



SMUD Plug-in Hybrid Vehicle And Electric Transportation Activities In Sacramento

March 7, 2007



Plug-In Partners
National Campaign



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What is a Plug-in Hybrid?



- A hybrid vehicle with a larger battery that provides enhanced electric assist based on grid recharging
 - All electric range vehicles
 - Blended mode vehicles
- Concept pioneered by UC Davis Professor Dr. Andy Frank
 - All electric range vehicles (cars and SUV's)
 - U.S. DOE Future Car and Future Truck winners
 - Early SMUD funding support
- Concepts now vary widely and hard to define
 - Light duty to heavy duty sizes
 - Blended vs. All Electric Range etc.



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Why Plug-in Hybrids?

**Lower Green House
Gas Emissions**

Energy Security

**High price of gasoline
Lower criteria pollutant emissions
Market success of existing hybrids
Short technology leap**



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What's SMUD doing with Plug-ins?



- **Converted Prius Testing**

- 120V Standard outlet charging
- Blended mode vehicle
- Side-by-side efficiency testing

- **EPRI Sprinter Van (2008)**

- Daimler Chrysler (1 of 30)
- Blended mode vehicle
- Multi-organization evaluation



- **Plug-in Bucket Truck (2008)**

- Eaton-Ford prototype
- Side-by-side testing



Blended Mode PHEV Prius Operation

- **Operates in AER mode < 34 mph, except engine turns on at lower speeds when:**
 - Driver turns on heat or defrost
 - Driver accelerates hard
 - Battery pack is low
 - SULEV controls require engine to remain on
- **Blended mode vehicles may be viable**
 - Lower cost potential with smaller battery, smaller motors and electronic controls
 - Incremental development to current hybrids

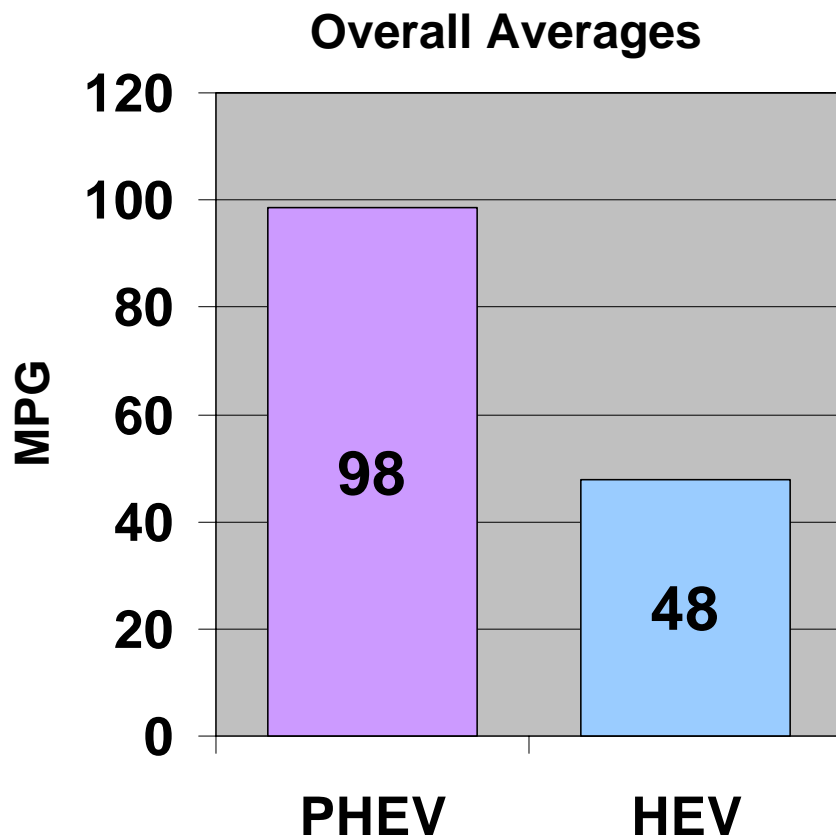


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Plug-in Prius Testing Results



- Prius versus Plug-in Prius side-by-side testing
- 28 tests on all road conditions
 - July/August 2006
- Combined City, Urban, Freeway
- Average 14.8 miles/trip
- 45 mile freeway assist range
 - 88% of most Sacramento commutes



