



# South Coast Air Quality Management District

21865 E. Copley Drive, Diamond Bar, CA 91765-4182  
(909) 396-2000 • www.aqmd.gov

## **Plug-in Hybrid Electric Vehicle Forum and Technical Roundtable (Held on July 12, 2006)**

### **Forum Summary and Report**

#### **Executive Summary**

##### **Introduction**

Advanced batteries are critically important to the development and near-term commercialization of plug-in hybrid electric vehicles (PHEVs). On July 12<sup>th</sup>, 2006, the South Coast Air Quality Management District (AQMD), with the assistance of the Electric Power Research Institute (EPRI), convened a Technical Forum and Roundtable on Plug-in Hybrid Electric Vehicles. The goals of this Forum were:

- 1) Understand the current state of advanced battery technology for PHEVs
- 2) Discuss the key challenges in readying the technology for near-term commercialization of PHEVs
- 3) Disseminate battery technical information to AQMD staff and interested members of the public.

Participants of the forum included Board Member Cynthia Verdugo-Peralta, Dr. Chung Liu, and Dr. Matt Miyasato of the AQMD, Tom Cackette of the Air Resources Board, and an expert panel of invited battery and other industry experts. This expert panel included:

- 1) Dr. Tien Duong, U.S. Department of Energy (DOE)
- 2) Mr. Michael Andrews, Johnson Controls – SAFT Advanced Power Solutions (JCS)
- 3) Dr. Ahmad Pesaran, National Renewable Energy Laboratory (NREL)
- 4) Dr. Daniel Doughty, Sandia National Laboratory (SNL)
- 5) Mr. Loïc Gaillac, Southern California Edison (SCE)

*Cleaning the air we breathe...*

6) Mr. Greg Hanssen, Energy CS

Mark Duvall of the Electric Power Research Institute assisted the AQMD in the organization of this forum and served as moderator of the discussion sessions.

### **Summary of Expert Panel Presentations**

There were a total of eight formal presentations from the six Expert Panel members, AQMD, and EPRI.

- 1) Matt Miyasato of AQMD introduced the forum, established the forum goals, and explained the strong interest and support of the AQMD for clean vehicle technologies, including PHEVs
- 2) Mark Duvall of EPRI explained the basic technology concept of a PHEV, reviewed the key questions posed to the Expert Panel and to the participants, and then outlined likely PHEV battery requirements and some expected performance for Lithium-Ion batteries.
- 3) Tien Duong of the U.S. DOE presented the new DOE program to develop battery technology for PHEVs and outlined key technical challenges of developing Li-Ion battery technology for PHEVs.
- 4) Ahmad Pesaran of NREL presented an overview of the characteristics of different lithium-ion chemistries and battery technologies. He also presented a detailed study of PHEV battery design methodology.
- 5) Dan Doughty of SNL presented on abuse tolerance testing of Li-Ion batteries.
- 6) Michael Andrews of JCS presented on battery system requirements and commercialization challenges for PHEVs
- 7) Greg Hanssen of Energy CS presented the design and demonstration of his company's converted Prius plug-in prototype that is currently operating in the AQMD fleet
- 8) Loïc Gaillac of SCE gave a status update of ongoing testing of batteries for the PHEV Sprinter Van Program at the SCE Electric Vehicle Technical Center.

The forum was organized to allow for ample time for questions, after speaker presentations and during a public comment period. A moderated session in between the presentations and public comments posed specific questions at the panel.

## **Key Conclusions**

The following conclusions emerged from the forum presentations and discussion.

### **Lithium-Ion battery is a key PHEV energy storage technology**

Several panel participants expressed strong support for the performance and durability of existing Li-Ion battery technology in the PHEV application. While acknowledging that development challenges still remain, the consensus was that the most mature Li-Ion batteries, like the SAFT VL41M, were capable of very good performance in the PHEV application.

### **Lithium-Ion battery technology has large potential for improvement**

There is a high degree of innovation and development activity regarding lithium-ion batteries. Most of this work is currently focused on high-power applications, but the new DOE PHEV battery R&D program is expected to help re-focus development efforts to include energy battery designs. Two nanotechnology companies, A123 and Altairnano, have recently demonstrated Li-Ion batteries with dramatic improvements in specific power, deep cycle life, abuse tolerance, and operational temperature range.

### **Safety and abuse tolerance is achieved by design and careful testing**

Dan Doughty (SNL) addressed concerns about abuse tolerance and safety in Li-Ion batteries. He pointed out that there are deliberate and effective application-specific processes for evaluating abuse tolerance of Li-Ion batteries for vehicle applications. Battery designers can and do incorporate a number of redundant passive and active safety features into their battery system designs. These comments were echoed by Michael Andrews (JCS).

### **Plug-in hybrid vehicle demonstrations are critical to battery development**

The panel reached an unusually strong consensus regarding the need for PHEV demonstration programs. Nearly all the panel members were in strong agreement on this idea and most expressed specific reasons for and benefits from demonstration programs. Michael Andrew (JCS) went as far to specify an optimum number of vehicles (200) in a demonstration program to produce the strongest data.

### **Stakeholders are debating the merits of “All Electric Range” (AER)**

“All Electric Range” (AER) or electric Vehicle Miles Traveled (eVMT) are terms used to describe the capability of a PHEV to drive using only its electric motor and battery for propulsion. The current ARB definition of a PHEV includes an AER minimum requirement of 10 miles on the UDDS cycle.

There is currently an active debate underway regarding whether or not the first PHEVs should be required to exhibit AER capability. Auto manufacturers have stated that PHEVs operating in a “charge depletion” hybrid mode with the engine and motor operating together most of the time while depleting the battery is likely to be the least expensive, nearest term implementation of PHEV technology. During the panel discussions, Michael Andrews (JCS) added that this style of operation is likely to be less stressful to the battery and therefore lower risk. Ahmad Pesaran presented simulation work at NREL whose results indicate that overall vehicle efficiency between a pure charge-depleting PHEV and an AER-capable PHEV may be similar. AQMD pointed out that without AER, they are concerned that emissions benefits of PHEVs may be no better than for a typical PZEV vehicle. It should also be noted that public comments from the audience were near unanimous in support of AER-capable PHEVs.