

Global Energy and Environmental Initiative

How to Make Electric Vehicles a Political and Economic Reality in the U.S. and Abroad

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15 Years of Advanced Battery and Hybrid Experience

- All R&D and manufacturing conducted in-house
- RAV4-EV introduced 1996 in U.S.
- E-com (EV commuter) U.S. demo program in 2000
- Prius, world's first mass produced gas-electric hybrid introduced in 2000 to U.S. Market
- Over 2 million Toyota hybrids sold worldwide, 1 million in the U.S.



1 Million Hybrids in the U.S. Market (10 Years) Currently 1% of Market/Year

Cumulative U.S. Sales of Toyota Hybrids

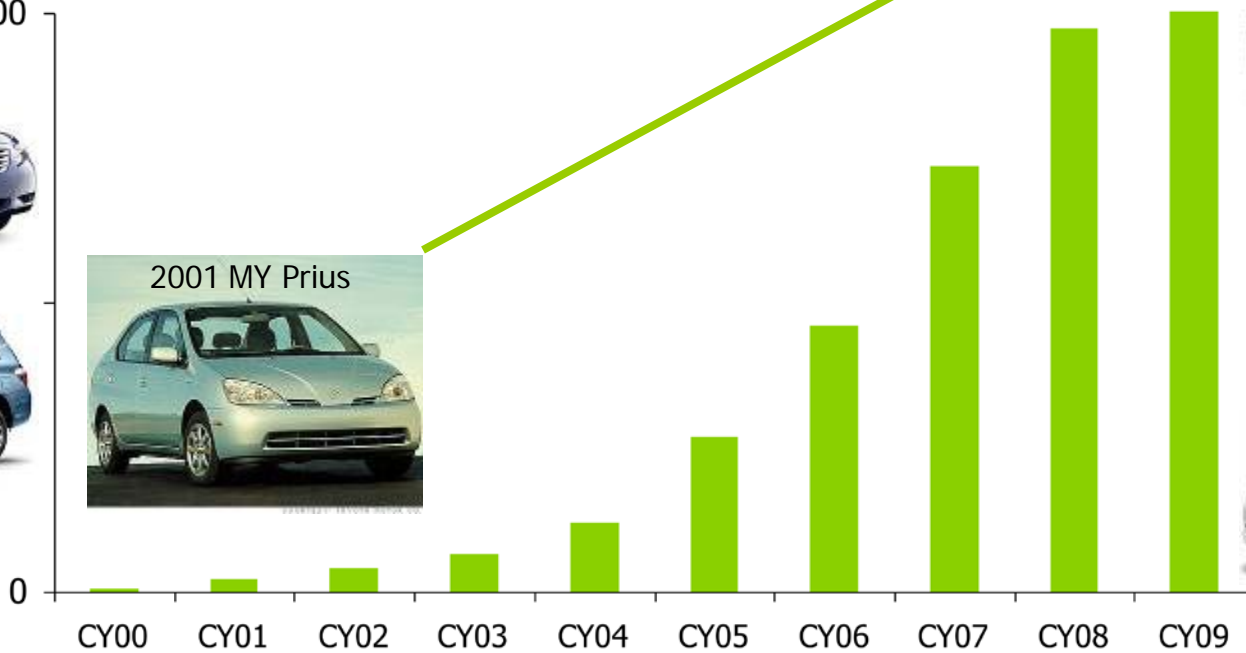
2010 MY Prius



1,000,000



2001 MY Prius



Source: TMS Marketing, 2009

Extensive Li-ion Field Testing Experience

- 3-year road test of 126 conventional Prius powered by Li-ion batteries
- More than 6 million miles driven in the program
- One of the vehicles logged more than 300,000 miles in the U.S., Japan and Europe

“The tests appear to be among the most thorough done by companies planning to introduce the batteries.”

