Environmental and Energy Study Institute's (EESI) Response to ACEEE report "Plug-In Hybrids: An Environmental and Economic Performance Outlook"

Plug-in hybrid vehicles (PHEVs) have increasingly captured the media, policymakers and public as a potential solution to address oil consumption, energy security concerns and reduce greenhouse gas emissions. As this technology gains traction, researchers and industry have attempted to characterize the environmental, energy consumption and economic impacts of this promising technology in order to better understand the role it can play in the transportation sector.

A new report from the American Council for an Energy-Efficient Economy (ACEEE) attempts to characterize the environmental and economic aspects of this technology, examining the benefits it would offer beyond conventional hybrids. While the overall report presents a positive picture for plug-in technology, there are some issues (detailed below) which must be raised in regards to the analysis and underlying assumptions. We would like to raise these questions/comments as part of the ongoing discussion on plug-ins and in the interest of presenting a complete and accurate picture of the PHEVs. As further research and analyses on this promising technology emerges (many studies are underway), we anticipate that they will help further inform and enhance the discussion.

GENERAL COMMENTS

- **The report which examines what PHEVS offer above and beyond standard hybrids misses the opportunity to characterize the benefits of PHEVS relative to conventional gasoline cars.** In 2005, of the **17.1 million light-duty vehicles sold, 205,749 vehicles (or 1.2 percent) were hybrids.** [1] Significant market penetration is not anticipated for many years. (The Office for the Study of Automotive Transportation UMTRI estimates that hybrids will represent **2.11 percent of the passenger vehicle market in 2011**. Fluctuating gas prices may impact these estimates.) Given that hybrids will continue to represent a small percentage of the auto market in the coming years, comparison of all three options – conventional cars, standard hybrids and PHEVS would be more representative of the future light-duty vehicle market.

- The PHEVS were compared with the MY 2006 Toyota Prius (which represented 52 percent of the hybrid light-duty vehicle market in 2005 and 41 percent in the first half of 2006). While the Prius is the market leader, it is not representative of the entire hybrid vehicle market. It is important to note that the fuel savings benefits offered by this vehicle far exceed other hybrid options with the exception of the Honda Civic and Insight. (see next point)

- The MY 2006 Toyota Prius offers a combined fuel economy of 55 mpg (EPA). However, only two other hybrid models (Honda Civic and Insight) offer fuel economy greater than 50 mpg. In addition, Honda has announced that they will discontinue production of the Insight in mid-2006 and introduce a replacement in 2009. The remaining available hybrid models (7 models offered by Toyota, Honda, and Ford) offer fuel economy ranging between 26 mpg and 39 mpg - a significant decrease from the Prius.

- Of the 168,686 hybrids sold so far in 2006, 92, 975 vehicles (60 percent) offered fuel economy greater than 50 mpg (combined sales of Prius, Civic and Insight). The remaining 40 percent of hybrids offered more modest fuel savings. New and upcoming models such as the Nissan Altima and Saturn VUE will offer fuel savings lower than the Prius (40 mpg and 30 mpg respectively).

- As automakers continue to offer more hybrid models, there is a trend towards less fuel-efficient hybrids (eg., Chevrolet Tahoe, Dodge Durango, GMC Yukon and Toyota Sienna are some of the

[1] U.S. Environmental Protection Agency, Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2005,

SUV and minivan models expected soon). With the exception of the Hyundai Accent (in 2009) and Honda Fit in 2008, there seem to be few options for hybrid cars and sedans (though there are reports that other hybrid options may be in the works). The ACEEE report does not seem to account for this changing hybrid picture.

- PHEV application in the heavy-duty sector was not considered. The potential of PHEVs to reduce oil consumption and greenhouse gas emissions in the heavy-duty sector is large. Vehicles being tested are for cargo application (Dodge Sprinter van) as well as mass transport (Dodge paratransit bus in Kansas City and plug-in hybrid school bus).

METHODOLOGY

- Methodology used to calculate in-use and upstream emissions is unclear. Authors mention source of methodology (a previous ACEEE publication), however, no details are provided.

- The analysis lacks consistency and does not account for different kinds of plug-in hybrids in the market. For example – fuel savings are shown for plug-in hybrids with different all-electric ranges (10 -60 miles). However, emissions analysis is presented only for plug-ins with a 40 mile electric range. No explanation is provided for choosing this option. This presents an incomplete picture of the emissions and fuel savings profiles of plug-in hybrids. Any large scale PHEV market would presumably include different types of vehicles with varying all-electric ranges. A more complete analysis would account for these plug-in types.

DISCUSSION ON BATTERIES

- The report assumes that addition of the battery pack to increase electric range will add additional weight to the vehicle (approx. 250 lbs). This assumption is based on adding more nickel metal hydride batteries to an existing conventional hybrid battery pack. It does not take into account the possibility that the internal combustion engine can be downsized. Further plug-in innovators have been looking at lithium ion batteries (which are lighter in weight and are more energy-dense thus occupying less space).

