State Clean Energy-Environment Technical Forum
Plug-In Hybrid Electric Vehicles (PHEVs)
March 15, 2007
Call Summary

Participants: 50 participants from 24 states and several national organizations (see the participants list at http://www.keystone.org/html/documents.html#plug)

Key Issues Discussed

- Current developments in PHEV technology development and testing
- Impacts of PHEV use on greenhouse gas emissions and petroleum use
- Obstacles to large-scale penetration of PHEVs in vehicle market

Summary of Presentations

Note: All of the presentations from this call are available for download at http://www.keystone.org/html/documents.html#plug . Please refer to these documents for additional detail on the presentations.

A. Welcome and Introduction – Sue Gander and Bob Larson, U.S. Environmental Protection Agency (EPA)

- EPA's Office of Transportation and Air Quality (OTAQ) has a new Transportation and Climate Division, which is now a year and a half old. One focus of this division is analysis of the potential vehicle technology and fuel pathways for reducing greenhouse gas emissions in the transportation sector.
- Plug-in hybrids electric vehicles (PHEV) represent an exciting technology with the potential to significantly increase fuel economy. PHEV is also a unique and interesting technology that brings together the power and transportation sector.
- As with any new technology, there are still many questions to resolve, such as PHEV performance, overall environmental impacts, and the implications for automakers and utilities. Today's forum addresses some of these questions, and how states are playing a role in advancing this technology.

B. PHEV Penetration, Electricity, and Greenhouse Gas Scenario Analysis – Dr. Simon Mui, EPA OTAQ

- A PHEV is a hybrid electric vehicle (HEV) with additional battery energy that can be charged from the electric grid and used to propel the vehicle for some portion of a trip. A PHEV can travel on electricity for longer than a conventional hybrid (50 miles per gallon (mpg)). PHEVs can get more than 90 mpg because they use energy from the grid not from gasoline.
- **Interest in PHEVs is growing for several reasons**:
  - Possibility of significant reductions in greenhouse gas (GHG) emissions
  - Energy security and import reduction
  - Transformative technology that can help move energy overall from conventional fuels to electricity
  - Fuel savings

    - Less need for large new energy supply infrastructure (unlike many other new energy technologies that do require new infrastructure)
- **PHEV development faces several key challenges:**
    - High upfront costs (after-market conversion kits costs between $10,000 and $12,000; lithium ion batteries cost between $3,000 and $5,000).
    - Battery durability and performance
    - Consumer acceptance
        - It is unclear if consumers will pay high upfront costs.
        - Consumers need access to garages and charging circuits.
        - Off-peak pricing is not available everywhere.
        - Resale value is unknown.
- **Analysis of PHEV and the electricity sector**
    - OTAQ did modeling of an aggressive "what if" scenario in which PHEV sales begin in 2011 and grow to 15% of all passenger vehicle sales by 2030. This sales trajectory would mean about 27 million vehicles on the road in 2030 or about 10% of PHEV passenger vehicles on the road. Currently Prius is 1.5% of total vehicle sales.
    - Electricity sales from PHEVs represent a small fraction of total U.S. electricity demand. In 2030, 1.2% of demand will be from PHEVs.
    - The additional load from PHEVs is small, as they could be charged during evenings and nights when electricity demand and costs are lower.
- **The source of electricity generation influences PHEV GHG emissions**.
    - The overall GHG emissions impact of PHEVs depends on electricity generation and can vary dramatically.
    - If coal is being used to generate electricity, then GHG reductions from a conventional hybrid or a PHEV are minimal. If electricity is generated using integrated gasification combined cycle (IGCC) or other cleaner energy sources, the reductions in GHGs dramatically improves for PHEV, even in comparison to the conventional hybrid. No matter what the electricity source, PHEVs will be better than conventional gas vehicles in terms of GHG emissions reductions.
    - After 2020, increased generation is expected to be almost entirely from coal. As demand increases, electric utilities will build more coal plants and fewer natural gas plants.
- In this scenario, purchasers of PHEVs reduce petroleum consumption by 5.5%, whereas HEVs only reduce consumption by 2.6%.
- **PHEVs also reduce passenger vehicle GHG emissions** by 2.9%, compared to 2.5% for HEVs. If PHEVs are used in combination with power plants using carbon capture and sequestration (or other low-emitting technology), then GHG emissions are reduced by 5.1%.
- **Costs of the PHEV scenario**
    - The largest cost is the additional vehicle expense.
    - The second largest cost is the expenditure on electricity.
    - Fuel savings are pretty large, so the net, cumulative cost of the scenario is $1.2 billion between 2011 and 2030.
- **Annual costs of PHEV scenario**
    - In the near term, vehicle costs exceed fuel savings.

