle improvements well beyond those needed to meet CAFE. The chance of achieving these important goals has been greatly enhanced by the Recovery Act investments of up to $2.8 billion in advanced efficiency technologies for highway transportation. Recovery Act projects started in 2009 are expected to accelerate the introduction of PHEVs and other advanced efficiency technologies in cars and trucks, and to lower their cost by establishing manufacturing capacity for batteries and electric drives. Investments are being made in higher efficiency combustion engines, vehicle light-weighting, ethanol and biodiesel deployment, battery and electric drive manufacturing, and vehicle electrification deployment and infrastructure development because of the associated contributions to reduced transportation energy use. These efficiency gains and fuel alternatives also provide other benefits, such as improving air quality, reducing CO_2 emissions, and enhancing energy security.

To accelerate the introduction and market acceptance of electric vehicles, the Program is greatly expanding its emphasis on the electrification of the vehicle (i.e., new generations of hybrid electric vehicles, plug-in hybrids, electric vehicles) through research and development of batteries and power

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

electronics, systems R&D on the electric drive to improve performance and cost, development of EV supporting infrastructure (e.g., advanced chargers, streamlined codes and standards), and efforts to help communities across the country become early adopters of electric vehicles. In addition, the Program is focused on developing highly efficient trucks, the testing of non-petroleum fuels so that they can move seamlessly into the marketplace, and other work that will facilitate rapid introduction of these technologies. In FY 2012, efforts focus on the area of Energy Systems Simulation for Internal Combustion Engines for the development of advanced chemical kinetics, computational fluid dynamics and large eddy simulation models, and experimental verification to validate these models. Increased focus will also be placed on identifying common barriers and activities for future efforts in power electronics (PE), which is an essential component of almost every aspect of electric vehicles. Entirely new areas of activity will begin, including non- and off-highway activities to incorporate rail and off-highway transportation modes and associated opportunities to reduce petroleum use and GHG emissions, and a Vehicle Miles Traveled (VMT) Reduction and Legacy Fleet Improvement activity to support the more efficient use of existing light-duty vehicle stock. By modifying its portfolio to include improving the efficiency of off-road vehicles, addressing rail efficiency, and decreasing the energy used in vehicles already on the road, VTP will expand the number of transportation pathways through which DOE can help to reduce petroleum consumption. These activities generate three major types of benefits:

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. PHEVs will allow consumers to displace petroleum with electricity, based on price and convenience.

VTP contributes to reducing GHGs (most importantly CO_2) by providing technology which will make the Nation's highway vehicles more efficient and make it possible to use low carbon fuels. Lightweight materials, advanced combustion, and hybrid drive-trains all reduce CO_2 emissions. For example, a hybrid vehicle that combines advanced, more efficient combustion with lightweight materials and a hybrid drive-train could easily double the fuel efficiency of a conventional vehicle – resulting in half the GHG emissions.

New technologies developed and manufactured within the U.S., and fuels produced domestically, will create jobs and economic growth. Achieving the VTP goals for reducing the cost of advanced vehicle technologies will save the consumer money that can stimulate other areas of the economy and accelerate the adoption of efficient vehicles.

Annual Performance Results and Targets

The Department is in the process of updating its strategic plan, and has been actively engaging stakeholders including Congress. The draft strategic plan is being released for public comment concurrent with this budget submission, with the expectation of official publication this spring. The draft plan and FY 2012 budget are consistent and aligned. Updated measures will be released at a later date and available at the following link http://www.mbe.doe.gov/budget/12budget/index.htm.

Batteries and Electric Drive Technology

Funding Schedule by Activity

(dollars in thousands)

	FY 2010 Current Approp[a]	FY 2012 Request
Batteries and Electric Drive Technology		
Battery/Energy Storage R&D	76,271	136,080
Advanced Power Electronics and Electric Motors R&D	22,295	46,656
SBIR/STTR	0	5,264
Total, Batteries and Electric Drive Technology	98,566	188,000

Benefits

The Battery and Electric Drive Technology (BEDT) subprogram addresses the utilization of electric energy storage, electric drives, and energy recovery in new, more efficient vehicle designs. The subprogram funds R&D on the core technologies necessary for hybrid and electric vehicles to achieve significant improvements in fuel economy without sacrificing safety, the environment, performance, or affordability. The following measures of the BEDT subprogram can contribute to meeting strategic objectives of developing, demonstrating, and deploying clean, efficient energy technologies:

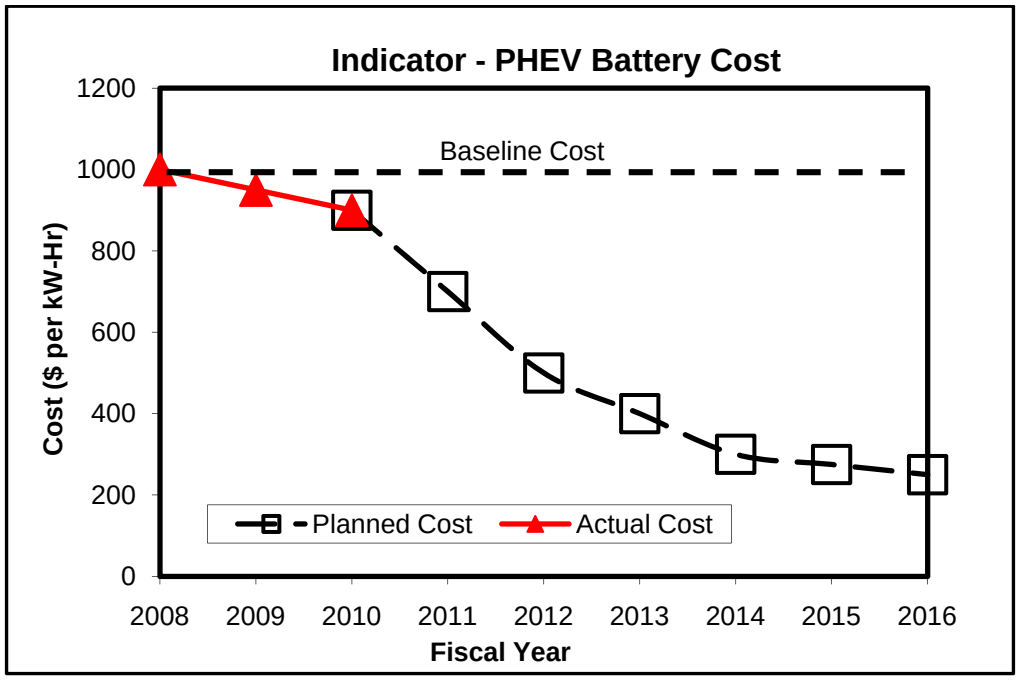
- Reduce the production cost of a high energy battery from $1,000/kWh in 2008 to $300/kWh by 2014, enabling cost competitive market entry of PHEVs.
- Reduce the cost of an electric traction drive system that can deliver 55kW of peak power for 18 seconds and 30kW of continuous power from $22/kW in 2008 to $12/kW in 2015, enabling cost competitive market entry of PHEVs and HEVs.

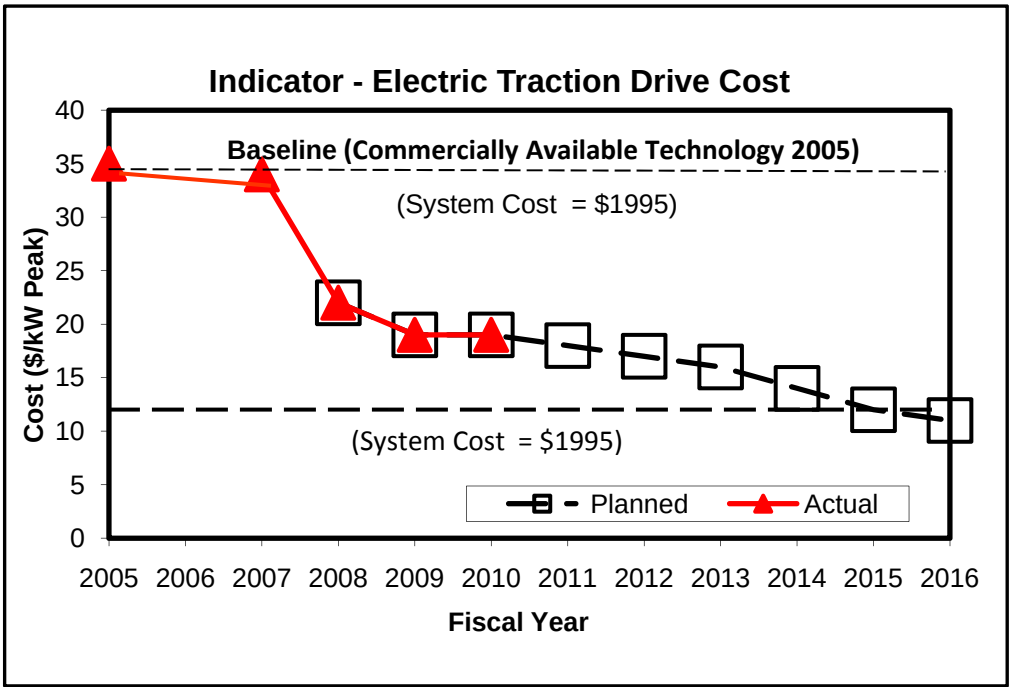
In FY 2012, the BEDT subprogram will continue to accelerate the development of low-cost, high-energy batteries and corresponding improvements to the electric drive systems (motors, power electronics, and electric controls) needed for cost-effective PHEVs. PHEVs offer the potential to provide significant additional fuel savings, particularly for commuter and local driving, for either combustion or fuel cell powered hybrid passenger vehicles.

