The Market for PEVs

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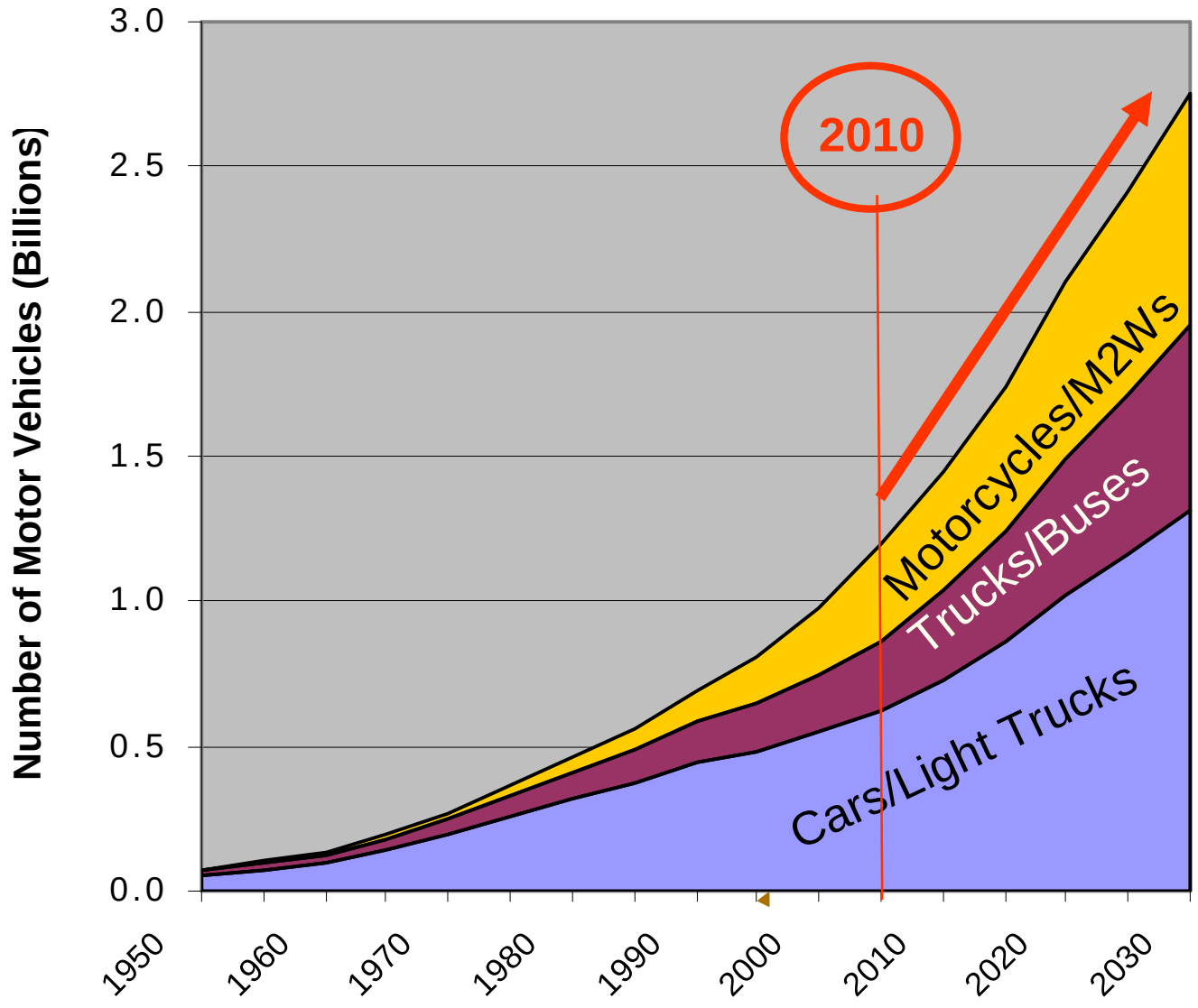
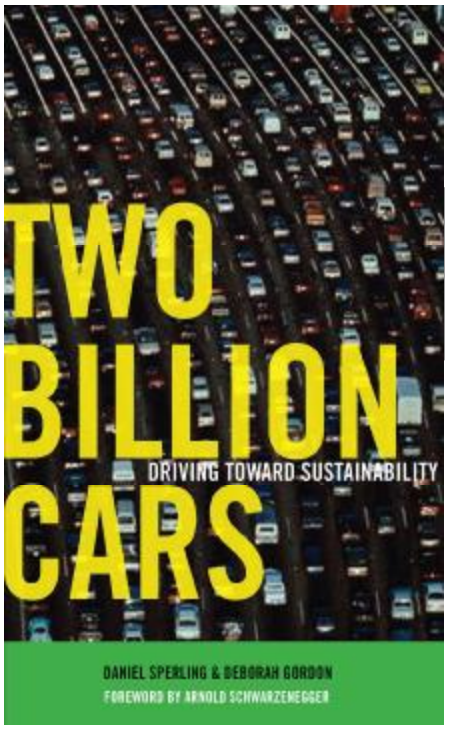
Tentative Findings

