STATEMENT OF

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FEDERAL VEHICLE TECHNOLOGY RESEARCH & DEVELOPMENT

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Chairman Baird, Ranking Member Inglis, Members of the Committee, thank you for the opportunity to appear before you today to discuss the U.S. Department of Energy's (DOE) Vehicle Technologies Program activities. Reducing U.S. dependence on oil is one of the most significant ways in which our Nation can improve energy security and address global climate change.

The mission of the Vehicle Technologies Program is to develop more energy-efficient and environmentally friendly highway transportation technologies for light-, medium-, and heavy-duty vehicles that meet emissions regulations and reduce petroleum dependence without sacrificing performance or passenger safety. Accomplishing the mission will contribute to climate change mitigation, energy and economic security, and enable more productive use of the Nation's total energy resources. The FY 2009 Omnibus Appropriations Act provides over $273 million for the Vehicle Technologies Program, compared to $213 million in FY 2008.

As the sector responsible for more than two-thirds of U.S. oil usage, advances in transportation technology can have a major impact on reducing oil dependence.[1] Additionally, according to one study, for every one percent improvement in vehicle fuel efficiency across the Nation's fleet, consumers could save more than two billion gallons of fuel annually.[2]

Our research agenda is guided by an extensive analysis, test and evaluation effort, as well as stakeholder involvement. Typically, projects undergo independent peer evaluation every year. This evaluation helps inform future direction and project closeout.

The Department leads a cooperative effort among energy companies, utilities and vehicle manufacturers to develop the next generation of personal transportation. Our entire program is reviewed every other year by the National Academy of Sciences National Research Council (NRC). NRC findings are evaluated and recommendations implemented to improve the effort's effectiveness.

In the area of personal transportation, the Department's Vehicle Technologies Program addresses the Nation's petroleum dependency on two fronts – improving efficiency of the vehicles we drive, and substituting to new fuels, including biofuels and electricity. The Program Research and Development (R&D) portfolio includes:

- Hybrid and Plug-in Hybrid Vehicles (PHEV) – R&D for battery, electrical machines, electric motors and battery systems research for hybrid, and PHEVs
- Fuels – Improved utilization of petroleum and non-petroleum fuels, addressing light-, medium-, and heavy-duty vehicles
- Materials – Advanced material development and manufacturing, e.g., carbon fiber and thermoelectric materials

[1] Transportation Energy Data Book Edition 27, Table 1.13.
[2] "Tires and Passenger Vehicle Fuel Economy," NRC, http://books.nap.edu/openbook.php?record_id=11620&page=4.

- Internal Combustion Engines (ICE) – Efficiency improvements for conventional ICEs
- Heavy-Duty Vehicle Systems and Components

Development of PHEVs can provide significant improvements in fuel economy and petroleum displacement by using electricity from the grid at off-peak hours. PHEVs are similar to the current generation of hybrid vehicles, except that the battery is significantly larger, providing a range of up to 40 miles in an all-electric mode and allowing the battery to be charged by "plugging in" to a standard wall socket.[3] Forty miles in an all-electric mode is more than adequate for the typical urban commuter, but not all U.S. drivers are typical; after 40 miles, the engine takes over and the vehicle operates similar to today's hybrids, achieving excellent fuel economy.

PHEVs displace petroleum by substituting electricity from the grid for gasoline. A PHEV stretches a vehicle's mileage up to 100 mpg on a gasoline basis.[4] Since PHEV owners would typically charge their vehicles at night, this would limit the impact to the electric grid and allow consumers to take advantage of off-peak electricity rates, in States where time-of-day pricing is in effect. A study by the Pacific Northwest National Laboratory has shown that 70% of the current vehicle fleet could be replaced with PHEVs without significant impact to the electric power grid.[5]

A key component of the emergence of PHEVs is a new generation of lithium-ion batteries. The success of the lithium-ion battery is imperative for PHEV deployment and commercial acceptance. However, these batteries are still too expensive and require further technological improvements for widespread consumer acceptance. Continued development of battery and electric motor technologies will allow future generations of hybrids and PHEVs to compete with conventional ICE vehicles on a cost competitive basis.

While the U.S. has a robust industry base in certain types of conventional batteries like alkaline "flashlight" batteries and lead-acid "starter" batteries, we have very little manufacturing capability for new generation batteries like lithium-ion, for which more than 95% of the world's production is located in Asia.[6] Because the vehicle fleet of tomorrow will include more and more hybrids, PHEVs, and even all-electric vehicles, there is a pressing need to establish the facilities to manufacture those batteries in the United States. The President made the first step towards doing just that last week when he announced the release of a $2 billion Advanced Battery Manufacturing solicitation funded by the American Recovery and Reinvestment Act (Recovery Act). The solicitation includes up to $1.5 billion to establish battery manufacturing facilities, representing an important step forward for vehicle technology. Making batteries in the

[3] "PHEV Batteries," Transportation Technology Research and Development Center, Argonne National Laboratory, http://www.transportation.anl.gov/batteries/phev_batteries.html.
[4] "All About Plug-In Hybrids (PHEVs)," http://www.calcars.org/vehicles.html.
[5] "U-M, PNNL study: Are plug-ins the next wave of hybrid vehicles?" Pacific Northwest National Laboratory, http://www.pnl.gov/news/release.asp?id=272.
[6] "Sourcing Report: Lithium Batteries," http://www.chinasourcingreports.com/csr/Electronic-Components/Lithium-Batteries/p/CSRLIT/Industry-Overview.htm.