The effects of the Recovery Act funding for the manufacturing of advanced batteries and electric drive components are not considered in the analyses that evaluate the impact of R&D on battery or electric drive component cost which already assume high volume manufacturing. Recovery Act funds are expected to hasten the introduction of PHEV and other electric drive vehicles.

Progress for energy storage and electric propulsion system R&D is indicated by cost per kilowatt-hour battery system and combined inverter/motor cost estimated for a production level of 100,000 systems per year. Actual and projected progress for PHEV battery cost and integrated inverter/ motor cost indicators are shown graphically below:

[a] SBIR/STTR funding transferred in FY 2010 was $2,535,125 for the SBIR program and $304,215 for the STTR program.





Note: 2005 and 2007 "Actual" data are cost for commercially available systems. In 2008 and subsequent years, "Actual" represents program results (modeled). The FY 2007 cost target is not shown because it was for a component of the electric drive, an electric motor, and cannot be put on a comparable basis with the systems cost targets beginning in FY 2008.

Detailed Justification

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Battery/Energy Storage R&D	**76,271**	**136,080**

The Battery/Energy Storage R&D activity supports the development of advanced high-energy batteries for PHEVs and EVs, high-power batteries for HEVs, and R&D into advanced materials to enable the development of next generation batteries and systems. Low-cost, abuse-tolerant batteries with higher energy, higher power, and lower weight are needed for the development of the next-generation of HEVs, PHEVs, and pure EVs.

Battery/Energy Storage R&D addresses the first building block of a hybrid-electric vehicle, electricity storage. The needs of "regular" hybrid vehicles 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.

The primary R&D focus will continue to be on lithium-based batteries. Lithium-based batteries offer the potential to meet all three applications. Other innovative technologies like ultracapacitors and advanced lead acid batteries offer the promise of significantly lower cost with possibly similar performance of lithium ion batteries in high power applications. Thus, those technologies are also being researched, tested, and developed.

VTP will continue work in the area of extremely high energy battery chemistries for use in EVs and PHEVs, and high power systems for HEVs. Higher energy (for EVs and PHEVs) and higher power (for HEVs) couples promise to significantly lower system cost as fewer cells should be needed in the entire system. One focus of this work will be on new materials and couples that offer a minimum of two times improvement in either energy or power over today's technologies. Some specific technologies which are of interest include, but are not limited to: the design and development of robust cells that contain high voltage (5V) and/or high capacity (>300mAh/g) cathodes; alloy or Lithium metal anodes; Lithium/air and Lithium/S systems; and high voltage and solid polymer composite electrolytes. In addition, VTP will continue work on cells and/or systems that offer significant cost reductions. The focus of this work will be on robust cells or systems that contain new materials and couples that offer a minimum of two times reduction in cost over existing technologies.

(dollars in thousands)

FY 2010 Current Approp	FY 2012 Request

Research will be conducted to expedite the development of more efficient designs and design processes (e.g., current collectors, separators, packaging) for high-volume production of large format Li-ion batteries. Currently, the "non active" components of a battery (~70 percent by weight of the battery) increase the volume, weight, and cost of the finished product. Approaches to reduce the inactive components in the cell and battery will be pursued. Developing much thicker electrodes and solid electrolytes would reduce the amount of inactive components required. In addition, today's thermal management technologies add weight, cost, and complexity to the system which could be reduced through the use of novel thermal management technology. Research will be conducted to both manage batteries' temperature and reduce the system cost. Approaches that significantly extend the operating temperature range of batteries will also be investigated.

In addition to new high-capacity electrode materials and high-voltage electrolytes, research efforts will be devoted to: the development of 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.

Full system development will continue in cooperation with industry both through the United States Advanced Battery Consortium (USABC) and direct contracts with DOE. All awards are selected under a competitive process and are cost-shared by developers. The FY 2012 activity will emphasize accelerating the development of batteries for PHEVs and EVs. This activity will also continue to validate requirements and refine standardized testing procedures to evaluate performance and life of PHEV and EV batteries, as well as identify areas requiring additional R&D. As the battery becomes larger, abuse-tolerance becomes more of a concern, requiring higher stability between the electrodes and the electrolyte, and enhanced thermal management at the system level. The focus of the high-power USABC subcontracts will be cost reduction, as high-power Li-ion systems appear able to meet the critical performance requirements.

VTP 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 and to ensure success of battery manufacturing facility awards made under the Recovery Act. Studies of recycling and reuse of lithium batteries will continue. In addition, these funds may be used to support peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

Ultracapacitors (Ucaps), hybrid ultracapacitors (in which one electrode may be an activated carbon and the other an electrode typical of a battery, such as in a Li-ion battery) and advanced lead acid batteries offer the possibility of significantly lower system cost with moderate reductions in certain performance characteristics. These and other non-traditional technologies will be tested in the laboratory, evaluated in vehicle simulations, and researched using advanced diagnostics to understand opportunities to enable more fuel efficient automobiles. Ucaps have relatively low specific energy (less than three watt-hours per kilogram), which limits their capacity to serve as the main energy-storage devices in hybrid vehicles. However, they offer the possibility of improved vehicle performance in a battery-plus-ultra-capacitor hybrid configuration and a 10 to 20 percent fuel economy improvement in city driving if used in a start/stop application. The battery/Ucap

(dollars in thousands)

FY 2010 Current Approp	FY 2012 Request

configuration will be evaluated and optimized for lower cost and improved durability in a PHEV platform when the Ucap is sized for power assist and the battery is sized for energy. Ucap R&D 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 specific energy.

In coordination with BES and OE, the VTP Battery/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 will be required to investigate these materials.

VTP will begin preliminary work on specific recycling research topics. Possible topics include improving the efficiency and cost effectiveness of current recycling processes, enhancing recycling processes to recover more materials, and restoring or refurbishing partially spent batteries to near new performance levels.

VTP will continue the EV battery Secondary Use R&D activity that was started in 2010. In addition, VTP will collect information on battery end-of-life performance, obtain industry input, evaluate second use applications, and conduct testing to assess the suitability of used batteries for secondary use.

In conjunction with SuperTruck activities initiated in 2010, energy storage technologies and systems specific to heavy vehicle applications will optimize maturing battery technologies for long-haul truck applications.

Additional funding will be used to support the Battery Readiness Initiative (BRI). The purpose of BRI is to move mature battery technologies closer to market entry through the design and development of advanced pre-production battery prototypes. BRI will also support the market entry of advanced battery materials by supporting material scale-up, pilot production, and commercial sampling activities. The initiative will also accelerate the development of advanced battery computer aided engineering tools and support battery standardization activities. All of this activity will result in accelerated development of lower cost, higher performing, and more abuse tolerant batteries which will lead to faster adoption of EDVs in the light duty vehicle marketplace.

This new VTP activity will prototype advanced electric drive vehicle (EDV) batteries to understand their behavior in simulated drive conditions, encourage their more rapid adoption by industry, and drive down their costs. The activity will be undertaken with integrated teams of battery and automotive manufacturers. All awards will be selected under a competitive process and cost-shared by industry. Awards will be chosen based on the teams' ability to deliver full EDV batteries that provide high performance (extended all electric range), low cost (such that the battery cost has the potential of achieving VTP's 2014 cost goal of $300/kWh) and that provide a path towards high volume production and sales of EDV batteries and vehicles. This activity will require the delivery of significant numbers (hundreds or thousands) of pre-production EDV cells and batteries for testing

(dollars in thousands)

FY 2010 Current Approp	FY 2012 Request

under realistic performance conditions and will include the integration and use of the batteries in hardware-in-the-loop simulations. The activity will provide valuable data regarding battery operation and the results will be used to drive down battery cost through optimization of battery cell and pack designs.

VTP will accelerate the market entry of advanced batteries by supporting the scale-up, pilot production, and commercial validation of new battery materials and processes. EDV batteries utilize significant amounts of advanced materials such as novel cathodes, anodes, and electrolytes. Furthermore, low cost manufacturing processes for producing these new materials and incorporating them into electrodes, cells, and batteries need to be developed. New materials are being developed by universities, National Laboratories, and industry, that address barriers such as battery cost, life, and safety, but the production scale-up of such materials is often limited in scope. Battery materials and cell manufacturing needs to evolve from loosely measured and controlled processes that often rely on the "resident expert" and perfect repetition to make reproducible batteries, to processes that have adapted significant automated and metrological methods. New tools that can be adopted industry-wide will be developed by cross-disciplinary teams, taking advantage of the complementary skills and approaches of university, National Laboratories, and industrial scientists and engineers.

Developing new battery designs is extremely time-consuming and expensive. Computer aided engineering (CAE) tools have been widely used throughout the aerospace and automotive industry to speed up the product development cycle. In contrast, the battery industry still relies heavily on the building and testing of prototypes in the design cycles. A virtual design toolset could identify an optimal design in days or weeks, compared to months or years for a hardware-based process. The development of battery CAE tools will accelerate design cycles, reduce the number of prototypes needed, reduce battery development cost and provide a competitive advantage to U.S. OEMs, suppliers, and battery manufacturers. In this activity, VTP will work with industry, National Laboratories and universities to accelerate the development of tools that model battery behavior, such as electrochemical processes, electrical performance and degradation, life prediction, thermal profiles, and battery cost. Furthermore, VTP will define global modeling parameters in order to develop a flexible, plug-and-play, open architecture software that will allow disparate, independently developed sub-models to operate in unison. This new framework will enable automobile manufactures, battery developers, material suppliers, research institutions, and universities the ability to incorporate different battery material, cell, and pack models into one system capable of modeling an entire electrochemical system. By introducing battery simulations and design automation at an early stage in the battery design life cycle it is possible to significantly reduce the product cycle time allowing quicker entry of new technologies into the market and reducing battery development costs.