- Over time, fuel savings start to make up for upfront costs, and in 2024 PHEVs start to break even.
- This means that by 2024, the incremental vehicle cost would have to be $15,000, which would be a substantial reduction from the current price of PHEVs.

- **Conclusion**
  - As part of a large suite of vehicle technologies, PHEVs have considerable potential to reduce use of petroleum, but GHG impacts will depend on the source of electricity generation.
  - PHEVs do not require additional, large energy infrastructure projects.
  - Cost will be the largest issue for market penetration of these vehicles.

Questions

To what degree did you factor in trying to achieve comparable performance? Did you address the increased power or gas consumption needed to haul around the larger battery?
We did not look at that. We are doing some vehicle modeling now looking at some of those issues. A lot of this is really preliminary. We assumed performance would be the same as the conventional hybrid, but we will do more on this with the Department of Energy (DOE) in the future.

What percent growth did you assume in terms of vehicle miles and gas consumption?
We took default values from our 2006 models--it was around 2% average growth per year in vehicles miles traveled, but that will vary from year to year.

Did you also consider the rate of decline in US petroleum production to see if PHEV reduced gas consumption close the gap between domestic demand and supply at all?
We did not look at that. Historical values on decline of domestic gas production are about 2%.

Didn't the Council on Environmental Quality (CEQ) determine in a lifecycle analysis that the break-even point in cost was at about 14 years?
Yes

What is the target range of the PHEV?
40 miles. We averaged two models with all-electrics ranges of 60 and 20. The range may change as battery costs come down.

Will the batteries hold up during the 14-year break-even period?
We did discuss that. No automaker would sell these cars if you needed to replace the battery a lot. So automakers will want to be sure that battery life is robust.

What is the current state of the art of battery life?
Battery packs for PHEVs are conversion kits; they are not mass-manufactured. Mass-manufactured batteries are being tested now. A standard Prius today can get about 150,000 miles on a conventional battery.

C. New York State PHEV Initiative - Joe Wagner, New York State Energy Research and Development Authority (NYSERDA)

- NYSERDA is a public benefit corporation that was created in 1975 to pursue energy savings, environmental benefits, and economic development. It is funded primarily by utility ratepayers.
- **NYSERDA has a history with electric and hybrid vehicles**
  - Had 500 electric Postal Service vehicles built between 1999 and 2001 and 100 electric station cars demonstrated between 2001 and 2003.
  - Had research and development programs working on hybrid vehicles as far back as 1995. The ongoing hybrid bus program has been one of its biggest successes, with 1,000 buses built or on order.
  - Was involved with PHEV projects to create a passenger bus and a delivery van.
  - Had a Prius converted to PHEV and exhibited at the White House in February 2007.
- **There are several advantages to PHEVs**:
  - Less petroleum use
  - Lower fuel costs
  - Potentially lower air pollution and carbon dioxide emissions
  - Can benefit the grid through off-charging
  - No range restriction, relatively small batteries, and optional/interruptible charging (unlike battery-electric vehicles)
  - Part of the path toward renewable energy for vehicles (increasing the role of wind in the energy supply is a high priority in New York)
- **Disadvantages of PHEVs include:**
  - Added cost, weight, and durability of batteries
  - Reluctance of car companies
  - Conversion issues (emissions certification, safety compliance, and loss of warranty)
- **New York State PHEV Initiative**:
  - $10 million will be spent converting conventional hybrid vehicles to PHEVs to jumpstart commercialization. The program is structured to provide help with technology through product development, testing, certification, and guaranteed sales (600 units will be purchased by the State).
- There are currently 4 types of hybrids in the New York State fleet: the Ford Escape, the Toyota Prius, the Honda Accord, and the Honda Civic.
- **The PHEV Technology Initiative has 2 stages** :
  - Stage 1: Validating the technology:
    - Resolving issues around specifications (battery size and configuration), certification (safety and emissions), performance (mileage and winter operation), best fit (driving cycle and garaging), and cost (of the vehicle, of infrastructure, of warranties, and of operations and maintenance)
    - In 2006, NYSERDA accepted proposals for up to $100,000 for sample vehicles. No specifications were provided, but bids had to include the base vehicle, PHEV conversion, field support, and documentation. It emphasized rapid delivery.