- Current ways of thinking lead to PEV failure
- Many consumers use different frames than "experts"
  - Many benefits derived from EV attributes
- Public charging should be low priority
- No business model for public charging
- Existing battery performance is adequate for high market penetration by PHEVs

Why PEVs?

Soaring Global Demand for Vehicles (and Oil)





Sperling and Gordon (2009), based on DOE, JAMA, other

PEV Success (and Failure) Depends On…

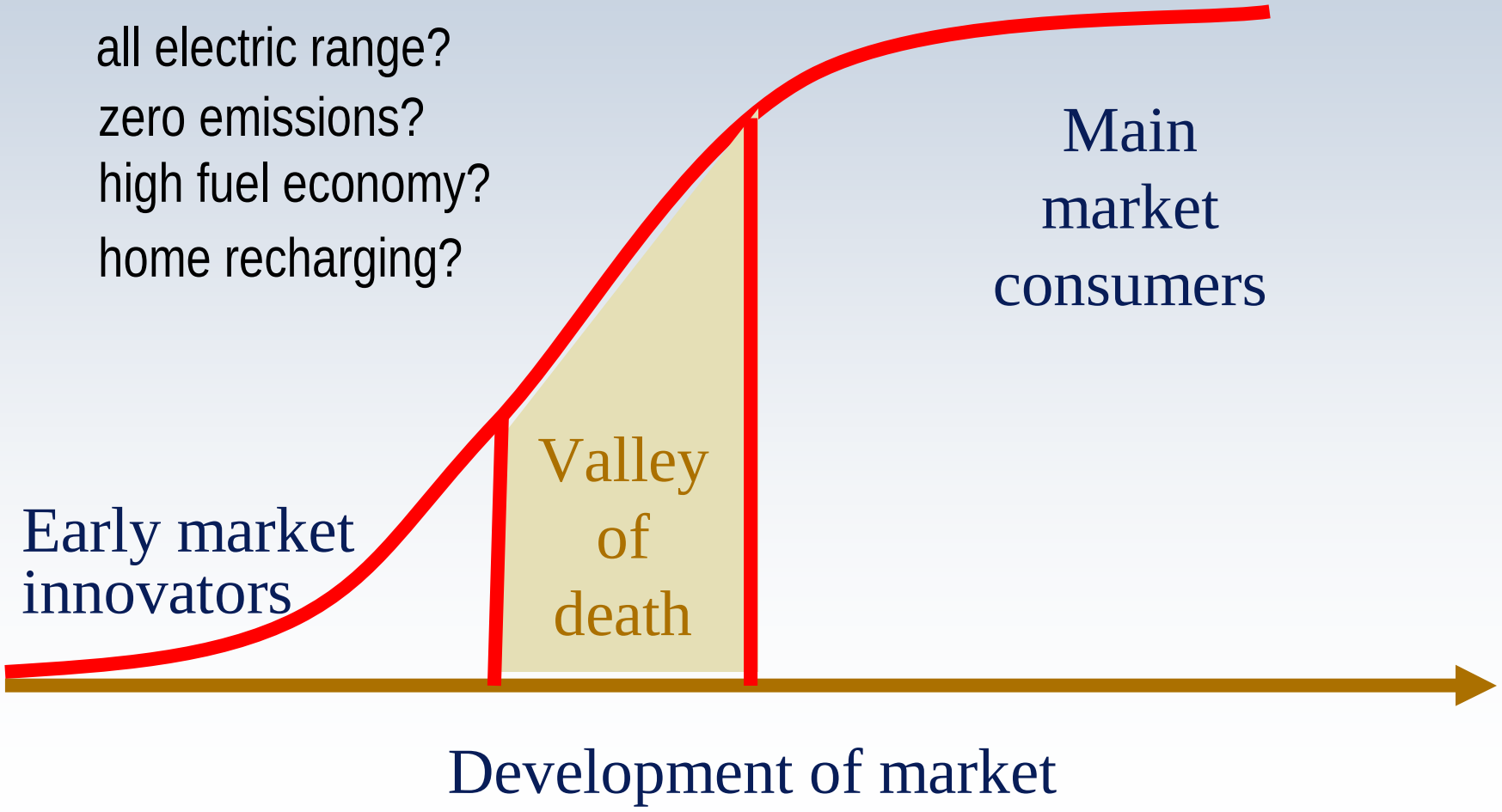
- Battery technology advances (costs, performance)
- Oil prices
- Government policy
- ***Consumer response***