VTP will support the accelerated development of standards for battery design, and will encourage and facilitate the implementation of these standards throughout the industry. While standards for conventional automotive starting batteries have been well established (with a family of system voltages, physical dimensions in group sizes, and performance ratings), there are few existing comparable standards for electric drive vehicle battery systems. Current lithium-ion battery technologies are manufactured in a wide range of system voltage, cell size and shape (e.g.,

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request

cylindrical, prismatic, or laminate), and materials used (e.g., metal oxides, iron phosphates). Although many standards-setting organizations such as SAE, IEEE, UL, IEC, and ISO have begun initial work to develop standards, the work is conducted largely on a volunteer basis, and therefore takes an extremely long period of time to develop and implement. VTP will work closely with major standards-setting organizations, battery manufacturers, and automotive OEMs, and provide financial assistance to speed the development of standards for battery design, performance ratings, commonality in labeling, and battery safety standards. In addition, VTP will work collaboratively with relevant agencies (such as the U.S. Department of Transportation and the United Nations) to develop standards for shipping/transportation of batteries. The establishment of battery standards will help to reduce battery costs, and thereby accelerated the widespread market introduction of electric drive vehicles.

The Battery/Energy Storage activity coordinates with other DOE programs working in advanced battery technologies to maximize returns on DOE's investments. Interactions include cooperation with Office of Science/BES to investigate electrochemical phenomena and to develop new battery materials. VTP works closely with ARPA E to identify and develop transformational EDV battery technologies. The activity also coordinates with the Battery/Energy Storage program in 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.

Advanced Power Electronics and Electric Motors R&D **22,295** **46,656**

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

Advanced Power Electronics and Electric Motors R&D addresses the second building block, which includes all the electric and electronic devices that tie the power stored in the battery to the vehicle's drivetrain: power control circuits; charging circuits; electric motors; logic to synchronize 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 driving modes.

The power electronics module conditions the flow of electrical power from the energy-storage device (such as a battery) 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 reduce the overall size of the battery. R&D efforts focus on developing advanced, low cost technologies compatible with the high-volume manufacturing of motors,

inverters, and DC/DC converters for electric drive vehicles. Focus on electric drive systems will enable coordinated R&D of the power electronics and electric motors to further reduce cost, weight and size.

In FY 2012, industry R&D efforts will continue 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, and advanced power electronics and electric motors are critical components for the successful deployment of advanced vehicles. These activities 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. Efforts will also accelerate 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/GaN components, low-cost permanent magnet materials, high-temperature capacitors, advanced thermal systems, and motor control systems to meet future passenger vehicle hybrid systems requirements. Work in these areas will address the performance requirements for vehicle electrification, including utilizing power electronics to provide plug-in capability by integrating the battery charging function into the traction drive, thereby reducing electric propulsion system cost.

The activity also supports DOE's power electronics crosscut initiative by continuing vehicle-focused R&D projects in power electronics that apply across program areas such as capacitor dielectric material development, wide bandgap materials, and semiconductor packaging R&D. The effort will evaluate the impact these existing projects have on similar applications across DOE, to understand common barriers, identify areas for future efforts, and share progress on R&D.

Activities focusing on advanced materials will 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 band gap materials and other enabling devices and technologies will be emphasized to enable earlier use of advanced devices and components. In FY 2012, VTP will continue to support the development of power electronics and motor technologies and devices to strengthen the U.S. based manufacturing to ensure success of manufacturing facility awards made under the Recovery Act.

Ongoing efforts will continue to focus on reducing and ultimately eliminating the use of rare earth materials in electric motors. Magnet material research is focused on near-term efforts to reduce the amount of rare earth materials in current generation magnets and long-term research to develop novel, low cost magnetic materials without any rare earth content that can meet automotive requirements. Other projects at National Laboratories and with industry partners focus on technology replacement, developing novel motor designs and concepts that reduce or eliminate rare earth materials while meeting future performance targets.

The power electronics and electric motors activity coordinates with other DOE programs with relevant work in advanced technologies to maximize the return on DOE's technology investments in

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request

this area. Interagency coordination on advanced power electronics and motors development is conducted through the 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 validated for performance and conformance to specifications. Crosscutting technologies also will be evaluated for potential application in advanced vehicles. Collaboration with SuperTruck activities will leverage recent advancements and further improve power electronics and electric motors for use in heavy-duty trucks. 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.

Electric vehicle drive systems, which include electric motors and power electronics, are a key technology for enabling advanced vehicle propulsion systems that reduce the petroleum dependence of the transportation sector. To have a significant effect and increase market penetration of advanced electric vehicles, electric drive technologies must be economical in terms of cost, weight, and size while meeting performance and reliability requirements. However, the push to meet these individual improvements must be balanced and considered as an overall drive system. A systems solution approach will realize significant breakthroughs for how power electronics and electric motors are structured, integrated, and executed. This new focus will provide a systematic, coordinated development of electric drive system technology to meet performance targets and realize drastic cost reductions. Significant tasks will include design and integration studies, definition of system requirements, and evaluating new technologies and topologies all with the primary focus of cost reduction. Specifically, cost reductions may be realized through the elimination of rare earth materials, the development of common part sizing, improvements in manufacturability, and/or the integration of other drive system components such as chargers and DC/DC converters.

SBIR/STTR	**0**	**5,264**

In FY 2010, $2,535,125 and $304,215 were transferred to the SBIR/STTR programs respectively. The FY 2012 amount shown is the estimated requirement for the continuation of the SBIR and STTR program.

Total, Batteries and Electric Drive Technology	**98,566**	**188,000**

Explanation of Funding Changes

	FY 2012 vs. FY 2010 Current Approp ($000)
Battery/Energy Storage R&D	
Additional funding will be used to support the Battery Readiness Initiative (BRI). The purpose of BRI is to move mature battery technologies closer to market entry through the design and development of advanced pre-production battery prototypes. BRI will also support the market entry of advanced battery materials by supporting material scale-up, pilot production, and commercial sampling activities. The initiative will also accelerate the development of advanced battery computer aided engineering tools and support battery standardization activities. All of this activity will result in accelerated development of lower cost, higher performing, and more abuse tolerant batteries which will lead to faster adoption of EDVs in the light duty vehicle marketplace.	+59,809
Advanced Power Electronics and Electric Motors R&D	
This increase in funding will initiate competitively awarded research and development of electric vehicle drive system R&D efforts focusing on a system-level design to optimize performance and dramatically reduce cost. This new focus will provide a systematic, coordinated development of electric drive system technology.	+24,361
SBIR/STTR	
In FY 2010, $2,535,125 and $304,215 were transferred to the SBIR/STTR programs respectively. The FY 2012 amount shown is the estimated requirement for the continuation of the SBIR and STTR program.	+5,264
Total Funding Change, Batteries and Electric Drive Technology	**+89,434**

Vehicle and Systems Simulation and Testing

Funding Schedule by Activity

(dollars in thousands)

	FY 2010 Current Approp[a]	FY 2012 Request
Vehicle and Systems Simulation and Testing		
Vehicle and Systems Simulation and Testing	43,732	52,332
Non- and Off-Highway Vehicles	0	5,000
SBIR/STTR	0	668
Total, Vehicle and Systems Simulation and Testing	43,732	58,000

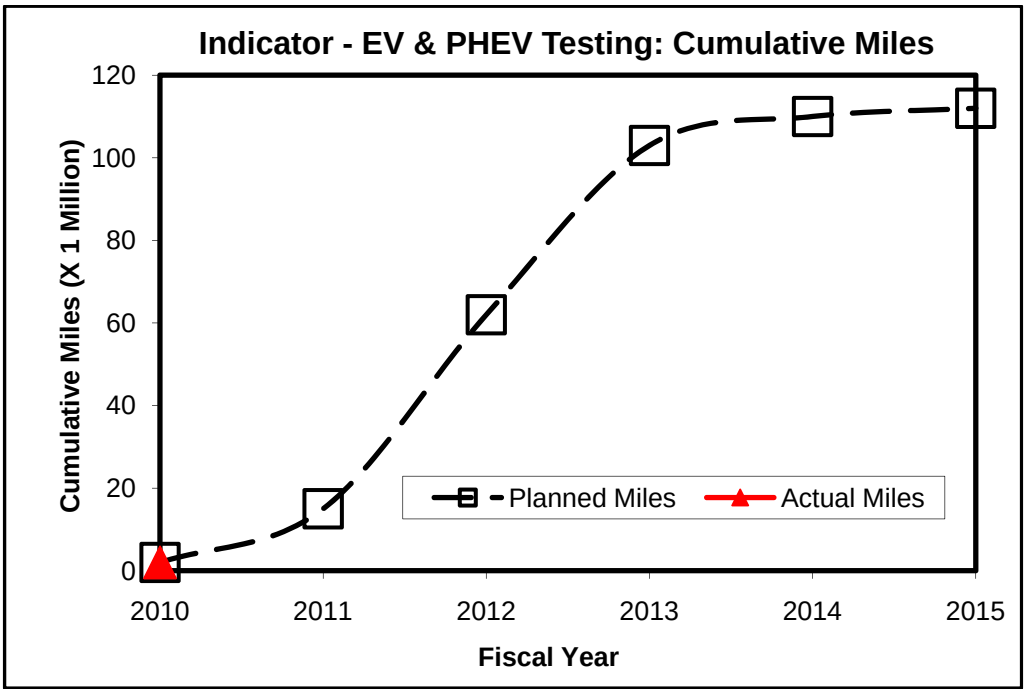
Benefits

The Vehicle and Systems Simulation and Testing (VSST) subprogram addresses the utilization of electric energy storage, electric drives, energy recovery, and other efficiency improving technologies in new, more efficient vehicle designs. These crosscutting activities contribute to meeting the VTP strategic objective of developing, demonstrating, and deploying clean energy technologies.

