Argonne NATIONAL LABORATORY

Transportation Technology

Argonne to lead DOE's effort to evaluate plug-in hybrid technology

Argonne National Laboratory has been designated by the U.S. Department of Energy's Office of FreedomCAR and Vehicle Technologies as the lead national laboratory for the simulation, validation and laboratory evaluation of plug-in hybrid electric vehicles and the advanced technologies required for these vehicles.

Plug-in hybrid electric vehicle (PHEV) technology is part of the president's Advanced Energy Initiative, which emphasizes the development of technologies that can significantly reduce the nation's dependence on foreign oil.

A plug-in hybrid electric vehicle is similar to the hybrid electric vehicles (HEVs) on the market today, but it has a larger battery that is charged both by the vehicle's gasoline engine and from plugging into a standard 110 V electrical outlet for a few hours each day.

"PHEVs and HEVs both use battery-powered motors and gasoline-powered engines to get high fuel efficiency, but PHEVs can further displace fuel usage with off-board electrical energy charged at home," explained Don Hillebrand, Director of Argonne's Center for Transportation Research.

The result is a vehicle that can achieve far greater gas mileage than today's HEVs, said Larry Johnson, Director of Argonne's Transportation Technology R&D Center. "Experts estimate that a PHEV could get more than 100 miles per gallon while the vehicle runs primarily on the battery — compared to the 30-55 miles per gallon that most of today[1]s HEVs achieve — at a charging cost that[1]s equivalent to roughly $1 a gallon. For PHEVs with extra large batteries and motors, commuters who drive less than 20 miles a day can potentially drive exclusively with its electric motor for their daily commute."

While PHEVs are a promising vehicle technology, many broad energy and environmental considerations must be examined before they become widely available. For example, while a PHEV might be less costly for the consumer to drive than a gasoline-powered vehicle, it would draw power from the electrical grid when charging.

PHEV TEST – A pair of plug-in hybrid electric vehicles are tested at Argonne's Transportation Technology R&D Center.

"Whereas virtually all electricity in the United States comes from domestic energy sources," Hillebrand said, "in some areas, much of that electricity would be generated by coal-burning power generation plants. The energy costs to extract and transport the coal, as well as the environmental considerations associated with burning the coal, are all part of the overall cost of using plug-in technology."

These issues decrease in importance as the amount of renewable energy in the electricity mix increases. There is also the question of how used batteries will be recycled, and how much that recycling will cost on a per-vehicle basis once all transport, processing, and disposal costs are considered.

Significant technical barriers must also be overcome before PHEVs are available at local car dealers. These include cost, battery size and performance, durability and safety.

Cost

PHEVs require additional, expensive components. Very large, heavy, and costly batteries are required to provide vehicle range. Also, power electronics need to be made smaller, simpler and less expensive.

The U.S. Department of Energy has determined that to be commercially viable, a hybrid technology vehicle must repay its extra upfront cost in the form of fuel savings within three years of the initial purchase.

Battery size and performance

The goals for a PHEV battery are compact size, high energy, high storage capacity and the ability to support both deep and shallow discharge/charge cycles. With today's technology, a battery that's powerful and durable enough to power a PHEV's electric motor takes up more space than many vehicle makers or consumers are willing to sacrifice. In addition to the space occupied by the battery itself, there is also space on top of and around the battery that for safety reasons cannot be used for design.

"Fortunately," Hillebrand said, "as battery technology evolves, these issues are likely to diminish."

Durability

"Chances are," Johnson said, "if you own any of today's high-tech rechargeable-battery-powered devices, such as MP3 players, PDAs or cell phones, you understand this problem firsthand. A battery small enough to meet the device's form factor and power needs must be recharged frequently, and over time, it loses its ability to take and hold a new charge."

Eventually, the battery will need to be replaced. In a car, however, consumers would expect the battery to last the life of the vehicle.

Safety

Any battery can be unsafe when mishandled or subjected to trauma such as physical blows, extremely high-temperatures or fire. Even though a vehicle is safe under normal conditions, a great deal of testing is required to determine its safety in a crash or fire. As new battery technologies are developed, they will require extensive testing before they are deemed suitable for in-vehicle use. Emergency responders must also learn how to safely handle new vehicle battery technologies in a crash or fire.

TEST DATA – Richard Carlson of Argonne's Center for Transportation Research monitors a test on the Mobile Advanced Technology Testbed. Argonne's capabilities for state-of-the-art testing of hybrids and PHEVs includes a custom data-acquisition-and-control system for advanced vehicles. Argonne's PHEV test data are based on consistent, unbiased technical evaluation results.

To address these issues and others, the U.S. Department of Energy's FreedomCAR and Vehicle Technologies Program is funding research in a variety of technical areas specific to PHEVs, including:

- Hardware-in-the-loop analysis
- Modeling & simulation
- Research and development for critical components such as batteries, motors and power electronics
- Component/subsystem testing and validation
- System and interface control development
- Vehicle testing and validation

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December 2006

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