United States will facilitate the Administration's goal of putting one million PHEVs on the road by 2015. In addition, these battery manufacturing facilities can supply advanced batteries for defense applications, consumer electronics, power tools, utility voltage regulation, and truck idling mitigation.

Along with increased battery and PHEV development, deployment of alternative fuels can reduce transportation oil consumption. DOE is a leader in facilitating the deployment of alternative fuels, including ethanol blends, biodiesel, hydrogen, and electricity while developing fuel infrastructures through partnerships with state and local governments, universities, and industry. The fuels effort supports R&D directed towards providing consumers with fuel options that are cost-competitive, enable higher fuel economy, deliver lower emissions, and reduce the use of oil. One specific activity is the evaluation of the impact intermediate blends of ethanol, such as E15 and E20 (15% and 20% ethanol mixed with gasoline), have on performance, emissions and durability of the existing vehicle fleet and on small, non-road engines. While alternative fuels can reduce dependence on oil imports, DOE recognizes that careful analysis is needed to assess the effects of such fuels on emissions.

Reducing vehicle weight and energy loss during vehicle operation directly improves vehicle fuel economy. The introduction of cost-effective, high-strength materials and thermoelectric[7] materials can significantly reduce vehicle weight without compromising safety while improving efficiency. The use of lightweight, high-performance materials such as carbon fiber, polymers, and metal alloys will contribute to the development of vehicles that provide better fuel economy, yet are comparable in size and comfort to today's vehicles. The goal is to develop and validate cost-effective high strength material technologies that could significantly reduce vehicle weight without compromising cost, performance, safety, or recyclability.

Improved combustion technologies and optimized fuel systems can provide near- and mid-term fuel efficiency gains. The goal here is to achieve engine efficiency for passenger vehicles of 45%, a substantial increase from the current average of 30%.[8] DOE's Vehicle Technologies Program focuses much of its effort on improving vehicle fuel economy while meeting increasingly stringent emissions standards. Achieving these goals requires a comprehensive understanding of relationships among fuel economy, emissions, and engine and hybrid system control strategies, in order to minimize the fuel economy penalty associated with emission controls. Researchers at universities, private industry and DOE's National Laboratories are working to identify technologies and engine control strategies that achieve the best combination of high fuel economy and low emissions for advanced diesel, gasoline, and hydrogen internal combustion engines for application in conventional and hybrid-electric drives.

[7] "Thermoelectric" refers to the conversion of heat directly to electricity.
[8] "Summary of Fuel Economy Performance" (Washington, DC: Annual Issues), National Highway Traffic Safety Administration, U.S. Department of Transportation, available at http://www.nhtsa.dot.gov/portal/site/nhtsa/menuitem.43ac99aefa80569eea57529cdba046a0/.

In the future, we see a continuing trend toward electrification of vehicle drivetrains and ancillary components, as well as lightweighting and widespread deployment of biofuels for use in the light-duty vehicle sector.

Highway vehicles account for 80% of the transportation sector with heavy-duty vehicles consuming approximately 25% of the fuel.[9] Trucks and other heavy-duty vehicles are of the utmost importance to the business community, with 69% of freight tonnage transported by truck.[10] When diesel prices go up, the trucking industry and many businesses struggle. The Energy Information Administration's 2008 Annual Energy Outlook (AEO) predicts that U.S. heavy truck fuel consumption will increase 23% between 2009 and 2020.[11]

Technological advancements are adopted by the heavy-duty vehicle industry more quickly than the light-duty sector due to several factors, including the willingness to be early-adopters and the immediate payoff and high return on investment that the industry sees upon implementation. It takes approximately 15 years for a technology to reach maximum penetration in sales of new cars and light trucks.[12] For the heavy-duty fleet, the timetable is closer to three years.[13] The quick adoption of technology by heavy-duty vehicle fleet operators may enable more rapid realization of job creation, improved energy security, and carbon mitigation benefits.

The Department leads the 21st Century Truck Partnership, a cooperative effort between the commercial vehicle (truck and bus) industry and major Federal Agencies to develop technologies that will make our Nation's commercial vehicles more efficient, clean, and safe. Specifically, Vehicle Technologies Program R&D aims to increase engine efficiency, develop hybrid powertrain technologies, reduce parasitic and idling losses, and validate and demonstrate these technologies. As noted above, NRC reviews the Partnership's progress every other year and provides findings and recommendations which are evaluated and implemented to improve overall effectiveness.

