



EnergyCS PHEV Prius Prototype Conversion Test Fleet

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EnergyCS Prototype PHEV Prius Conversion Program Goals

- ✓ OEM Approach –integrate one battery system
- ✓ Increase ZEV mode
- ✓ Improve fuel economy (>100 mpg)
- ✓ CARB emissions testing & certification (9/2006)
- ✓ Provide real world data and examples of plug-ins on the road (2004-2006)
- ✓ Develop a product that could be commercialized in the form of a plug in retrofit kit



Vehicle Fleet Composition – 2004-2006 MY 13 Toyota Prius PHEV Conversions

- Prototype – EnergyCS company car: >40000mi on original PHEV battery
- 5 in SCAQMD Fleet– SCAQMD (2), City of Santa Monica, Calcars, Clean-Tech
- 7 Early Adopters – SMUD, SCE, PG&E, Manitoba Hydro (CAN), INL/ETA, NREL, Amberjac Projects (UK)



AQMD / Early Adopter PHEV Prius Battery System

- Valence Saphion LiFePO_4 cathode material
- Increase usable energy by factor of 20
- Monitor each parallel cell group voltage
- Monitor 18 temperatures distributed throughout the pack
- Monitor pack level current and voltage
- Control cooling, safety limits



Prototype PHEV Integration Issues

- Process Development
 - Documented processes
 - Standardized BOM
 - Conformity of mat'ls
- Testing & Validation
 - On road data
 - Lab data
 - Cell data
 - Pack performance & life cycle data



- Battery
 - Availability
 - Rework required
 - Shipping costs
- Electronics
 - Seamless integration
 - Custom design
- OEM limits
 - Learning curve
 - Operating within
- Software



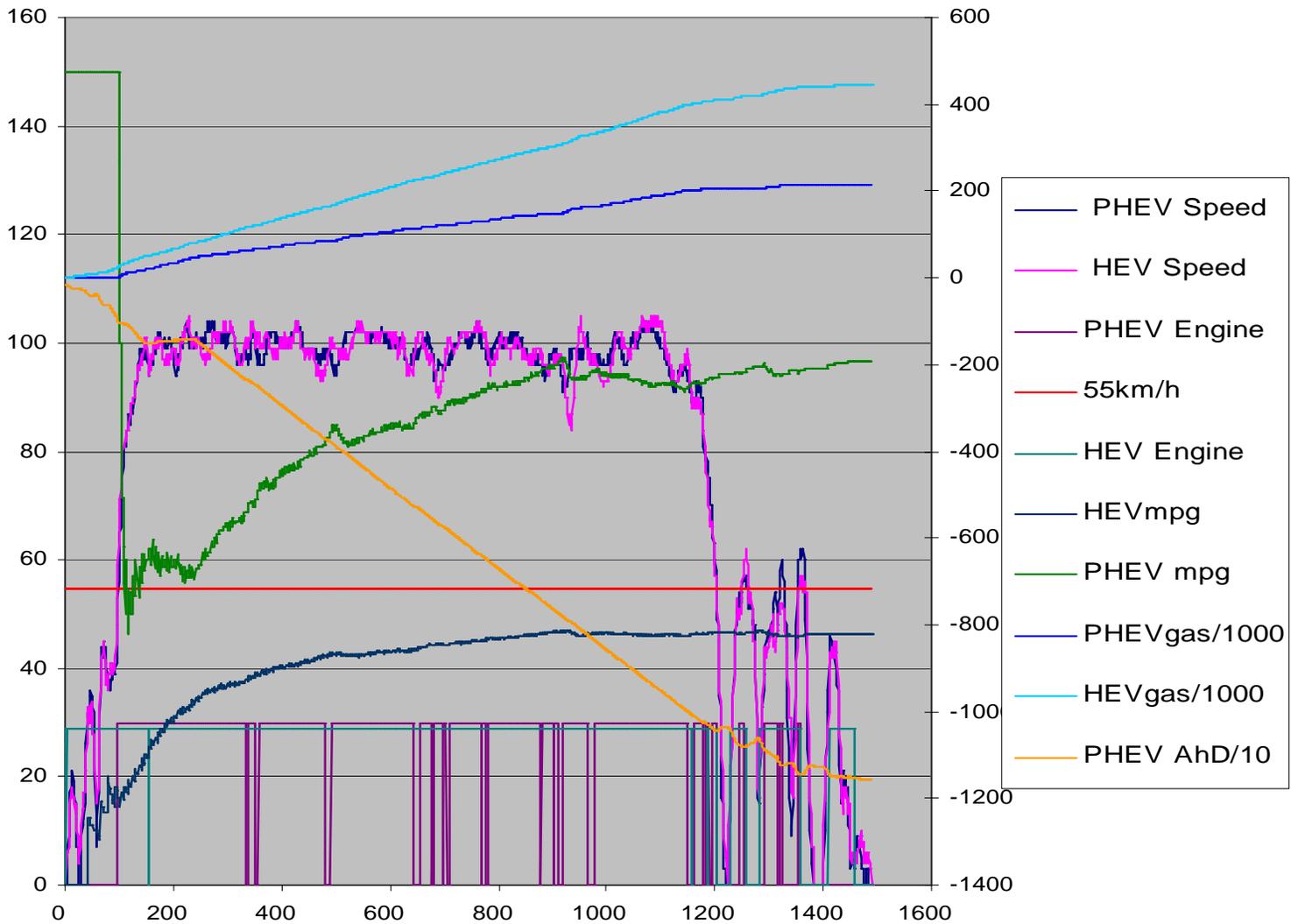
Conversion Platform – Issues and Opportunities

- OEM limits of conversion
 - Battery power limit – HV DCDC
 - Synergy Drive™ transmission – engine speed
 - Available space – trunk, spare, FMVSS
 - Thermal management – cabin air, sealing
- SULEV emissions
- Charging power, rate and infrastructure



Operating Modes of EnergyCS, SCAQMD and Early Adopter Prototypes

- ZEV mode: initial startup mode if state of charge (SOC) adequate, revert to ZEV when possible
 - City: speeds below 34mph, Power < 20kW, others
 - Freeway: speeds below 69mph, Power < 20kW
- Boost mode: entry based on power request or speed, state of charge
 - City: any speed
 - Freeway: any speed
- HEV mode: charge sustaining after pack depleted
- Charge mode: standard 120VAC GFCI outlet



Real Time Comparison – PHEV vs. HEV



Summary

- ~40000 mi on EnergyCS prototype pack
- EnergyCS fleet of SCAQMD and Early Adopters = REAL WORLD DATA
- Batteries are expensive, integration is time consuming
- Charging is simple, ubiquitous – PHEV works if you plug it in
- Electricity displaces petroleum → Renewable displaces non-renewable