DISCUSSION ON FUEL SAVINGS

- The fuel savings analysis bases its assumptions on a converted plug-in Prius which engages the gasoline engine when speeds exceed 35 mph. Typical driving patterns indicate 57 percent of the driving is done in highway mode where speeds do not dip below 40 mph. As a result, ACEEE bases its fuel savings calculations on the PHEV operating in all-electric mode 50 percent of the time and in hybrid mode for the rest of the time. However, prominent electric vehicle and plug-in hybrid car experts (Andrew Frank, UC Davis and David Goldstein, DC Electric Vehicle Association) assert that this assumption is not quite accurate. They contend that PHEVS can operate in electric mode at speeds above 35 mph. Significant market penetration will involve mass manufacture of PHEVS. So it is reasonable to assume that future plug-in vehicles will not be conversions but will be OEM so the low speed all-electric operation issue can be addressed.

- In addition, NREL and EPRI contend that plug-ins in blended mode (where the gasoline engine provides additional power)[2],[3] are most likely in the short-term because of lower costs associated with this design. The report acknowledges this issue but does not provide potential fuel savings associated with the operation of a PHEV based on the blended mode design. NREL studies show that even a 50 percent reduction in power (smaller batteries and electric motors) still provides

[2] Markel, T. *Plug-in Hybrid Electric Vehicles: Current Status, Long-Term Prospects and Key Challenges*. National Renewable Energy Laboratory. Presentation at the Clean Cities Congress and Expo May 8, 2006

[3] Duvall, M. Electric Power Research Institute (EPRI). *Plug-In Hybrid Electric Vehicles: Technology Challenges*. Presentation at the ZEV Technology Seminar, California Air Resources Board September 27, 2006

almost all the fuel consumption benefit of operating in all-electric mode.

DISCUSSION ON EMISSIONS

- The CO2 emission figures in the ACEEE report are much more conservative when compared to other estimates. They estimate that a PHEV with a 40 mile electric range will have CO2 emissions **15 percent lower than a hybrid**. According to Joseph Romm, a Prius +PHEV (converted Prius) produces **35 percent fewer** CO2 emissions compared to a regular Prius hybrid (using the current U.S. grid).

- At the recently concluded Zero Emissions Vehicle Symposium in California, the Charles Clark Group presented preliminary data from a study undertaken for EPRI. This study used EPRI's model of the whole U.S. power grid (with detailed characteristics of every generating plant), 30 percent-peak and 70 percent off-peak charging regimes, and PHEV penetration of 25 million in 2030 and 70 million in 2050, various regulatory scenarios and other factors. Initial results indicate that nationally a PHEV-20 would have well-to-wheel CO2 emissions of 500 grams/kiloWatt-hour (decreasing to 300 g/kWh by 2050). This compares to 850 g/kWh for a conventional hybrid and 1,200 g/kWh for a conventional gasoline car. **The PHEV-20 reduces CO2 by about 40 percent compared to the conventional hybrid (mid-sized sedan), and 60 percent compared to the gasoline car.** In California, reductions are even greater, with the PHEV emitting 375 grams per kWh, declining to 200 g/kWh. [4]

- Discussion on the potential of renewable energy to provide the electricity for plug-ins is almost non-existent. Plug-in hybrids offer an additional opportunity to make renewables such as wind an attractive option for utilities because they will help address storage and demand concerns (plug-ins can charge at night when wind is often at its strongest). A recent NREL report predicts that significant market penetration of PHEVs will result in an increase in wind generation between 13 percent and 105 percent by 2050 depending on the kind of PHEV produced. NREL predicts that significant penetration of PHEV-20 (20 mile all-electric range) will result in a **13 percent increase in wind generation**. In the case of a PHEV-60 (60 mile all-electric range) fleet, **the growth of wind generation is 105 percent in 2050** from 757 TWh/year to 1554 TWh/year. (The study assumes 448 million light-duty vehicles in the overall fleet with 50 percent market penetration by PHEVs). [5] Both peak and base load renewables (solar, geothermal, incremental hydro and biomass power) also offer enormous opportunities for greening the grid.

- Ancillary benefits of PHEV technology (including the ability to generate peak load power for the grid etc.) are not discussed. These benefits are projected to generate revenues for PHEV owners helping to reduce the incremental cost associated with these vehicles.

- In the discussion on cost, the analysis uses average electricity rates (nine cents per kWh) to calculate the annual cost of driving a plug-in. Proponents of this technology argue that users could charge at night thereby taking advantage of off-peak rates (nearly half the cost of peak rates or lower depending on the region). This would make the technology an extremely attractive option because the cost of "fuel" would be far lower than the price of conventional gasoline and could be a strong market driver. According to the Argonne National Laboratory, the cost per mile to operate a mid-sized Camry hybrid (fuel economy of 40 mpg), is 5.5 cents per mile and for a plug-in hybrid vehicle the cost would be 2.5 cents per mile (Assumption - national average price of 8 cents per kWh in 2005 and efficiency of 0.32 kWh per mile). **So operating a plug-in hybrid could cost half as much as operating a hybrid (even at low gas prices of $2.25 and average electric rates).** At off-peak rates, the price could range from 1.0 to 1.5 cents per mile making it even cheaper.

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[4] Clark, C. *Environmental Benefits of Plug-In Hybrid Electric Vehicles.* Presentation at the ZEV Technology Seminar, California Air Resources Board September 27, 2006

[5] Short, W. and Denholm, P. *A Preliminary Assessment of Plug-In Hybrid Electric Vehicles on Wind Energy Markets.* National Renewable Energy Laboratory. April 2006