Heavy-duty vehicle R&D focuses on advanced combustion and increased engine efficiency, including utilizing waste heat recovery; optimizing engines for urban and highway hybrid applications; encouraging the use of renewable diesel fuel; and reducing power-train losses. One research goal is to develop and demonstrate an emissions-compliant engine system for a typical tractor trailer or "Class 8 trucks" with 20% greater engine system fuel efficiency by 2014. NRC recommended that DOE complete a demonstration of improved engine thermal efficiency. DOE will consider this recommendation as part of a future heavy-duty vehicle solicitation.

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[9] Transportation Energy Data Book Edition 27, Table 2.5, page 2-1.
[10] American Trucking Trends 2008-2009, p. 5.
[11] "Annual Energy Outlook 2008," Energy Information Administration, Table A7.
[12] "Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 2006," EPA420-R-011, July 2006, p. 62.
[13] "Heavy Truck Research, Development, & Demonstration: Looking for Return on Investment," 2009 SAE Government-Industry Meeting Presentation, U.S. DOE, slide 9.

Medium-duty trucks such as buses, delivery vehicles, and waste hauling trucks are important because they normally operate under city driving conditions and often in air quality non-attainment areas. Medium-duty applications are also an excellent way to transition light-duty technology into the heavy-duty sector. R&D accomplishments in this area include the dual mode hybrid technology co-developed with a transmission manufacturer. This technology was first developed for hybrid transit buses, with the goal of attaining higher power density and lower component cost for the electric drive motor and power electronics. Since October 2003, more than 500 hybrid buses have been deployed in 44 U.S. cities, a deployment that was supported by the Federal Transit Administration.[14] Converting transit bus fleets to hybrids in the nine largest U.S. cities would impact 18 thousand buses, equivalent to replacing 720 thousand conventional vehicles with hybrid cars.[15] The success with hybrid transit buses has not only capitalized on an opportunity to penetrate the mass transit market, but has also opened the technology pathway for the next generation of commercially viable advanced heavy- and light-duty hybrid vehicles. NRC recommended that the potential benefits of hybrid Class 8 trucks be evaluated and that if benefits appeared promising, this activity should accelerate development of the necessary hybrid technology and demonstrate it in prototype vehicles.

Electrification of heavy-duty vehicles and idle reduction measures can yield major fuel savings in the trucking industry, as truckers often idle their vehicles at truck stops for hours at a time to provide sleeper compartments with electricity for heat, air conditioning, and small appliances. Truck stop electrification allows truckers to operate necessary systems without idling the engine, reducing diesel fuel emissions and saving trucking companies the cost of that fuel. The Department's Vehicle Technologies Program has also investigated ways to electrify mechanical engine accessories to achieve greater efficiency and is developing thermoelectric devices to convert exhaust heat energy to electricity to provide on-board power. The NRC committee recommended continued R&D of the system components that will provide additional improvements in idle reduction and parasitic losses. DOE agrees with this recommendation.

The next step toward making significant technological advancements will be to look at the vehicle system as a whole. In a heavy-duty vehicle, the powertrain, fuels, materials, aerodynamics, hybridization, and idle reduction capabilities must be engineered together to reach the most efficient vehicle energy balance.

The goal with this systems approach is to improve Class 8 freight efficiency in "ton-miles per gallon"[16] by 50% through accelerated R&D by industry teams led by truck manufacturers. This would involve developing and integrating a unique combination of technologies which may include engine efficiency, lightweighting, hybridization, and

[14]Motor & Power Electronics Development, Arthur McGrew, Allison Transmission, General Motors Corporation, February 8, 2007.
[15] Ibid.
[16] Since a fully-loaded Class 8 tractor trailer combination weighs 80 thousand pounds, the term "freight efficiency" in ton-miles per gallon is a more accurate characterization of this vehicle's efficiency.

parasitic load reduction. Each of these radically redesigned tractor trailer systems would then be evaluated in controlled engineering tests followed by rigorous in-service use by fleet operators.

The benefits of mitigating the Nation's addiction to oil through diverse research, development, deployment, and demonstration activities include energy security and greenhouse gas reduction. During this period of economic challenge, it is critical that we forge an even stronger R&D alliance with industry to develop the next generation of world-class clean, efficient vehicles for both personal and commercial transportation.

The Department's focus on hybrid and PHEV R&D for battery, electrical machines, electric motors and battery systems research; improved utilization of petroleum and non-petroleum fuels; advanced material development and manufacturing; efficiency improvements for conventional ICEs; and heavy-duty vehicle systems and components will help mitigate the security, environmental and economic challenge the Nation faces today.

Thank you again for the opportunity to appear before you today to discuss these important issues. I am happy to answer any questions.