– Menahem Anderman, President, Advanced Automotive Batteries

EV Issues Common to All

- Shorter driving range
- Need for charging infrastructure
- Charging time
- Higher production cost
- Broader variation in battery pack life

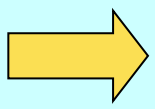
EV and PHV Duty Cycles and Battery Life

SOC Distribution Curve

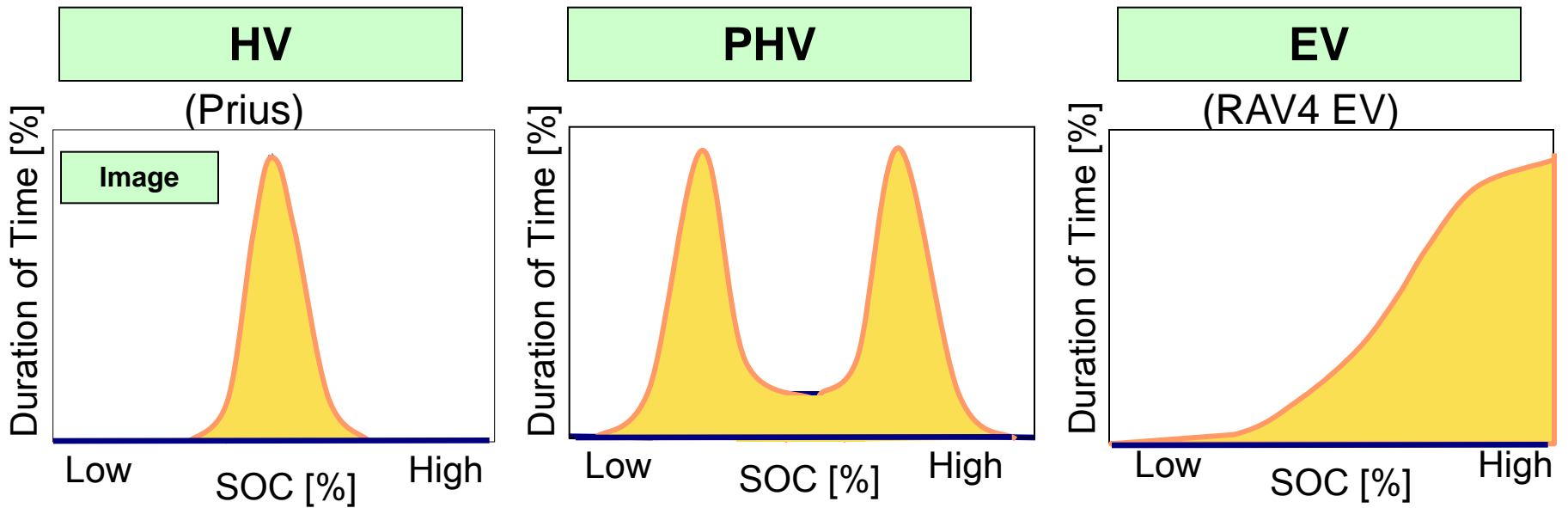
HV : Single peak at a controlled value

PHV : Wide SOC Swing with High SOC peak added to lower one

EV : SOC widely covers over 50% by frequent full charging



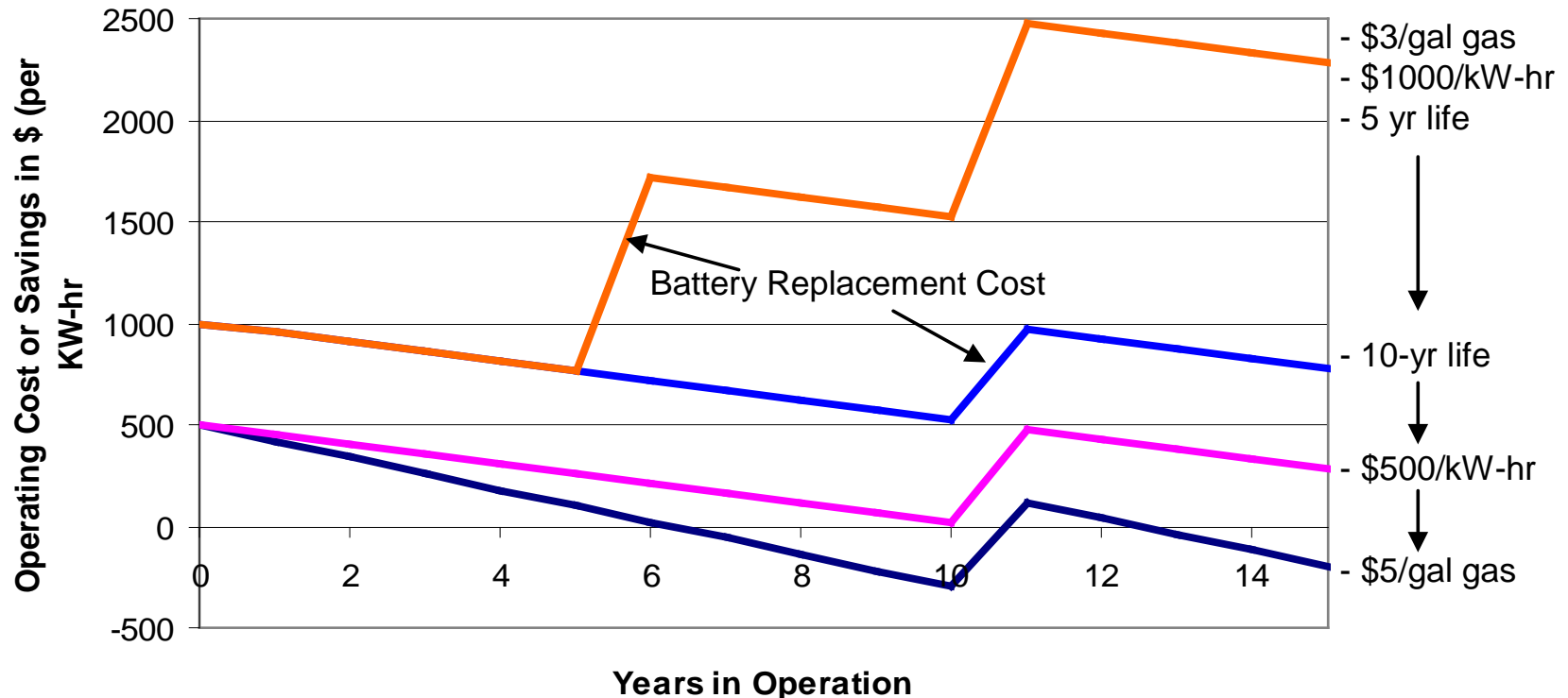
Severe condition of PHV and EV due to SOC wide swing needs breakthrough for long battery life