In the VSST activity, modeling and simulation tools are developed and utilized to help specify the necessary performance characteristics of powertrain technologies in order to establish program goals and predict the overall efficiency and performance for various vehicle configurations. Simulations and laboratory testing are used to evaluate the development of individual components and predict how well they will integrate with other components in a vehicle system. Vehicle-level testing is done through dynamometer, closed-track, and on-road evaluations in conjunction with industry partners to measure the real-world performance of advanced technology vehicles, and to validate simulation results. Development of supporting infrastructure, such as advanced vehicle chargers, and the interaction of advanced vehicles with infrastructure is also evaluated. Each of these activities contributes to the development of components, vehicles, and testing codes and standards that are necessary for the successful market introduction of electric-drive vehicles. In addition, VSST conducts R&D to reduce auxiliary vehicle loads and parasitic losses in both passenger vehicles and commercial medium and heavy duty vehicles. In the Non- and Off-Highway Vehicles activity, the key effort is to identify and utilize information from highway vehicle R&D that can improve efficiency as a means to reduce petroleum use.

VSST contributes to meeting national energy security, environmental, and economic objectives by striving to demonstrate market readiness of electric-drive vehicle technologies by 2015. Market readiness will be determined from accumulated test data from over 100 million test miles of electric propulsion vehicles as indicated in the progress indicator figure below. The Non- and Off-Highway Vehicles activity will benefit the Nation's oil and GHG reduction efforts by improving the efficiency of vehicles in these sectors. These vehicles are expected to account for 25 percent of transportation GHG emissions by 2030.

[a] SBIR/STTR funding transferred in FY 2010 was $531,936 for the SBIR program and $63,832 for the STTR program.


Indicator - EV & PHEV Testing: Cumulative Miles
Cumulative Miles (X 1 Million)
120
100
80
60
40
20
0
2010
2011
2012
2013
2014
2015
Fiscal Year
Planned Miles
Actual Miles

Detailed Justification

	(dollars in thousands)	
	FY 2010 Current Approp	FY 2012 Request
Vehicle and Systems Simulation and Testing	**43,732**	**52,332**

VSST integrates the modeling, systems analysis, vehicle testing and evaluation, codes and standards development, and systems optimization efforts that support VTP. The key activity uses a systems approach to define technical targets and requirements, guide technology development, and validate the performance of VTP-sponsored technologies for passenger and commercial vehicles. To accomplish this, VSST 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, EV and fuel cell vehicles; and
- Develop advanced vehicle performance and characteristics data that is then used to predict market potential and petroleum displacement, which helps guide VTP-wide research.

FY 2012 actions will support modeling of advanced electric drive vehicles and systems, as well as baseline testing and evaluation of both commercial and passenger electric drive vehicles in cooperation with manufacturers, utilities, and other industry partners. Laboratory and field evaluations 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 will be conducted. The VSST activity will also research heavy vehicle systems to develop models, as well as conduct R&D on technologies that will reduce non-engine parasitic energy losses from aerodynamic drag, friction and wear, under-hood thermal conditions, accessory loads, and tires.

In FY 2012, the activity will continue simulation studies of advanced control strategies and components for PHEVs and other electric drive vehicles, as well as the validation of advanced electric drive vehicle 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. VSST will continue to collaborate with EPA to share vehicle modeling and simulation expertise, as well as results from vehicle testing activities. VSST will also 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 complete the integration of turbulence and other computational fluid dynamics (CFD) models. The activity will continue efforts to incorporate detailed component models into the overall vehicle systems integration model to ensure the use of the most accurate component data. This effort supports the Autonomie modeling platform, a centralized vehicle modeling and simulation tool developed through a cooperative research and

(dollars in thousands)

FY 2010 Current Approp	FY 2012 Request

development agreement (CRADA) with industry to standardize vehicle modeling across manufacturers and component suppliers, thus reducing component and vehicle development costs and bringing technologies to market faster. The Autonomie model also increases the accuracy of simulation results and enables simulations that support R&D in all other VTP subprograms.

VSST will utilize the Mobile Automotive Technology Testbed (MATT) and hardware-in-the-loop (HIL) techniques that operate selected pieces of hardware linked to a real-time simulation of a virtual vehicle, 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 2012, VSST will continue HIL evaluations of advanced energy storage systems and dual battery systems, advanced combustion technologies developed by other VTP 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 power electronics and energy storage technology R&D activities, and examine overall vehicle impacts associated with integration of other advanced vehicle technologies.

The activity will conduct evaluations of advanced original equipment manufacturer (OEM) PHEVs and electric drive vehicles and their recharging infrastructure, and complete tests of vehicles retrofitted with components developed through VTP R&D activities. Evaluations will include testing on laboratory dynamometers, closed tracks, and real-world monitored fleets. 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 electric drive vehicle knowledge base and help accelerate market introduction of these fuel saving vehicles.

The Recovery Act provided substantial new resources for EERE to expand the impact of base activities. The Transportation Electrification Initiative is enabling the purchase, deployment, and evaluation of thousands of PHEVs and EVs and charging infrastructure for test demonstrations in various locations across the U.S., as well as education and training programs to support these activities. The data collected from the Recovery Act Transportation Electrification advanced electric drive vehicle demonstrations will be analyzed to identify technology needs and improvements to be addressed through VTP R&D activities to accelerate the market introduction of electric drive vehicles. Efforts focus on infrastructure/vehicle interface evaluations and potential impacts on the electricity grid. VSST will work with OE to demonstrate the potential benefit of electric drive vehicle commercialization coupled with smart grid technologies to improve the value proposition of electric drive vehicles while promoting grid reliability and utilization.

VSST will expand activities in FY 2012 to develop, evaluate, and demonstrate advanced wireless charging technologies with efficiencies approaching those of plug-connected recharging equipment. These stationary and in-motion EV wireless chargers will increase the use of electricity for vehicle propulsion and reduce petroleum consumption while reducing the size and cost of batteries required to meet consumers' range expectations and needs. VSST will expand its

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request

government/industry cooperative efforts to identify and resolve codes and standards for component, vehicle, infrastructure, communications, and testing that need to be updated for new vehicle technologies. Specific activities will include development and validation of component safety, performance, and communications standards for electric-drive vehicles and infrastructure, as well as conducting on-vehicle testing of components integrating new standards to ensure vehicle performance, reliability, efficiency, and safety. Work will be initiated to develop and validate additional codes and standards identified as deficient through partnership with government and industry stakeholders and to coordinate U.S. standards with those in Europe and Asia to reduce vehicle costs through component compliance in multiple markets.

In FY 2012, additional vehicle testing data will be collected through VSST activities, as well as other independent testing sources, and will be utilized to validate medium duty vocations in the heavy vehicle model. In FY 2012, VSST will continue to fund financial assistance awards with SuperTruck awardees to develop, build and demonstrate advanced Class 8 tractors & trailers with a 50 percent improvement in on-road fuel economy. The funds will also support CRADAs and National Laboratory projects to reduce drive-train friction and wear, and develop and evaluate under-hood thermal management approaches that will improve vehicle efficiencies while increasing component reliability and life. VSST will also work directly with industry partners to accelerate the development and validation of advanced medium and heavy hybrid vehicles.

In FY 2012, VSST will also work to develop high efficiency vehicle air conditioning and HVAC components and technologies to reduce vehicle heating and cooling load requirements. These technologies will help reduce the amount of battery energy or petroleum used for HVAC loads in passenger and commercial vehicles, thus dramatically improving overall vehicle efficiency and range.

Non- and Off-Highway Vehicles	**0**	**5,000**

VSST's Non- and Off-Highway activity will incorporate rail and off-highway transportation modes and associated opportunities to reduce petroleum use and GHG emissions. New rail activities will be coordinated with the Department of Transportation, locomotive manufacturers, rail companies, and others to develop a rail oil and GHG reduction roadmap. Early activities will center on the application of existing advanced VTP technologies initially developed for heavy vehicles—combustion, light-weighting, and alternative fuels—to rail systems, where appropriate. New off-highway activities will focus on identifying and coordinating with stakeholders, with whom VTP will adapt and deploy existing technologies, as appropriate. For both rail and off-highway activities, VTP will identify and initiate new R&D where existing VTP technologies are not applicable. 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.

	(dollars in thousands) FY 2010 Current Approp	FY 2012 Request
SBIR/STTR	**0**	**668**

In FY 2010, $531,936 and $63,832 were transferred to the SBIR and STTR programs respectively. The FY 2012 amount shown is the estimated requirement for the continuation of the SBIR and STTR program.