Valley of Death Looms for Many Companies…

from drop in oil prices, policy shift, consumer disinterest.

How will consumers value…

all electric range?
zero emissions?
high fuel economy?
home recharging?



Many US Policies Support PEVs

Vehicles

- § Fuel economy & GHG standards: 35 mpg by 2016 (and further reductions thercafter), with special treatment for EVs
- § Tax Credits for low carbon vehicles (Feds: $2500-$7500/veh)
- § Subsidies for automotive battery and EV mfg plants, and EV companies (Fisker, Tesla)
- § ZEV requirements (California and 10 other states)
- § R&D for batteries

Fuels

- § Low carbon fuel standards (California, 2009)
- § Fed and state subsidies for public charging stations

Virtually no policies for electric trucks, maritime, rail (except at ports)

New EPA GHG Stds (2012-16)

- **EVs rated as 0 g/mile, for first 200,000 EVs sold by each manufacturer (thru 2016)**
- If manufacturer sells 25,000 EV-type vehicles/year in 2012, then cap increases to 300,000.
- After 200,000 (or 300,000) vehicles, EVs rated roughly same as hybrids
  - Based on 642 gCO2/kWh for US average grid emissions, grid efficiency factor of 0.93, charging efficiency factor of 0.90, and adjustment for upstream gasoline vehicle emissions (not counted in tailpipe emissions accounting).
- PHEV rating method not yet formalized.
- CAFE: PEVs treated like an FFV (calculate their mpg based on electricity used and divide by 0.15 (the gasoline fraction of E85), giving many hundreds of mpg to count towards CAFE.

ZEV Requirements in California (and 10 other states)

	2012 – 2014	2015 – 2017
Required Vehicles	25,000	50,000
Allowable Option	7,500 FCVs or 12,000 BEVs, plus ~60,000 PHEVs	At least 25,000 pure ZEVs and ~80,000 PHEVs

California Low Carbon Fuel Standard

adopted by California April 23, 2009 (and in process in other states)

Strong incentives for electricity use in vehicles (where low-carbon electricity is available)

- Requires 10% reduction in carbon intensity of transport fuels (gCO_2-eq/MJ)
- Encompasses all fuels: NG, petroleum, unconventional oil, biofuels, electricity, H2
- Based on lifecycle measurements (source to wheel)
- Imposed on oil refiners
- Companies can buy and sell credits (from electricity and/or infrastructure suppliers)

Incentives from Local Governments

New California law (SB375) calls for reduction in sprawl and vehicle use (likely to be replicated in national transportation and/or energy and climate bills).