SOC Distribution Curves

Hypothetical Payback Analysis

PEV Operating Cost/Savings vs. Prius



- Assumptions:
- Baseline Vehicle - Prius @ 50mpg
 - PEV Efficiency - 4 mi/kW-hr
 - Electric Operation - 2/3 Battery Capacity/day
- 300 Days/yr
 - Electricity Cost - \$0.05 kW-hr

Lessons Learned

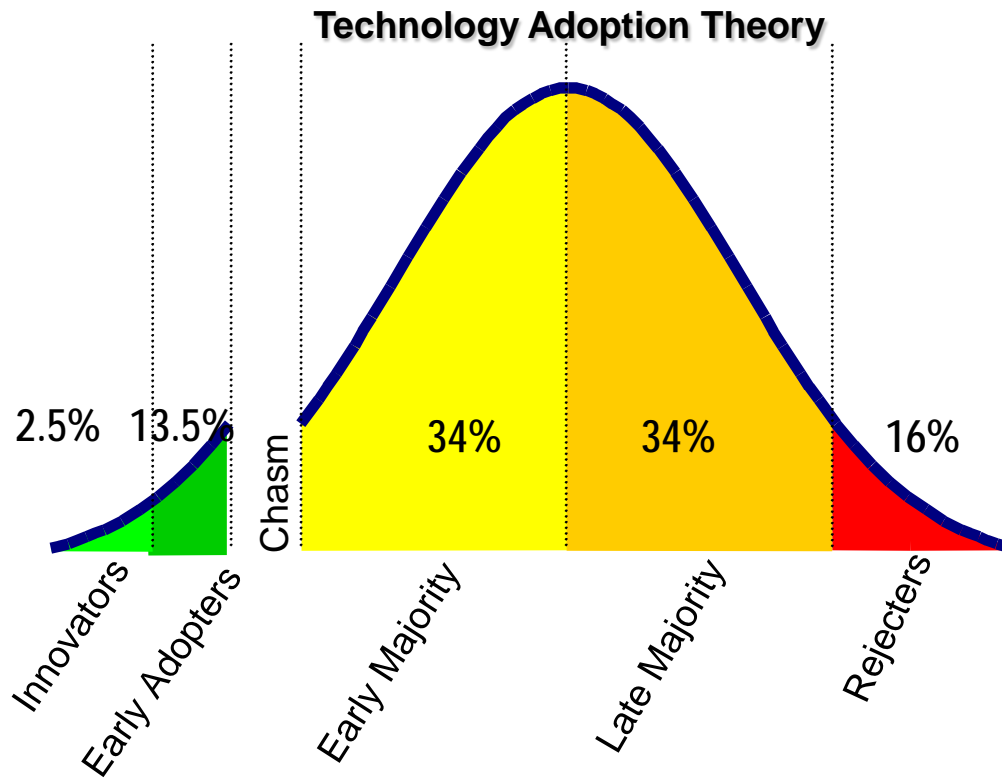
- NiMH batteries have historically been the best choice for conventional hybrid vehicles and will be for some time
- Higher energy density of Li-ion batteries will be required to power future EVs and PHVs
 - However, cost will be an issue for years and will not be off-set by volume
 - Major technical breakthroughs are still needed for mass market production