Total, Vehicle and Systems Simulation and Testing	**43,732**	**58,000**

Explanation of Funding Changes

	FY 2012 vs. FY 2010 Current Approp ($000)
Vehicle and Systems Simulation and Testing (VSST)	
Development of wireless charging technologies for both stationary and in-motion EVs will be expanded to decrease the size of batteries needed in EVs, increase the useable range of EVs without plugging in to recharge, increase the use of electricity for vehicle propulsion, and increase consumer acceptance of EVs. In addition, development of advanced air conditioning and HVAC components and systems and technologies to reduce HVAC loads and component sizes will be conducted to minimize the amount of battery energy used to meet HVAC requirements, thus improving the overall efficiency and range of EVs. Development, validation, and coordination of codes and standards that currently limit and slow the introduction of EVs will be conducted in cooperation with vehicle and component manufacturers, standards setting organizations, and utilities	+8,600
Non and Off-Highway Vehicles	
The Non- and Off-highway is a new activity in FY 2012. This funding will enable VTP to leverage existing technologies for application to rail and off-highway transportation modes, thereby expanding the number of transportation media through which VTP reduces petroleum consumption and GHG emissions.	+5,000
SBIR/STTR	
In FY 2010, $531,936 and $63,832 were transferred to the SBIR and STTR programs respectively. The FY 2012 amount shown is the estimated requirement for the continuation of the SBIR and STTR program. .	+668
Total Funding Change, Vehicle and Systems Simulation and Testing	**+14,268**

Advanced Combustion Engine R&D

Funding Schedule by Activity

(dollars in thousands)

	FY 2010 Current Approp[a]	FY 2012 Request
Advanced Combustion Engine R&D		
Combustion and Emission Control	47,239	40,824
Solid State Energy Conversion	8,748	6,804
SBIR/STTR	0	1,372
Total, Advanced Combustion Engine R&D	55,987	49,000

Benefits

The Advanced Combustion Engine R&D subprogram focuses on removing critical technical barriers to commercializing higher efficiency, advanced internal combustion engines for passenger and commercial vehicles. Increasing the efficiency of internal combustion engines is one of the most cost effective approaches to reducing the petroleum consumption of the Nation's fleet of vehicles in the near- to mid-term. Using these advanced engines in HEVs and PHEVs will enable even greater fuel savings benefits. Improvements in engine efficiency alone have the potential for dramatically increasing vehicle fuel economy and reducing GHG emissions. Accelerated research on advanced combustion regimes, including homogeneous charge compression ignition (HCCI) and other modes of low-temperature combustion, lean-burn gasoline, and multi-fuel operation, is aimed at realizing this potential.

The Advanced Combustion Engine R&D subprogram contributes to VTP goals by dramatically improving the efficiency of internal combustion engines, and by identifying fuel properties that improve the system efficiency or enable displacement of petroleum-based fuels. Improved efficiency and petroleum displacement can directly reduce petroleum consumption and GHG emissions.

The following representative measures of the Advanced Combustion R&D subprogram can contribute to meeting strategic objectives of developing, demonstrating and deploying clean energy technologies:

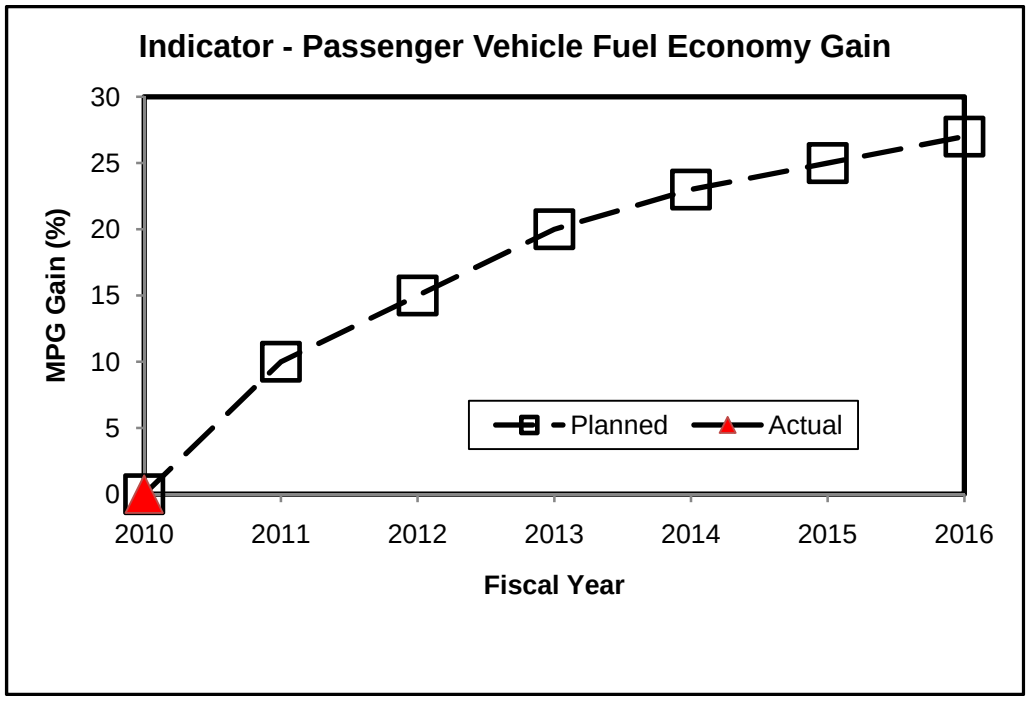
- Passenger vehicles: Increase the efficiency of internal combustion engines resulting in fuel economy improvements of 25 percent for gasoline vehicles by 2015 compared to a 2009 baseline gasoline vehicle.
- Commercial vehicles: Increase the efficiency of internal combustion engines demonstrating a fuel economy improvement of 20 percent in 2015, and 30 percent in 2018, when compared to a 2009 baseline vehicle.

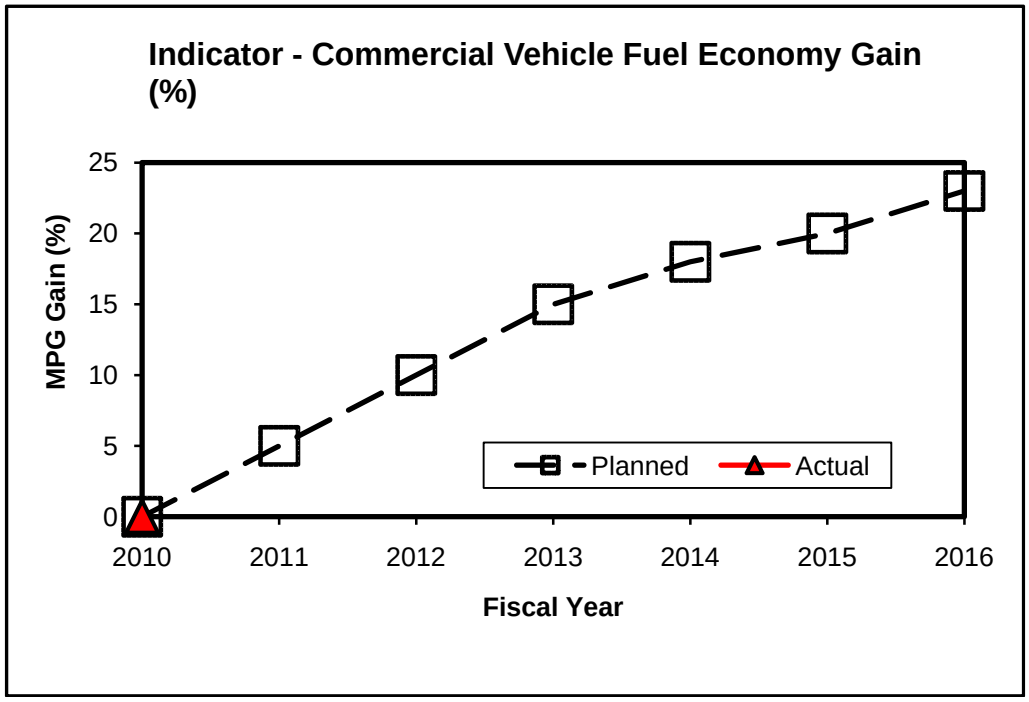
Passenger and commercial vehicle goals will be met while utilizing advanced fuel formulations that incorporate non-petroleum based blending agents to reduce petroleum dependence and enhance combustion efficiency.

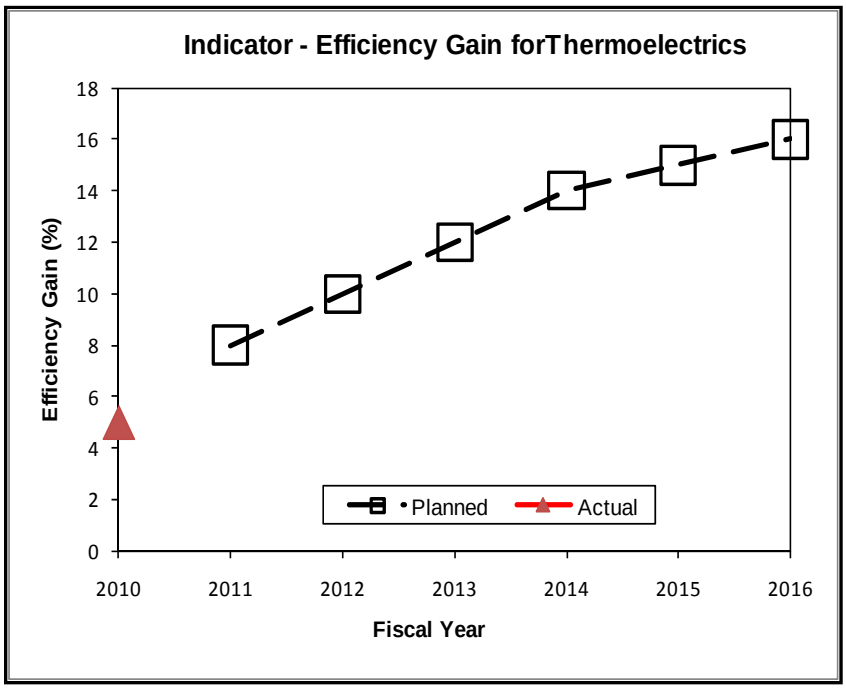
- Solid State Energy Conversion: Increase the efficiency of thermoelectric generators to convert waste heat to electricity from eight percent in 2011 to greater than 15 percent in 2015 and reduce air conditioning load by 30 percent in 2015.