- Sets targets for each metropolitan area
- Local governments have flexibility in how they reduce GHGs from passenger travel
- Local gov't will create incentives for EV use?!

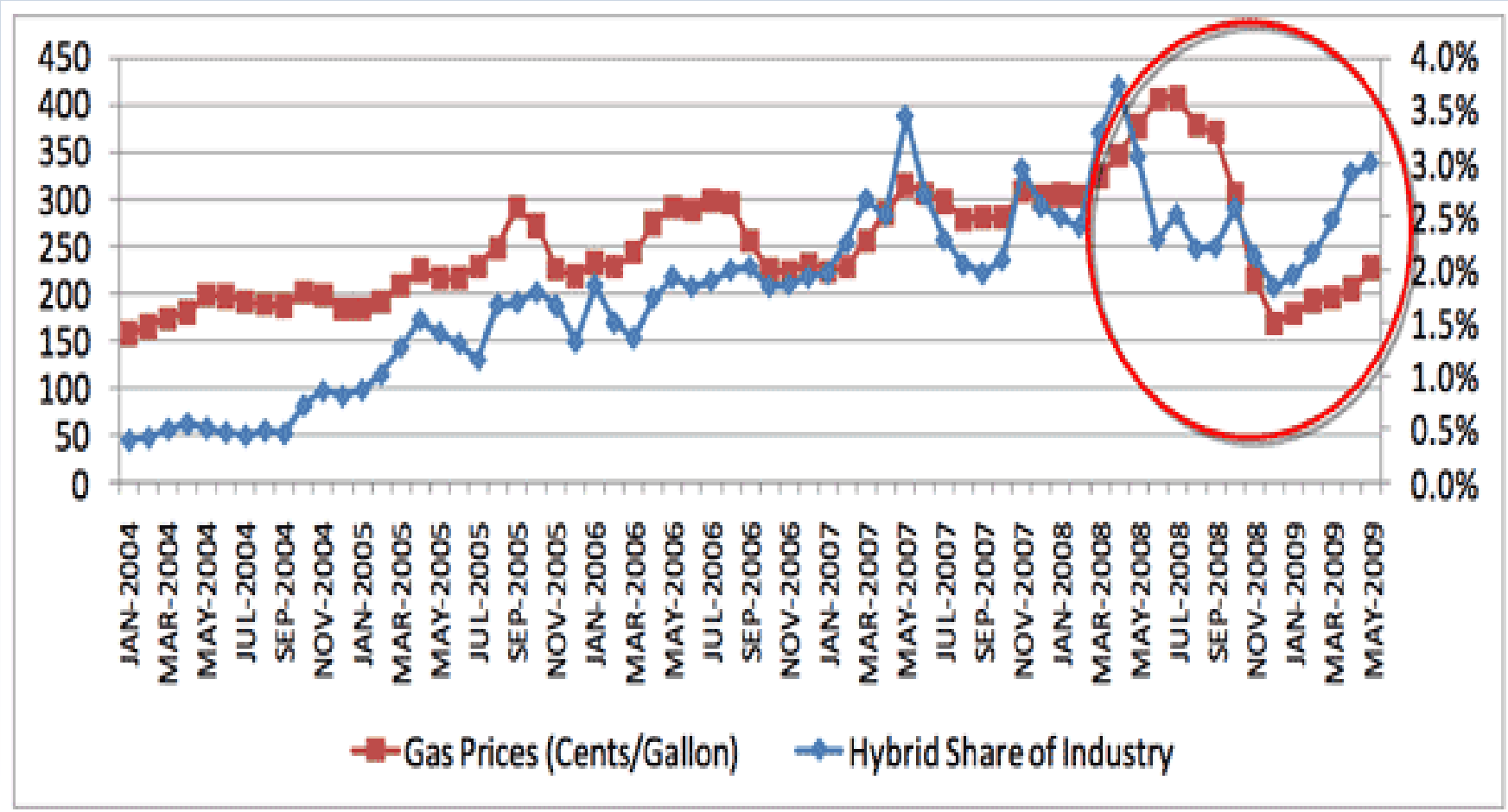
How Will Consumers Respond? What Will They Purchase?