Lessons Learned

- Now, making best effort on Li-ion
- May need a battery beyond Li-ion, capable of much higher energy density, lower cost and more stable performance
- Toyota established its own internal advanced battery group to look beyond Li-ion



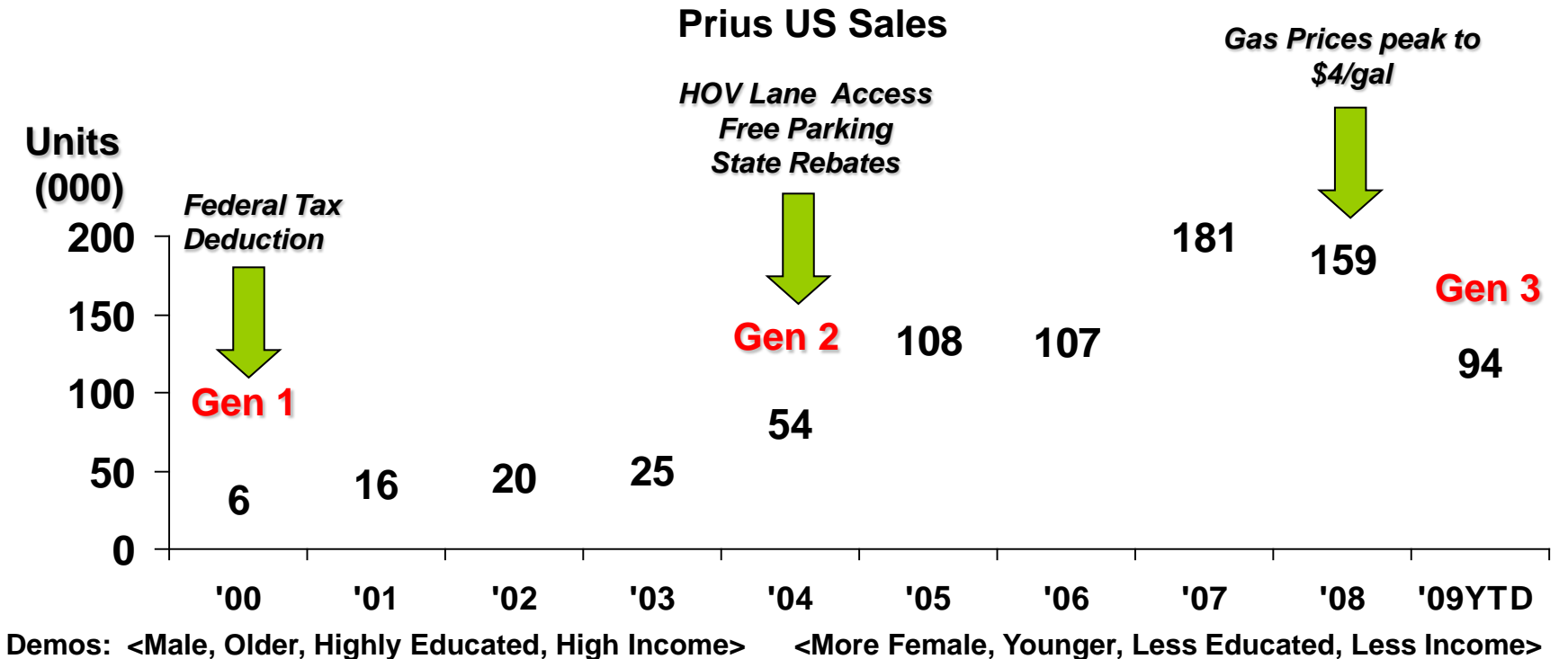
Toyota Experience with Technology Adoption



