National Renewable Energy Laboratory
Innovation for Our Energy Future

A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy

Analysis of PHEV Impacts on Utility Systems

BACKGROUND/OVERVIEW

The combination of high oil costs, concerns about oil security and availability, and air quality issues related to vehicle emissions are driving interest in "plug-in" hybrid electric vehicles (PHEVs). Utilities are interested in the net costs and benefits associated with this potential new load, including power plant fuel use, emissions and possible benefits of improved system utilization enabled by controlled PHEV charging. NREL has used several tools to evaluate the impacts of PHEVs on utility system operations. These include an NREL developed vehicle analysis tool (ADVISOR) a PHEV load shape analysis tool and a commercially available production cost model (PROSYM).

VEHICLE CHARGING PROFILES AND LOAD IMPACTS

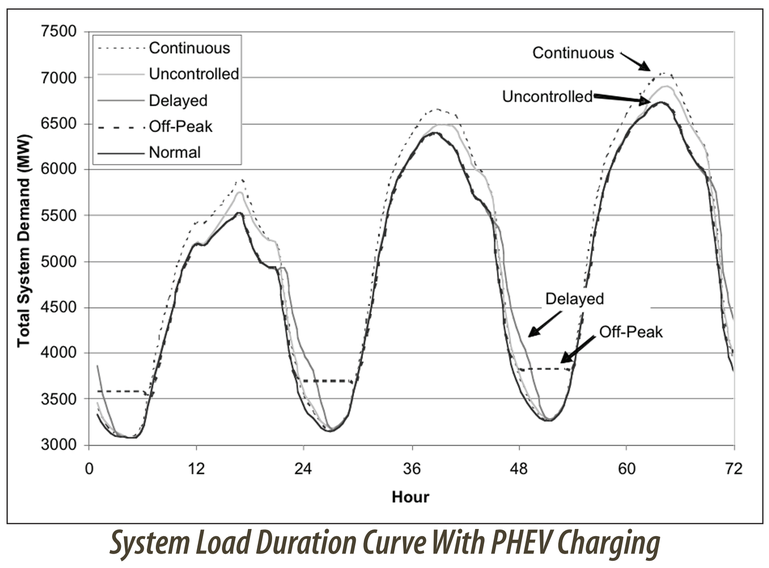
A series of PHEV charging profiles were developed using GPS-tracking vehicles simulated at PHEV-20s using NREL's ADVISOR model.

Four different charging patterns were developed:

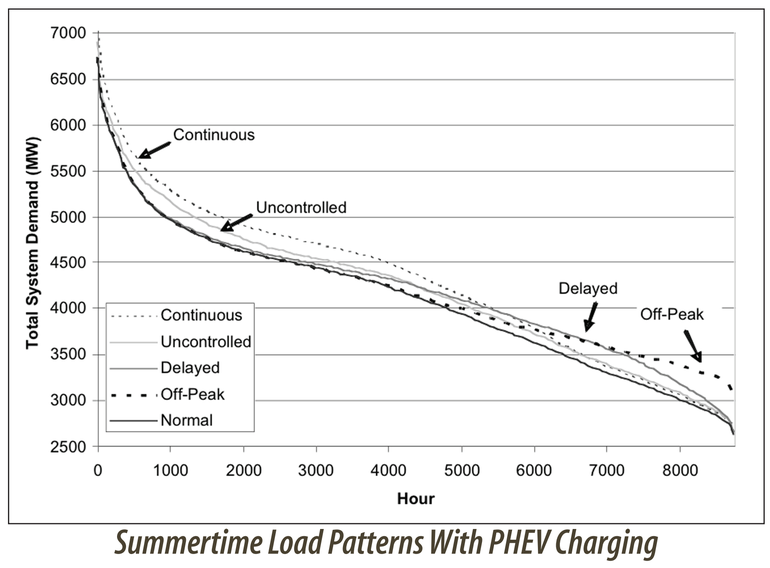
1. **Uncontrolled Charging*** – Vehicles leave the for day; return home and begin charging immediately

2. **Delayed Charging to 10pm*** – As above, but a timer delays charging until 10pm

3. **Off-Peak Charging*** – As above, but control vehicle charging to occur in the lowest load hours.