ITS-Davis has 25 Years Studying Consumer Demand for Alternative Fuel Vehicles

1991-96	Electric vehicles: EV conversions; hypothetical interviews, surveys
2001-02	Neighborhood EVs & City Electrics: Nissan Hypermini City EVs
2002-05	Fuel cell vehicles: Toyota Highlander FCHEV
2003-06	Hybrids: Prius, Insight, Civic; Escape, Accord, Highlander, Altima,…
2007-10	PHEVs: Consumer-designed PHEVs; hypothetical national survey and converted Priuses in households
2009-10	EVs: BMW MINI E

Cautionary Note (as Pat Davis indicated):

HEVs needed 10 years to reach 3% market share (of new vehicles). PEVs are more expensive, and require infrastructure investments and changes in driver behavior?!



Dominant “Frame” for “Problemitizing” Electric Vehicles

- EVs are different from conventional cars, therefore people will not buy them
  - Driving range limits
  - Long recharge times
- To solve these “problems” we need
  - “advanced” batteries
  - public recharging infrastructure

What are Frames?

Mental structures that shape…

the way we see the world,

the goals we seek,

the plans we make,

the way we act, and

what counts as a good or bad outcome of our actions.”

Another Frame for Electric-Drive Vehicles

- PEVs give access to new values and benefits
  - Avoid gasoline stations
  - Superior driving feel
  - Don’t finance terrorists
  - Don’t support Big Oil
  - Energy independence
  - Reduce climate change
  - Reduce air pollution
  - Reduce noise
- People learn and adapt to different set of constraints and opportunities
  - People will buy PEVs ***because*** they are different!

Is Range a Problem?
Responses of MINI E drivers

~1/3 ~100 mile range plus home-based charging easily covers all travel

~1/2 ~100 mile range plus home-based charging covers more than 90% of driving—and is acceptable with minimal adaptations

- Constraint on the 10% of trips more likely to be cargo/passenger space than range

~1/6 100 mile range only acceptable with major adaptations—careful planning, charging at work, or eliminating trips

(NJ/NY) Variability in driving range due to cold weather is not just a battery issue, but a battery management issue and driver learning/adaptation issue, too.

Some MINI E Drivers Plan, Learn, Adapt

- On-line maps used by many households to plan long days
- Drivers learn distances to work, to store, to family, etc.
- Learn terrain and routes
- A game to many drivers
  - § Games can be fun, engaging, competitive, and cooperative

Charging at Home Meets Most Needs of MINI E drivers

- MINI E drivers in LA mostly charge at night, at home.
  - § Most didn't take advantage of possible workplace charging – not sure about etiquette, rules, norms
- New values: Feeling of independence, not visiting gas stations, stability of electricity rates compared to gasoline prices

Will Public Charging Expand EV Markets?

Conventional thinking ("dominant frame") says yes, but people with experience say no.

- Anecdotal: MINI E drivers in Berlin aren't using public recharge network
  - § Similar results from 1990s EV demos, e.g., La Rochelle and Mendrisio

Early conclusions

1. Public charging availability encourages people to buy EVs, esp those in apartments and condos (Tokyo)
2. Few people will use public charging, esp in US with its high home ownership (and large homes w/garages).
   - § No business model (except as fringe benefit offered by employers/retailers)?!
3. Availability of public charging encourages on-peak usage (reducing environmental and economic benefits), but effect is minor