[a] SBIR/STTR funding transferred in FY 2010 was $1,439,489 for the SBIR program and $172,499 for the STTR program.

Progress of R&D for improving passenger and commercial vehicle combustion engine efficiency is shown graphically below.







Detailed Justification

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Combustion and Emission Control	**47,239**	**40,824**

Combustion and Emission Control research supports the VTP 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 VTP'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. The goals for 2015 emphasize increasing the efficiency of internal combustion engines resulting in fuel economy improvements over real-world driving cycles.

Meeting anticipated future emission standards will be challenging for high efficiency diesel and lean-burn gasoline engines. To address this issue, research on innovative emission control strategies will be pursued through National Laboratory, industry and university projects designed to reduce cost and

(dollars in thousands)

FY 2010 Current Approp	FY 2012 Request

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 can further improve the efficiency and reduce the cost of engines used in commercial vehicles.

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 includes 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 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 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 in collaboration with the Non- and Off-Highway Vehicles activity.

In FY 2012, the Combustion and Emission Control activity will continue funding one of the four non-ARRA funded cooperative agreements awarded in FY 2010 for passenger vehicle advanced power-train systems targeting the demonstration of a 25 to 40 percent improvement in vehicle fuel economy by 2015. The activity will also continue three of six awards made to universities to conduct research on combustion and develop emission controls systems for advanced engines. The activity will delay or eliminate non-ARRA SuperTruck awards from the FY 2010 solicitation. These awards were to 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, friction and pumping losses to meet these engine system goals.

Through simulation and experimentation, the activity will conduct R&D on advanced thermodynamic strategies that will enable engines to approach 60 percent thermal efficiency. 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.

The activity will support the Energy Systems Simulation-ICE Initiative, in collaboration with Office of Science/BES, in the development of advanced chemical kinetics, computation fluid dynamics (CFD) and large eddy simulation (LES) models, and computationally intensive direct numerical simulations (DNS) to model transients and cycle to cycle variability in engine combustion events. The activity will support the development of better solver algorithms to make these models more computationally tractable while

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request

providing experimental verification (e.g. laser diagnostics for optical engines and Advanced Photon Source for spray diagnostics) to validate these models. The activity will simulate stochastic in-cylinder processes, minimize the cycle-to-cycle variations inherent in ICEs and allow for more rapid optimization of overall engine combustion and air handling. In addition, this activity will develop more accurate liquid fuel injection models that simulate cavitations, atomization, and vaporization. Working cooperatively with industry, VTP will make these codes user friendly to reduce the number of iterations needed to design a more efficient combustion engine. This activity will also develop robust engineering design tools for validation of simulation models using full-scale engine testing and diagnostics.

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	**8,748**	**6,804**

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 and provide cooling/heating for vehicle interiors. Thermoelectric generators can directly convert a nominal 1kW of electric power from engine waste heat for passenger vehicles and up to 5kW for commercial vehicles.

In FY 2012, this activity will pursue cost-shared cooperative agreements (typically three to five years in duration) with industry and academia to develop and fabricate high-efficiency thermoelectric generators to produce electricity from waste heat and thermoelectric air conditioner/heaters to replace current R134-a gas air conditioners in passenger and commercial vehicles. The activity will also investigate scaling up production of thermoelectric modules for demonstration in vehicle applications with the potential to improve vehicle fuel economy by up to 10 percent. This activity will continue to support a collaborative effort with the National Science Foundation to fund thermoelectric projects at several universities. Research on advanced thermoelectric materials and scale-up for demonstration in vehicle applications will also continue.

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**	**1,372**

In FY 2010, $1,439,489 and $172,499 were transferred to the SBIR and STTR programs respectively. The FY 2012 amount shown is the estimated requirement for the continuation of the SBIR and STTR program.

Total, Advanced Combustion Engine R&D	**55,987**	**49,000**

Explanation of Funding Changes

	FY 2012 vs. FY 2010 Current Approp ($000)
Combustion and Emission Control	
Funding will be delayed or eliminated for three of four cooperative agreements for passenger vehicle advanced power-train systems and three of six university awards on combustion and emissions control systems for advanced engines will be reduced. The FY 2012 funding level maintains one cooperative agreement and three university awards. In addition, the activity will delay or eliminate non-ARRA supported SuperTruck awards from the FY 2010 solicitation. Reductions will also be made at the National Laboratories for research on high efficiency combustion processes and emission control systems. These reductions will be made in order to focus on large-scale computational simulations of combustion, a potentially cost-effective means to develop efficient combustion engines.	-6,415
Solid-State Energy Conversion	
To focus on higher priority activities within the Advanced Combustion Engine R&D, solid-state energy conversion activities will be reduced from three to two awards made to industry teams previously to improve the efficiency of thermoelectric generators to recover energy from waste heat.	-1,944
SBIR/STTR	
In FY 2010, $1,439,489 and $172,499 were transferred to the SBIR and STTR programs respectively. The FY 2012 amount shown is the estimated requirement for the continuation of the SBIR and STTR program.	-1,372
Total Funding Change, Advanced Combustion Engine R&D	**-6,987**

Materials Technology

Funding Schedule by Activity

(dollars in thousands)

	FY 2010 Current Approp[a]	FY 2012 Request
Materials Technology		
Propulsion Materials Technology	12,989	9,720
Lightweight Materials Technology	30,652	26,244
High Temperature Materials Laboratory	5,662	972
SBIR/STTR	0	1,064
Total, Materials Technology	49,303	38,000

Benefits

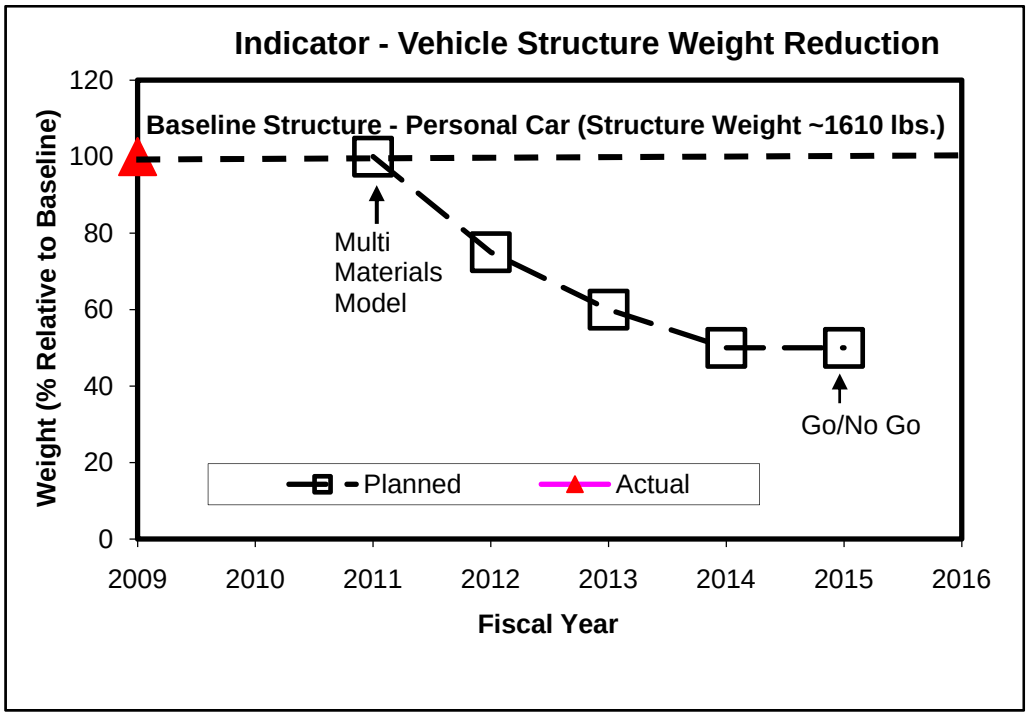
The Materials Technology subprogram develops higher performing, more cost-effective materials that will make lighter vehicle structures and more efficient power systems. Lighter vehicles require less energy to operate and thus reduce fuel consumption. Likewise, better propulsion materials can enable more efficient power systems that will contribute to a vehicle's reduced energy consumption. For a mid-sized or larger vehicle, every 10 percent reduction in a vehicle's weight could result in a six to eight percent increase in vehicle fuel economy.[b]

The following measure of the Materials Technology subprogram can contribute to meeting strategic objectives of developing, demonstrating and deploying clean energy technologies:

- By 2015, validate (to within 10 percent uncertainty) the cost-effective reduction of the weight of passenger vehicle body and chassis systems by 50 percent with safety, performance, and recyclability comparable to 2002 vehicles.