System Load Duration Curve With PHEV Charging



Summertime Load Patterns With PHEV Charging

4. **Continuous Charging** – Vehicles have access to the grid throughout the day charging whenever they are parked.

Total load impacts on the Xcel Colorado system were evaluated using a PHEV-load tool.

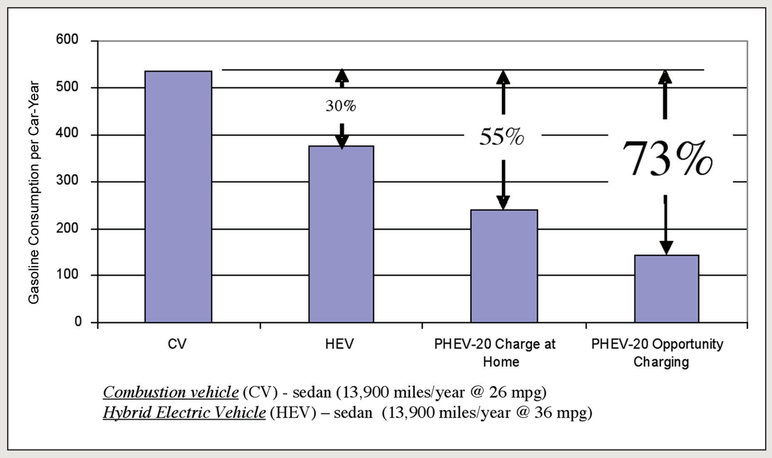
**Options one through three represent charge at home regimes*

AVOIDED GASOLINE

An average PHEV-20 charging once daily reduces fuel consumption by over 50% compared to the base vehicle.

Continuous charging may reduce fuel use by over 70%

At $3/gallon gasoline and $0.09/kWh electricity, savings for an average vehicle would exceed $700/year.



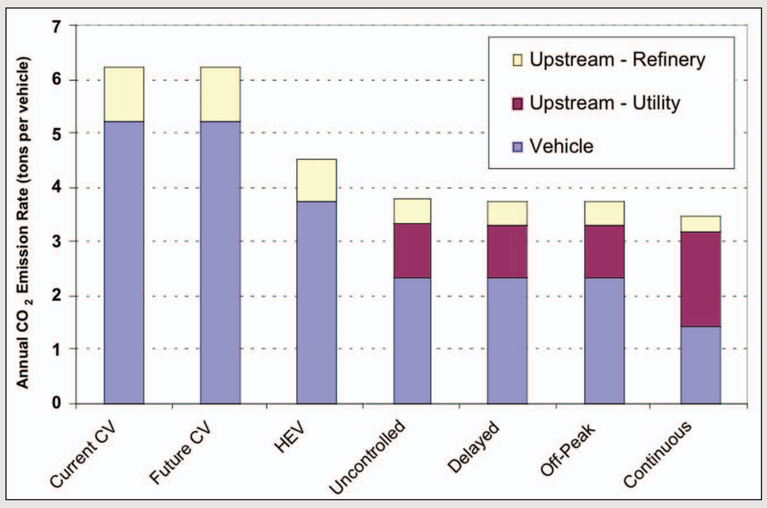
Comparative Fuel Consumption for PHEVs

EMISSIONS

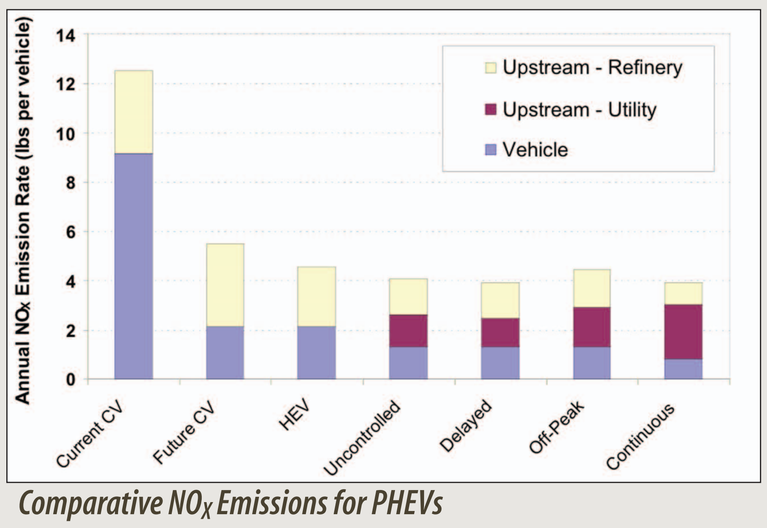
Emissions levels are driven mostly by gasoline use and the generation fuel mix.

