OPTION 2C
GRID-CONNECTED HYBRID ELECTRIC VEHICLES

Summary

Grid-connected hybrid electric vehicles (HEVs), also known as plug-in hybrids (PHEVs), are a viable option for reducing petroleum use. These vehicles are powered with both petroleum fuel and electricity from the grid. They can be designed with varying amounts of all-electric range, depending on the anticipated needs of drivers, policy goals, and economic factors.

The introduction of grid-connected HEVs would require little or nothing in the way of infrastructure improvements—a vehicle can be adequately charged on a nightly basis using existing 120 volt electrical outlets.[1] Maintenance of the vehicles would be similar to currently-available HEVs, which is in turn similar to conventional vehicles.

PHEVs use significantly less gasoline than conventional vehicles. If 10 percent of the cars sold in California are replaced with PHEVs, approximately 525 to 725 million gallons of gasoline could be saved each year, depending on the all-electric range of the vehicles used.[2]

As with any technology that reduces petroleum fuel use, PHEVs would result in a loss of government revenue in the form of reduced collection of fuel excise taxes.

Because of the additional, more expensive materials used in making PHEVs, this option also comes with an incremental cost to the consumer. A mid-sized PHEV would cost approximately $4,200 to $8,300 more than its conventional counterpart, again depending on the all-electric range built into the vehicle.[3] Based on this incremental vehicle cost and the fuel savings predicted, there could be a net additional cost to consumers for using these vehicles.

Description

Grid-connected HEVs use much of the same technology deployed in current HEVs, but can also draw electricity from the grid to recharge their batteries. This gives them the ability to travel a limited distance using electricity as the primary “fuel”; when this all-electric range is exhausted, normal (petroleum-fueled) HEV operation resumes. Because 63 percent of consumers’ daily trips are less than 60 miles in length,[4] a significant portion of grid-connected HEV use could be in all-electric mode.

Two types of grid-connected HEVs are considered:

- PHEV 20, an HEV with a 20-mile all-electric range
- PHEV 60, an HEV with a 60-mile all-electric range

Grid-connected HEVs are essentially a combination of two existing technologies: gasoline-electric hybrid vehicles and battery electric vehicles. There will likely be only minor technical difficulties involved in developing PHEVs, though there will be an incremental cost compared to a conventional gasoline vehicle. Both gasoline and electricity are readily available for use in grid-connected HEVs.

The PHEVs considered in this analysis have performance characteristics similar to conventional vehicles of the same size and function. Also, the vehicles would not have to be fueled with gasoline as often. In focus groups, consumers have shown a preference for charging at home over fueling at a gas station.[5]

Key Input Parameters and Values

To perform this analysis, the staff used a spreadsheet model of the state's light-duty vehicle population called the Futures Model.[6] Conventionally-fueled mid-sized cars in the model were compared to the Electric Power Research Institute's predicted characteristics of mid-sized PHEV 20s and PHEV 60s. Resulting fuel savings and incremental costs were then extrapolated for all vehicles in California. The staff assumed the state's greenhouse gas (GHG) emission standard is in effect.

For this analysis, vehicle deployment was scaled to assume that 10 percent of vehicles sold by 2022 will be grid-connected HEVs.

High and low potential gasoline fuel costs were considered. Fuel costs used in the analysis were:

1. For the maximum cost: an average of "high" fuel costs over the years 2004-2025 from the Futures Model.

2. For the minimum cost: an average of "low" fuel costs over the years 2004-2025 from the Futures Model.

High and low potential electricity fuel costs were also considered. Electricity costs used were:

1. For the maximum cost: an average of electricity rates projected by the Energy Commission over the years 2004-2016.

2. For the minimum cost: an average of electricity rates projected by the Energy Commission over the years 2004-2016, multiplied by 0.6 to account for the

40 percent discount offered to electric vehicle owners for off-peak EV charging.

Results

As shown in Table 1, replacing 10 percent of California's cars with PHEV 60s or PHEV 20s could save 4.9 percent or 3.7 percent of our base-case gasoline demand, respectively. While a mid-sized car with this technology would cost about $4,000 to $8,000 more than a comparable conventional car, some of this cost would be recovered by the reduced fuel use.

Over the next 20 years, consumers buying PHEV 20s would recover much, though not necessarily all, of the incremental cost of their vehicles. Those purchasing PHEV 60s would not achieve the same economic benefit, in the absence of additional factors.

One such possible factor, not quantified here, is the ability to provide regulation services for the power grid. In short, this would mean using the vehicles' batteries to supply small amounts of power to the grid, in order to keep the grid's voltage and frequency consistent. If this technology were developed and adopted, it could potentially improve plug-in hybrids' economics for consumers and government alike.

Table 1. Petroleum Reduction and Benefits for Grid-Connected HEVs

Alternative Fuel Option or Scenario	Displacement in 2025, billion gallon gasoline equivalent	Reduction from Base Case Demand, percent	Highest Cumulative Benefit or Change, Present Value, 2005-2025, 5% discount rate, Billion $2005				
			A	B	C	D	A+B+C+D
			Direct Non-Environmental Benefit	Change in Government Revenue	Direct Environmental Net Benefit	External Cost of Petroleum Dependency	Direct Net Benefit
PHEV 20	0.55	2.64	0.62	(0.11)	0.13	0.08	0.72
PHEV 60)	0.73	3.5	(0.40)	(0.36)	0.4	0.21	(0.16)

Key Drivers and Uncertainties

Because the PHEV is compared to a conventional gasoline vehicle with GHG control technology, the amount of fuel reduction potential for the PHEV is much lower than compared to today's vehicle. California's GHG standard results in much higher fuel economy for the conventional vehicles this option is being compared to, making the option comparatively more expensive and less beneficial in terms of petroleum displacement. If the GHG standard is not in effect, the grid-connected hybrid vehicles would show a larger benefit in both areas.

Batteries for PHEVs are expensive and account for much of the incremental costs associated with this option. If the price of batteries decreases, due to a technological advance or other reason, there would be a corresponding decrease in the incremental vehicle cost.

Gasoline price also has a significant effect on the economics of these vehicles. As the price of gasoline rises, a decision to purchase grid-connected HEVs become more economically viable.

Endnotes

[1] Electric Power Research Institute, *Comparing the Benefits and Impacts of Hybrid Electric Vehicle Options*

[2] Values for petroleum reduction are calculated from EPRI's grid-connected hybrid vehicle fuel efficiency figures, and fuel use and fuel economy predictions found in the following document: California Energy Commission, *Forecasts of California Transportation Energy Demand 2005-2025 in Support of the 2005 Integrated Energy Policy Report*.

[3] Electric Power Research Institute, *Comparing the Benefits and Impacts of Hybrid Electric Vehicle Options*. Adjusted for inflation, and compared to the base price of more-expensive, more fuel-efficient cars of the same type required by Pavley regulations.

[4] Electric Power Research Institute, *Comparing the Benefits and Impacts of Hybrid Electric Vehicle Options*

[5] Ibid

[6] Derived from data contained in: California Energy Commission, *Forecasts of California Transportation Energy Demand 2005-2025 in Support of the 2005 Integrated Energy Policy Report.*