        - 16 proposals were submitted by 9 teams using the Ford Escape (6), the Toyota Prius (8), or the Honda Civic (2) as the base vehicle.
        - 4 proponents were selected to build 6 PHEVs.
        - Some projects aimed to provide a new battery in parallel with the existing battery in the base vehicle, while others sought to replace the original battery altogether.
    - **Stage 2: Converting state-owned HEVs to PHEVs**:
        - Successful Stage 1 participants will be invited to submit proposals to convert State HEVs for $10 million.
        - The proposal deadline has not yet been set.
- NYSERDA will be doing substantial testing and analysis of the produced vehicles.
    - Performance and durability tests, as well as fleet demonstrations, will be done with DOE.
    - Best-fit options and site-specific infrastructure assessments will be done with Electric Transportation Engineering Corporation.
- It is still early in the program, so little technological data is available. However **NYSERDA's preliminary observations include:**
    - These are truly technological "firsts" and they must be tested
    - Emissions regulatory status is proving more difficult than anticipated and must be resolved
    - Fuel gains need to be economic
    - Cost remains a concern (particularly with regard to the battery and the loss of the manufacturer's warranty because of after-market conversion)
    - Optimum battery size remains elusive
    - "Electric-only" range is a misleading term; these vehicles will have a "blended mode"
    - Plugging in may be difficult for fleet operators
- **Commercial success of PHEVs may depend on public policy.** Clear and accommodating regulations will need to be established, including incentives for PHEV purchasing and regulation of carbon dioxide. Vehicle cost is a substantial barrier, and an innovative market structure may be necessary.
- Car manufacturers are beginning to show interest. In the last 6 months, GM, Toyota, and Nissan have announced preliminary PHEV plans.

Questions

Is the mode of operation being converted in the test vehicles?

The degree to which the controls are being modified is unknown. We have not tested them to see how they will operate. We think the vehicles will still have the same control strategy from the factory, which does have implications for the vehicles' ability to operate on electric only.

Are any of the proposals NYSERDA received intending to change the manufacturer controls?

They may use various control options, and some were designed with the thought that there could be a switch.

Do you think other states should also try to accelerate the introduction of PHEVs into the market? What is a critical mass for getting this to market?

NYSERDA does not make policy, but we think that our work and work being done elsewhere is making people ask questions of car companies about why they are not working more aggressively on PHEVs. It is possible that car manufacturers could come up with a new design, maybe with shared funding.

What do you mean when you say that the emissions status must be resolved?
Once you change the power train in a vehicle, you void the emissions certification and the warranty for the emissions control hardware. The vehicles need to be able to meet California emissions regulation standards. We may need waivers from the California Air Resources Board (CARB), and we may need to find a protocol for recertifying these cars.

What does EPA think about that?
(EPA response) We think that as long as the fuel source has not been changed, recertification will not be hard. The problem is that the conversion is voiding the warranty--will the conversion company stand behind the new emissions control system as well as the original automaker stood behind the original warranty?

D. Southern California PHEV Pilot Program – Lisa Mirisola, South Coast Air Quality Management District (SCAQMD)

- The Greater South Coast Air Basin is a 4-county region in California (including Los Angeles and Orange Counties). It is 11,000 square miles, is home to 16 million people, and houses 261,000 diesel vehicles and 9 million gasoline vehicles. The Basin requires additional reductions of nitrogen oxide emissions and particulate matter to meet health standards.
- Air quality in the Basin has improved since 1990, but the rate of improvement is slowing. The easy solutions have been found and implemented.
- Mobile **sources of pollutants are big contributors to air quality problems**, but these are not regulated locally. State and federal agencies set mobile emissions standards. SCAQMD is relying on advanced technology and alternative fuels for improvements in air quality.
- **The Advanced Technology Office** began in 1988 to look at short- and long-term solutions. There are now several programs for technology demonstration and development in many areas. Multiple pathways are needed to improve efficiency and emissions.
- **From 1998 to 2005, SCAQMD co-funded development of PHEVs** for entry into a DOE competition. It also co-funded development of a single demonstration vehicle—a PHEV utility bucket truck with an engine that runs on natural gas.
- In 2006, the SCAQMD Board directed staff to expand PHEV activities and pursue greater involvement in technology development and outreach.
- **Recent efforts include a PHEV forum and technical roundtable in July 2006**. This meeting included presentations and discussions by experts. The webcast and presentations are available online. Several issues were addressed at the conference:
    - Respective benefits of all-electric range vehicles and blended vehicles
    - The need to measure emissions benefits of the vehicles (using cold-starts or other approaches)