Off-peak charging using greater amounts of coal has higher emissions then mid-day charging using more natural gas.

In all cases, PHEV emissions of NO_X and CO2 are substantially lower than conventional vehicles.



Comparative CO_2 Emissions for PHEVs



Comparative NO_X Emissions for PHEVs

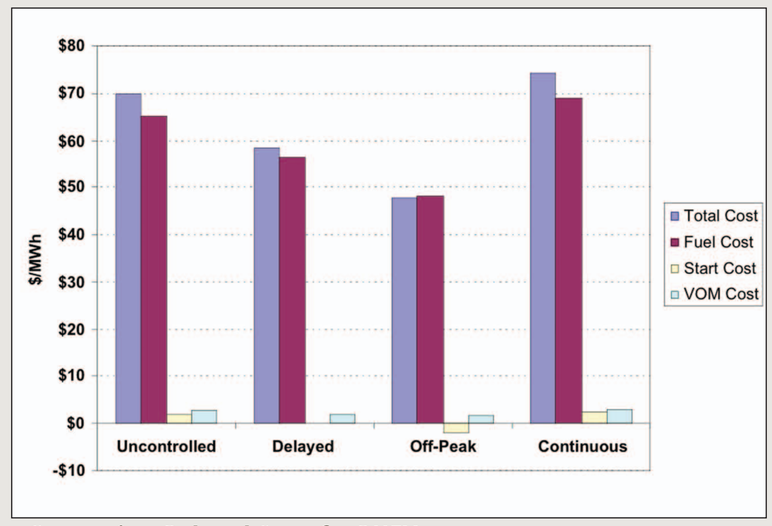
CHARGING COSTS

Current system charging costs driven by the cost of natural gas used to fuel marginal generation in Colorado.

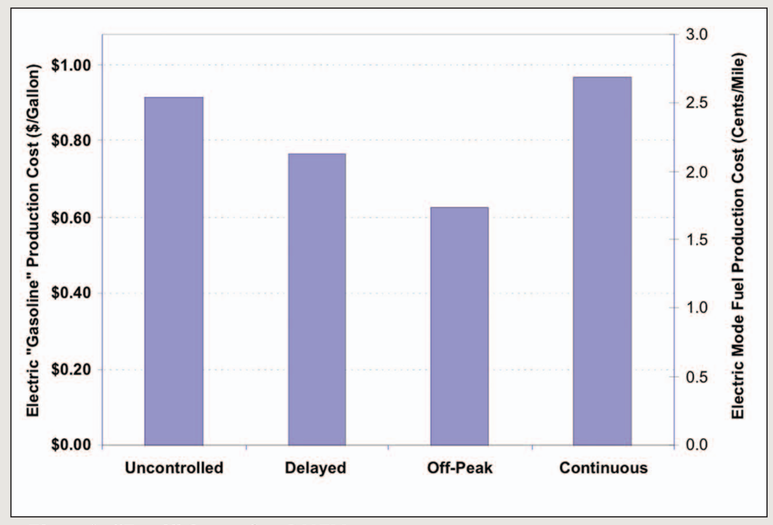
Off-peak charging allows more use of coal, but most charging is derived from natural gas.

Off-Peak charging better utilizes baseload power plants, reducing costs associated with plant shut-down and start-up.

Even using natural gas for generation, the cost of electricity is equivalent to less than $1/gallon.



Generation-Related Costs for PHEVs



Electric "Fuel" Costs for PHEVs

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