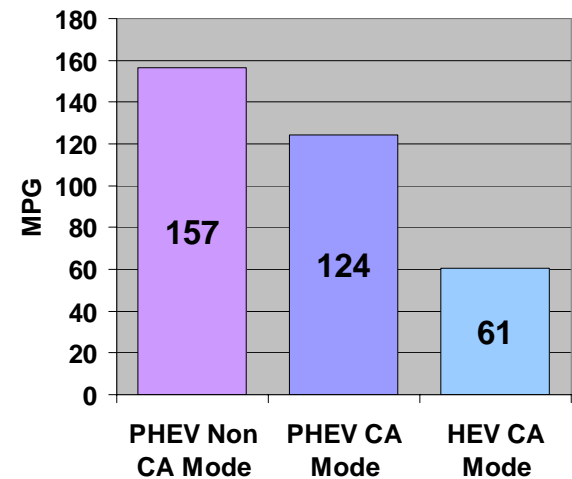
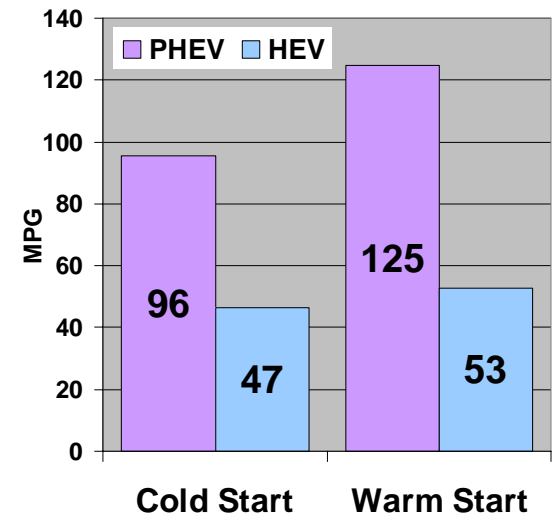
Emission controls must be satisfied

- **Emission control system dictating engine operation**

- Engine/Cataylst needs to be warm
- Engine operates more than needed to maintain temperature for SULEV

- **Non-California mode test shows trend**

- 1 test in Non-California mode showed higher mileage



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Fuel Cost: 50 Mile Trip

- Assume gasoline at \$2.75/gal.
 - Assume electricity at \$0.102 / kW
 - 154 whrs/mile from the grid in enhanced boost mode
 - 290 whrs/mile from grid in all electric mode
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- Typical V8 (16 mpg) = \$8.61
 - CAFE vehicle (27.5 mpg) = \$5.00
 - Standard Prius (50 mpg) = \$2.75
 - PHEV Prius blended (100 mpg + 154 whrs/mi) = \$2.17
 - PHEV Prius all electric mode (290 whrs/mi) = \$1.48



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TIAX Study Shows Emission Reduction Potential California Statewide 2020 Estimate

GHG (million tons per year equivalent), Criteria (tons per day)

Electric Drive Technology	Expected GHG/Criteria	Achievable GHG/Criteria
Plug-in HEV's	1.46 / 5.81	11.5 / 7.95
Truck Idle Reduction	1.38 / 0.91	3.02 / 121
Hydrogen FCEV's	0.52 / 0.87	0.65 / 1.08
Off-road Industrial Vehicles	0.31 / 1.31	2.90 / 17.1
Alternative Marine Power	0.20 / 7.76	0.30 / 11.5
Electric Transport Refrigeration Units	0.09 / 3.11	0.28 / 13.8
On-Road Battery Electric Vehicles	0.04 / 0.04	1.24 / 1.23
Lawn & Garden Equipment	0.00 / 0.00	0.39 / 18.6
Other	0.01 / 0.01	0.23 / 2.24
Totals	4.00 / 72.1	20.05 / 194.5



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Other SMUD Electric Transportation Activities



Truck Idle Reduction



Fuel Cell Vehicle Testing



Airport GSE



Forklifts



Light Rail Energy Recovery



Summary

- **Plug-in Hybrids now gaining wide stream support**
 - Original concepts pioneered by UC Davis Dr. Frank
- **Multiple design concepts and vehicles under development**
- **SMUD testing shows benefits of early conversion vehicle**
 - Approximately 100mpg for up to 45 miles
- **Additional vehicle testing to continue in Sacramento Area**
- **SMUD Electric Transportation activities supports local environmental protection efforts**