    - Potential benefits of early demonstrations of 100-200 vehicles (getting user feedback data to manufacturers)
- **The conclusions of the roundtable include**:
    - The lithium ion battery is the most promising but also very expensive
    - "Blended" strategy is most likely in early vehicles
    - All-electric range promises the most air quality benefits but it requires a larger battery
- **There are several current projects underway in the Basin**:
    - SCAQMD has contracted with EnergyCS, and they have provided 2 PHEV Prius vehicles. Several employees have been driving one of these vehicles. Early feedback suggests that people who have driven a conventional Prius like the PHEV.
    - 2 prototype Sprinter vans are being tested by Southern California Edison. The conventional version of this vehicle is made by the Mercedes Sprinter group but sold under the Dodge label in the U.S. SCAQMD is hoping to get 5 more made on an alternative fuel vehicle production line in Europe.
    - The PHEV Jetta with lithium batteries and AC propulsions is being demonstrated this year. It is a series hybrid that is seeing increased interest by manufacturers.
    - The PHEV Utility Boom truck is built on a Ford F550 chassis. There are several demonstration vehicles currently being tested.
    - SCAQMD is working with the California Air Resources Board on emissions certifications of vehicles and is providing early feedback on how emissions are shaping up in these demonstration vehicles.
    - A Request for Proposals for 30 PHEV vehicles was issued in November 2006. 5 proposals were received and evaluated. $2.7 million will be spent on demonstrations at up to 15 sites on production of 20 Quantum Escape PHEVs and 10 Hymotion Prius PHEVs. Prototypes are expected by the end of 2007.

<u>Questions</u>

Have you seen the paper by the American Council for an Efficiency Economy on PHEV and economic performance outlook? It offers a grid-by-grid look at all electric generation impacts on carbon dioxide, nitrogen oxides, sulfur oxides, etc.

Yes, we are aware of the overall perspective. We are more focused on the individual certification of vehicles. Changing out the battery pack voids the initial warranty. If it is done well, the improvements could be good for emissions. The warranty issue raises questions about how fast we should roll out a program based on conversions.

How does the deodine bus fit into the array of demonstration vehicles?

The bus may be similar to passenger vehicles with AC propulsion. We are interested in both approaches. The series hybrid may have a lot of potential, but it hinges on the cost of batteries and on safety and reliability.

What are the most important policy drivers for increasing state PHEV investments?

Air quality is the key driver in California.

Another potential driver is to allow the electricity industry to get credit for assisting the development and purchase of hybrids. Have local utilities reimburse ratepayers for PHEV purchases and give the utilities credits against carbon caps. That would provide a lot of money to overcome initial capitalization requirements.

Innovative approaches are needed and utilities should be involved. Policy drivers are needed at a national level. Utilities should organize and suggest a plan—the form of a policy or plan would be strongly influenced by whoever initiated it.

Do people from the National Renewable Energy Laboratory (NREL) want to add anything to this discussion?
Yes. There are potential synergies between the benefits of intermittent renewables and hybrids. We can use surplus wind and/or surplus photovoltaic energy at night to charge PHEVs. NREL is currently running production cost models on overnight charging strategies and midday charging to look at the potential displacement of petroleum imports.

Do any of the speakers have any advice for states that might be considering initiating similar PHEV efforts?
There are a lot of resources listed in the background document for this call. I recommend reading and getting familiar with them. Get involved with some of the other groups that are pursuing this kind of work and express your interests to them. It is important to do your due diligence with the engineering companies that propose to conduct the conversions.

Have a set budget for your initiative and just do something. Talk with the speakers on this call to see what kind of cooperation we can offer. There is strength in numbers in buying vehicles, producing data, etc. We could create something like a state PHEV users group for discussion.

NEXT TECHNICAL FORUM CALL: April 12th, from 2:00 p.m. to 3:30 p.m. ET
TOPIC: The role of energy efficiency in helping states meet peak electricity demand.