Source: "Crossing the Chasm", G. Moore

- Prius buyers for 1st four years were Innovators and Early Adopters (attained big market share of very small segment of the population)
 - Tech Pioneers – looking for the latest technology
 - Environmentally Friendly – sensitive to environmental issues

Prius Sales Took Time to Grow



Source: TMS Marketing, August Month End 2009

- Prius – niche volume sales until 2nd generation
 - Vehicle size, comfort and mpg improved
 - Government consumer incentives were critical in creating market demand
- Buyer demographics shift reflected move into Early Majority phase and consideration by more mainstream consumers

Wide Variation in Prius Natural Demand Level

- Because of regional differences in the importance of buying an environmentally friendly or fuel efficient vehicle, the demand for Prius varies by region
- Demand for Prius is much higher in California
 - No other state has even half the level of demand
- Demand for plug-in vehicles likely to follow similar pattern

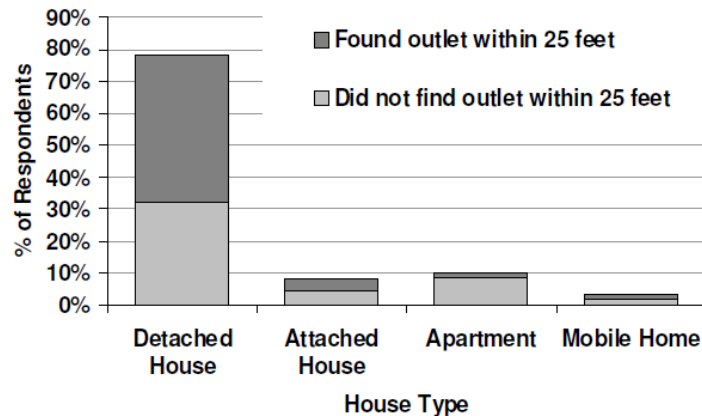
12-mos. Toyota Prius Intentions for Top 10 States

Prius Hybrid	
California	21.9%
New York	8.2
Florida	6.1
Texas	4.9
Virginia	4.8
New Jersey	4.3
Illinois	4.3
Massachusetts	3.0
Pennsylvania	2.8
Maryland	2.7

Source: GfK Automotive Intentions Study, Q1 & Q2 2009

Charging Access is Very Limited for Dwellers in Dense, Urban Areas

Fig. 9: Access to home recharge by housing type (all respondents, n = 2,373)