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 transferred in FY 2010 was $1,268,075 for the SBIR program and $152,169 for the STTR program.
[b] Argonne National Laboratory Power Train Systems Analysis Toolkit (PSAT) analysis, 2008.



Note: 2009 value is baseline

Detailed Justification

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Propulsion Materials Technology	**12,989**	**9,720**

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

In FY 2012, research efforts will support three VTP teams: 1) Advanced Combustion Engines; 2) Fuels; and 3) Hybrid Electric Systems to achieve energy efficiency improvements and petroleum displacement goals. Much of the materials work will support diesel engines because they currently operate at much higher efficiencies and pressures than gasoline engines and will provide insights to the materials hurdles confronting engine designers as they strive to achieve the higher peak cylinder pressures necessary for improved thermal efficiency. Researchers will use specialized characterization and processing techniques to develop materials for in-cylinder thermal management, friction reduction, improved dynamic response, increased peak cylinder pressure, and increased power to weight ratios supporting the development of high efficiency advanced combustion engines. In cooperation with the VTP fuels team, researchers will identify and mitigate interaction issues between

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request

new fuel formulations and engine component materials. Materials will be developed to improve the performance of energy recovery systems such as turbo-compounding and solid state thermoelectric devices. Efforts to develop materials for hybrid- and electric-drive components will target cost effective domestic magnetic materials for drive motors and high-temperature power electronics. All activities include technology transfer components to communicate results to industry, thereby accelerating deployment of beneficial 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.

Lightweight Materials Technology **30,652** **26,244**

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- matrix composites reinforced with fibers. Since cost-effectiveness is the major materials challenge, this element supports R&D and validation of materials needed to meet the 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 achieve the FY 2015 goal of cost neutrality.

In FY 2012, funding will continue to focus on new development and demonstrations of technologies for reducing the effective costs of magnesium, next generation advanced high strength steel, aluminum, carbon-fiber and carbon-fiber composites, and components and structures made from these materials. Funding will support work on multi-material enabling technologies, such as advanced joining or corrosion prevention techniques. Work will also continue in the field of modeling and integrated computational materials engineering (ICME). One focus will be on completion of a detailed design and cost model for a multi-materials vehicle (MMV) that is 25 percent lighter weight compared to the baseline assessment currently underway. 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.

High Temperature Materials Laboratory (HTML) **5,662** **972**

The HTML facility is an advanced materials characterization laboratory which provides materials characterization services for VTP, academia, and a number of small business industrial users through the HTML Users Program at the Oak Ridge National Laboratory. To focus on other priority activities within the Materials Technology Subprogram, the FY 2012 funding provides limited support of the HTML facilities and instruments and reduces support of the HTML user program. 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 2010 Current Approp	FY 2012 Request
SBIR/STTR	**0**	**1,064**

In FY 2010, $1,268,075 and $152,169 were transferred to the SBIR and STTR programs respectively. The FY 2012 amount shown is the estimated requirement for the continuation of the SBIR and STTR program.

Total, Materials Technology	**49,303**	**38,000**

Explanation of Funding Changes

	FY 2012 vs. FY 2010 Current Approp ($000)
Propulsion Materials Technology	
Work on longer-term technologies such as low friction coatings will be reduced to focus on activities with higher near term potential. The hydrogen/natural gas injector work has demonstrated benefits and has reached its conclusion. Non-rare earth magnetic materials work will be transitioned to the hybrid drive systems team.	-3,269
Lightweight Materials Technology	
The reduction in the Lightweight Materials Technology key activity is due to a shift in focus to higher priority efforts in VTP. This will necessitate the following changes: no new platforms will be addressed for research in metal extrusions; and only predictive engineering tools will be pursued for polymer composites. In addition, the number of anticipated new demonstration projects planned to be funded in FY 2012 through the USAMP cooperative agreement will be reduced.	-4,408
High Temperature Materials Laboratory (HTML)	
This reduction eliminates funding for the HTML User program, however maintains funding for overhead for the HTML. The current User program offsets the costs of conducting research at the facility if the project meets the criteria (e.g., results are published). This aspect of the program will be eliminated.	-4,690
SBIR/STTR	
In FY 2010, $1,268,075 and $152,169 were transferred to the SBIR and STTR programs respectively. The FY 2012 amount shown is the estimated requirement for the continuation of the SBIR and STTR program.	+1,064
Total Funding Change, Materials Technology	**-11,303**

Fuels Technology

Funding Schedule by Activity

(dollars in thousands)

	FY 2010 Current Approp[a]	FY 2012 Request
Fuels Technology		
Advanced Petroleum Based Fuels (APBF)	6,780	0
Fuels and Lubricant Technologies (formerly Non-Petroleum Based Fuels and Lubricants)	16,641	17,985
SBIR/STTR	0	518
Total, Fuels Technology	23,421	18,503

Benefits

The Fuels Technology subprogram supports the mission of VTP to develop more energy-efficient and environmentally friendly fuels that enable the U.S. to use less petroleum. Activities are coordinated with, and are supportive of, EPA's fuels and emissions related activities as well as with VTP's Advanced Combustion Engine R&D subprogram.

The lubricant R&D activities are designed to reduce the detrimental effects of lubricants on emissions formation and exhaust after treatment devices and improve fuel economy. The relative impact of lubricant combustion products on emissions has increased as overall emissions have declined. Moreover, lubricants can contain specific undesirable compounds not generally found in fuels that contribute to pollutant formation in unique ways, specifically to toxics and particular matter (PM) formation and to after treatment system degradation. Lubricant R&D will elucidate the mechanisms by which these pollutants are produced and direct development of lubricants without these properties. In addition, improved lubricants (e.g., engine and transmission oils) are among the few simple and inexpensive technologies that can improve the fuel economy and emissions of vehicles already in use.

Renewable and alternative fuels R&D is required to develop and test fuels that can directly displace petroleum fuels in the transportation sector (e.g., advanced next-generation biofuels). Under current law, the U.S. is mandated to use substantially more renewable fuel in the near future – 36 billion gallons annually by 2022 versus about 10 billion today. This mandate cannot be implemented using currently available fuels. R&D is needed to improve the compatibility of vehicles and fueling infrastructure with renewable and alternative fuel components and to assess the impacts of new components on the environment and human health.

[a] SBIR/STTR funding transferred in FY 2010 was $602,375 for the SBIR program and $72,285 for the STTR program.

Detailed Justification

	(dollars in thousands)	
	FY 2010 Current Approp	FY 2012 Request
Advanced Petroleum Based Fuels (APBF)	**6,780**	**0**

Activities specific to petroleum-based fuels have concluded. Fuel science activities related to fuels in general that have formerly been conducted under this budget line have been subsumed by the Fuels and Lubricant Technologies activity.

Fuels and Lubricant Technologies (formerly Non-Petroleum Based Fuels and Lubricants)	**16,641**	**17,985**

The Fuels and Lubricant Technologies activity evaluates advanced fuels, fuel components and lubricants used, or proposed for use, in current and advanced engines. Fuels of interest range from pure alternative fuels to fuels containing mixtures of conventional and unconventional components (e.g., butanol or green diesel). Biomass-based, renewable fuels and bio-synthetic fuels are emphasized. 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.

Next-generation biofuels are of particular interest due to their potential interchangeability with conventional fuels in use today and their small carbon footprint, relative to most alternatives. Fuel interchangeability eliminates an enormous barrier to the increased use of biofuels by eliminating the need to develop a new fuel distribution, blending and fueling infrastructure. However, assessments of candidate "drop-in" replacement fuels are necessary to ensure that such potential fuels serve their intended purpose. 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.

Advanced lubricants, for both engines and transmissions, have great potential to directly improve fuel economy by reducing parasitic efficiency losses (e.g., internal friction). Lubricants also represent a rare opportunity to develop a technology that can be used as a retrofit to existing technology, in many cases, increasing and vastly accelerating petroleum displacement in the marketplace.

In FY 2012, the activity will continue studies of the effects of physical and chemical property variations in renewable and alternative fuels on the performance and emissions of advanced combustion engines. These activities will be undertaken in close coordination with the Advanced Combustion Engine R&D subprogram. In addition, the activity will expand studies of next-generation biomass-derived transportation fuels into a comprehensive R&D and testing program to assess the feasibility of large-scale deployment of such fuels. In FY 2012 the activity will also initiate a comprehensive study of advanced lubricants for increased efficiency.

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
SBIR/STTR	**0**	**518**

In FY 2010, $602,375 and $72,285 were transferred to the SBIR and STTR programs respectively. The FY 2012 amount shown is the estimated requirement for the continuation of the SBIR and STTR program.