Source: UC Davis Plug-in Hybrid Research Center, 2008



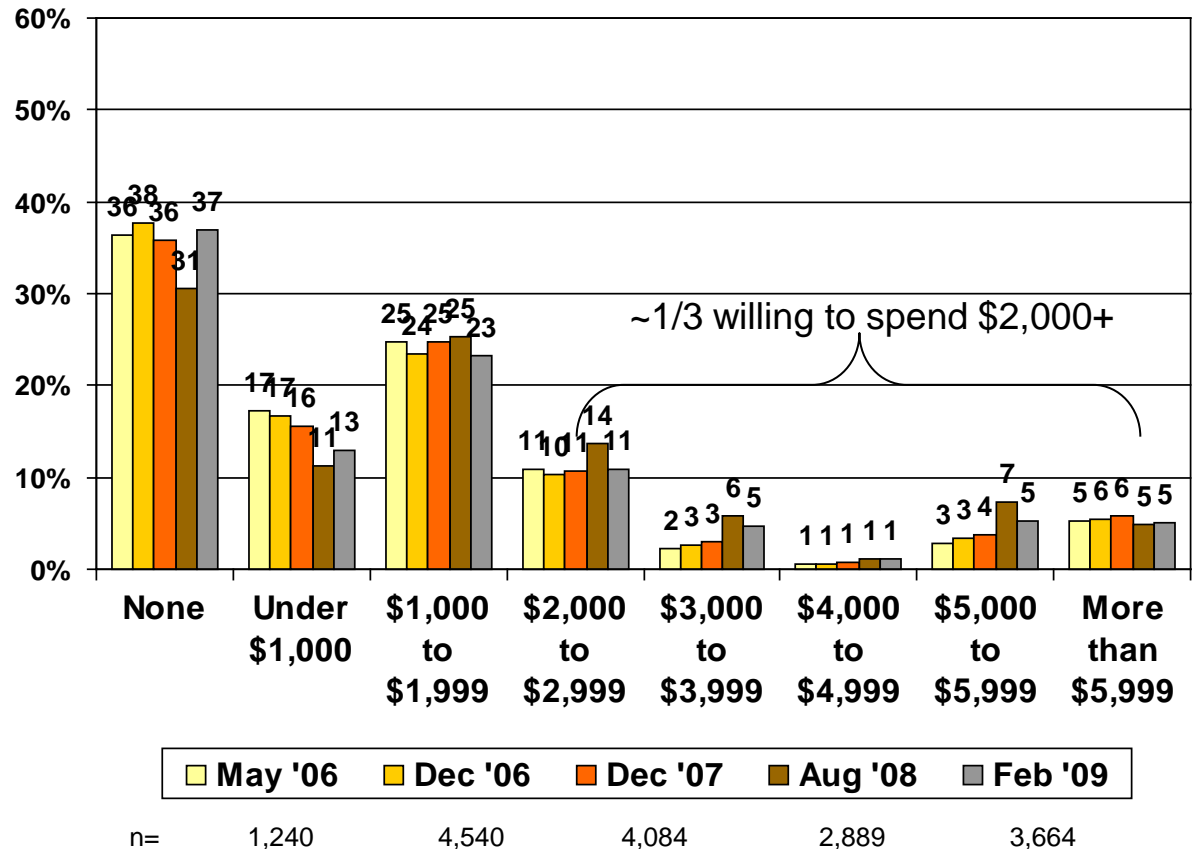
- Large Eastern cities typically build up and are more dense due to pre-auto development patterns
 - In NYC, 61% live in a structure of 5+ units and 26,403 persons per square mile (2000 US Census)
- A majority of people living in multi-family structures did not find an outlet within 25 feet, and nearly all people that parked on the street or in a lot did not find an outlet within 25 feet (2008 UC Davis Study)

Willingness to Pay for Plug-in Hybrid 15-20 mi. Range

Far Below Current Cost of the Battery Technology!

- As fuel prices have shown a sharp decrease since last Summer, willingness to spend on a PHV has dropped. Average price willing to pay now slightly below Dec 2007 level.

Amount Willing to Pay for PHV Over a HV



Mean Price Willing to Pay

May 2006	\$1,640
Dec 2006	\$1,670
Dec 2007	\$1,790
Aug 2008	\$1,830
Feb 2009	\$1,770

Source: Synovate, February 2009

PHV: Need to Determine Ideal Balance for Market Acceptance

- Demonstration program with 500 vehicles using Li-ion batteries beginning in January
- Key goal:
 - Determine ideal balance for all-electric range vs. selling price, GHG reduction, and customer usage



Toyota Plug-in Hybrid Prototype

Consumer Acceptance is Critical for All Plug-in Technology

- Consumers will not widely adopt new technology product unless it is better in every way than what is available
- Anecdotal evidence of robust markets is not a substitute for true market acceptance.
- If consumers are disappointed, then **market adoption is not guaranteed** and can
 - Permanently harm the technology image and future market potential

Until the Hurdles are Overcome, Advanced Technology Vehicles will Need Support

- Major challenges face plug-ins in terms of product readiness to market and state of the technology
 - EV and PHV tax credits
 - Battery replacement or EV end-of-life rebates
 - Single occupancy HOV lane access
 - Adequate fueling infrastructure
 - Funding for fleet vehicle purchases



Summary

- Technology adoption by consumers is difficult to force
- Market readiness for plug-in hybrid and electric vehicles and lack of infrastructure for electric vehicles present serious challenges
- Managing expectations on the readiness of advanced technologies is critical to future consumer acceptance
- Creating consumer demand for advanced technology vehicles will require substantial government engagement
 - Assistance with market incentives is crucial to market development
 - Market incentives should address consumer behavior and needs
- Strategic partnerships needed to deploy the technology effectively and efficiently