Total, Fuels Technology	**23,421**	**18,503**

Explanation of Funding Changes

	FY 2012 vs. FY 2010 Current Approp ($000)
Advanced Petroleum Based Fuels (APBF)	
In FY 2012, APBF will discontinue studies on the impact of lubricants on emissions from conventional vehicles and studies on the influence of petroleum-based fuels and fuel composition on advanced combustion regimes; and will cease development of computer models for the chemical kinetics of fuels that supported computer aided engine design. These conventional fuels-related activities are being discontinued to focus on higher priority technologies for transportation electrification, including advanced batteries, power electronics, electric motors for hybrid and plug-in hybrid electric vehicles, as well as deployment activities to develop infrastructure for increased use of these technologies. Future requirements will be assessed and included as appropriate.	-6,780
Fuels and Lubricant Technologies (formerly Non-Petroleum Based Fuels and Lubricants)	
The FY 2012 funding increase will support the acceleration and expansion of activities related to next-generation renewable/biofuels and the initiation of a study of the potential impact of advanced lubrication on fuel economy.	+1,344
SBIR/STTR	
In FY 2010, $602,375 and $72,285 were transferred to the SBIR and STTR programs respectively. The FY 2012 amount shown is the estimated requirement for the continuation of the SBIR and STTR program.	+518
Total Funding Change, Fuels Technology	**-4,918**

Outreach, Deployment & Analysis

Funding Schedule by Activity

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Outreach, Deployment & Analysis		
Graduate Automotive Technology Education (GATE)	1,000	1,000
Advanced Vehicle Competitions	2,000	1,000
Legislative and Rulemaking	2,004	2,000
Vehicle Technologies Deployment	25,510	229,000
Biennial Peer Reviews	2,700	500
VMT Reduction and Legacy Fleet Improvement	0	3,000
Total, Outreach, Deployment & Analysis	33,214	236,500

Benefits

The Outreach, Deployment & Analysis subprogram contributes directly to VTP's climate benefits by accelerating the movement of advanced technologies into widespread usage. For the existing program, 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.

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. VTP 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 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.

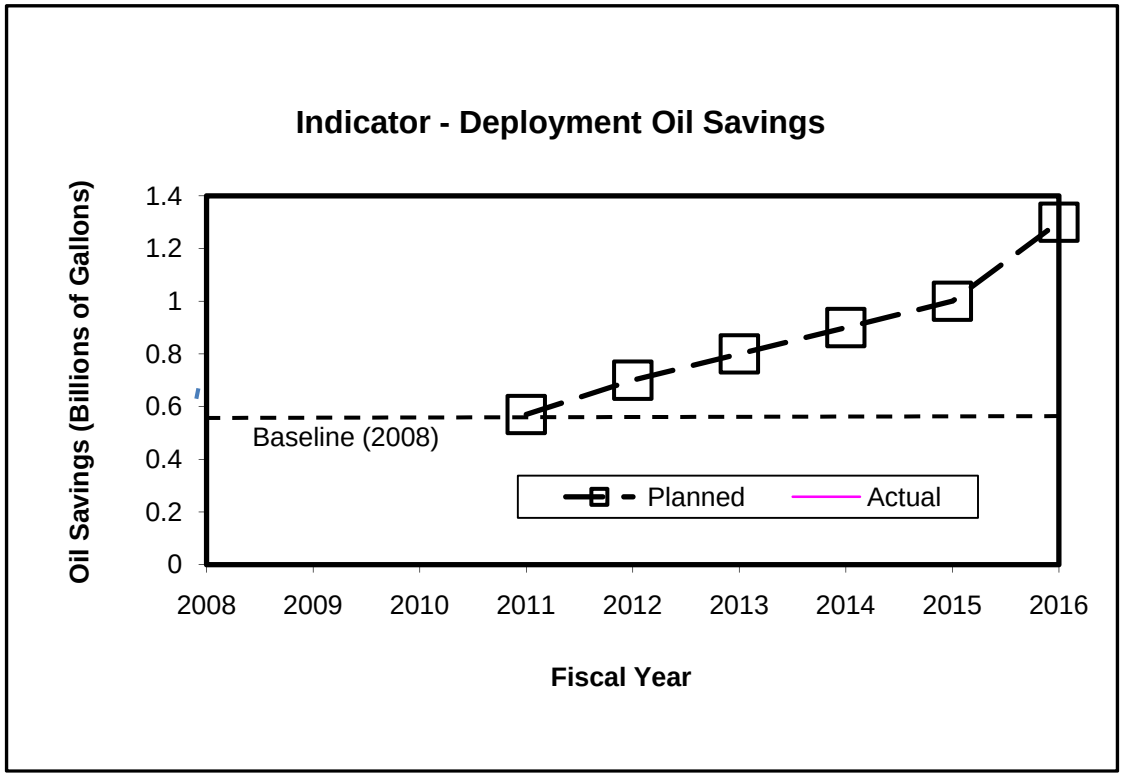
Activities such as the Advanced Vehicle Competitions and Graduate Automotive Technology Education (GATE) encourage the interest of university student engineers and engage their participation in advanced technology development. This helps address the need for more highly trained engineers in hybrid and fuel cell technologies to overcome barriers in the marketplace. GATE also supports a pipeline into the auto industry of new engineers familiar with the most advanced technologies.

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

A key goal of the subprogram is to:

- Achieve a petroleum reduction of 2.5 billion gallons per year by 2020 through the adoption of alternative fuels and advanced technology vehicles, development of the infrastructure needed to support them, and increased public awareness about the energy and environmental benefits associated with using these fuels and technologies.

The progress indicator for this goal is shown below.



Applied R&D benefits are not parsed to individual subprograms because of the interdependency of the R&D and technologies within the program. VTP 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 2010 Current Approp	FY 2012 Request
Graduate Automotive Technology Education (GATE)	**1,000**	**1,000**

In FY 2012, this activity will establish and expand course study work and research to support graduate engineering degrees with a focus or certificate in critical automotive technology areas. This activity will help train a future workforce of automotive engineering professionals knowledgeable about, and experienced in, developing and commercializing advanced automotive technologies to help overcome technology barriers preventing the development and production of cost-effective, high-efficiency vehicles for the U.S. market. 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	**2,000**	**1,000**

The Advanced Vehicle Competitions activity will educate the next generation of young engineers in automotive technology, providing first-hand experience with advanced technologies such as PHEVs and advanced combustion alternative fuel 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.

Legislative and Rulemaking	**2,004**	**2,000**

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 impacts of 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 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.

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Vehicle Technologies Deployment	**25,510**	**229,000**

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: alternative fuel and electric drive advanced technology vehicles and related fueling/charging infrastructure; idling reduction for commercial trucks and buses; expanded use of non-petroleum and renewable fuels; 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 will also 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 that include: transit, refuse trucks, school bus, delivery trucks, and municipal fleets.

Section 405 of EPAct 1992 and Sections 721, 1001, and 1004 of EPAct 2005 direct DOE to:

- Expand consumer education;
- Promote technology transfer; and
- Address implementation barriers.

VTP 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 alternative fuel and electric drive 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 website (www.fueleconomy.gov) 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.

FY 2012 Vehicle Technologies Deployment funding includes $200 million for the expansion of electric drive vehicle deployment and related infrastructure development activities, in support of the President's goal to put 1 million electric vehicles on the road by 2015. This competitive grant program will support communities to become early adopters of electric drive vehicles through regulatory streamlining, infrastructure planning and development, and other investments.

Biennial Peer Reviews	**2,700**	**500**

Funding is used to conduct reviews of the government/industry partnerships by an independent third party, such as the NAS/National Academy of Engineering, to evaluate the progress and direction of the program. Reviews will include evaluation of progress toward achieving the technical and program

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request

goals supporting each partnership, as well as an assessment of the appropriateness of Federal investment in each of the activities. Based on evaluations, resource availability, and other factors, partners will consider new opportunities, make adjustments to technology specific targets, and set goals as appropriate. 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.

VMT Reduction and Legacy Fleet Improvement	**0**	**3,000**

The new activity will support the more efficient use of existing light-duty vehicle stock by encouraging efficient driver behavior, reducing the number of vehicle miles traveled (VMT), and by developing and deploying simple aftermarket tools and technologies to reduce fuel consumption. This activity will encourage more efficient light vehicle driver behavior via the development and deployment of driver feedback devices that stimulate efficient driving. The activity will also encourage less frequent use of light vehicles by initiating a dialogue with DOT, EPA, and others on strategies to reduce VMT and subsequently implementing those strategies. VTP will interact with DOT and tire manufacturers to develop a tire improvement strategy, which will assess technology gaps to cost-competitive low rolling resistance tires and identify demonstration and deployment strategies to raise consumer awareness and achieve quick market penetrations throughout the legacy fleet. 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.

Total, Outreach, Deployment & Analysis	**33,214**	**236,500**

Explanation of Funding Changes

	FY 2012 vs. FY 2010 Current Approp ($000)
Graduate Automotive Technology Education (GATE)	
No change.	0
Advanced Vehicle Competitions	
Funding is decreased to focus on priority activities in VTP. The decrease will reduce the number of students exposed to advanced automotive technologies through the competition series, scale back the number of participating universities and the scope of the competition.	-1,000
Legislative and Rulemaking	
No significant change.	-4
Vehicle Technology Deployment	
Increased funding will be used to support expanded transportation electrification efforts, advanced technology vehicle deployment, and infrastructure development activities. This includes competitive awards to deploy electric vehicles and the charging infrastructure services needed to support them.	+203,490
Biennial Peer Reviews	
In FY 2010, funding was provided for a one-time comprehensive analysis of energy use within the light duty vehicle transportation sector. No funds are requested for this analysis in FY 2012.	-2,200
VMT Reduction and Legacy Fleet Improvement	
The VMT Reduction and Legacy Fleet Improvement Activity is new in FY 2012. This funding will enable VTP to reduce the fuel consumption and emissions of vehicles already on the road by developing and deploying feedback devices that encourage efficient driver behavior, by reducing miles traveled, and by developing and deploying cost-efficient, fuel-efficient aftermarket tires.	+3,000
Total Funding Change, Outreach, Deployment & Analysis	**+203,286**