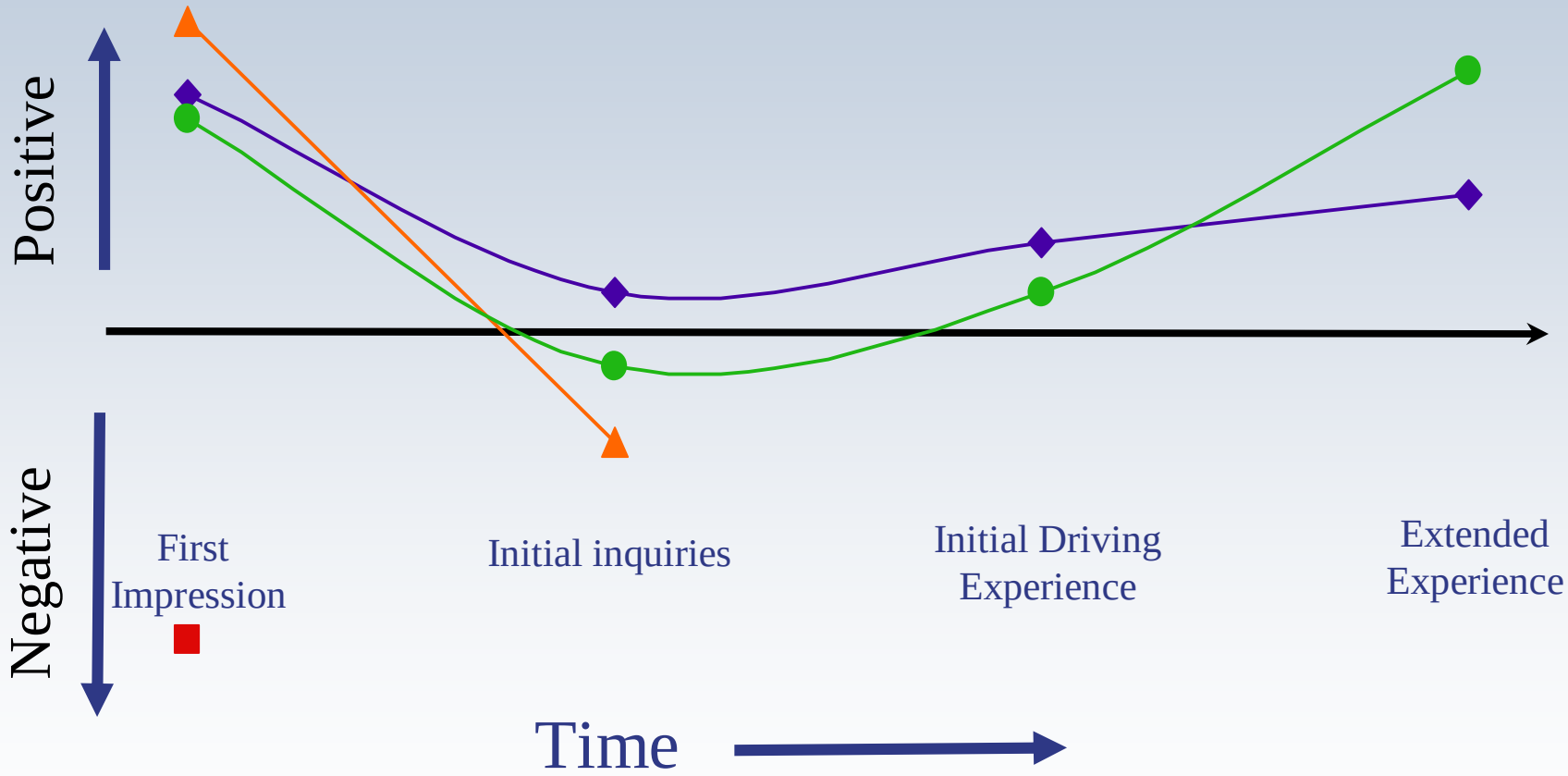
How long does it take to access drivetrain benefits?

From ride-'n-drives to long-term vehicle leases; from crude conversions to limited production vehicles…

…almost all EV drivers say they like the feel and sound of electric drive

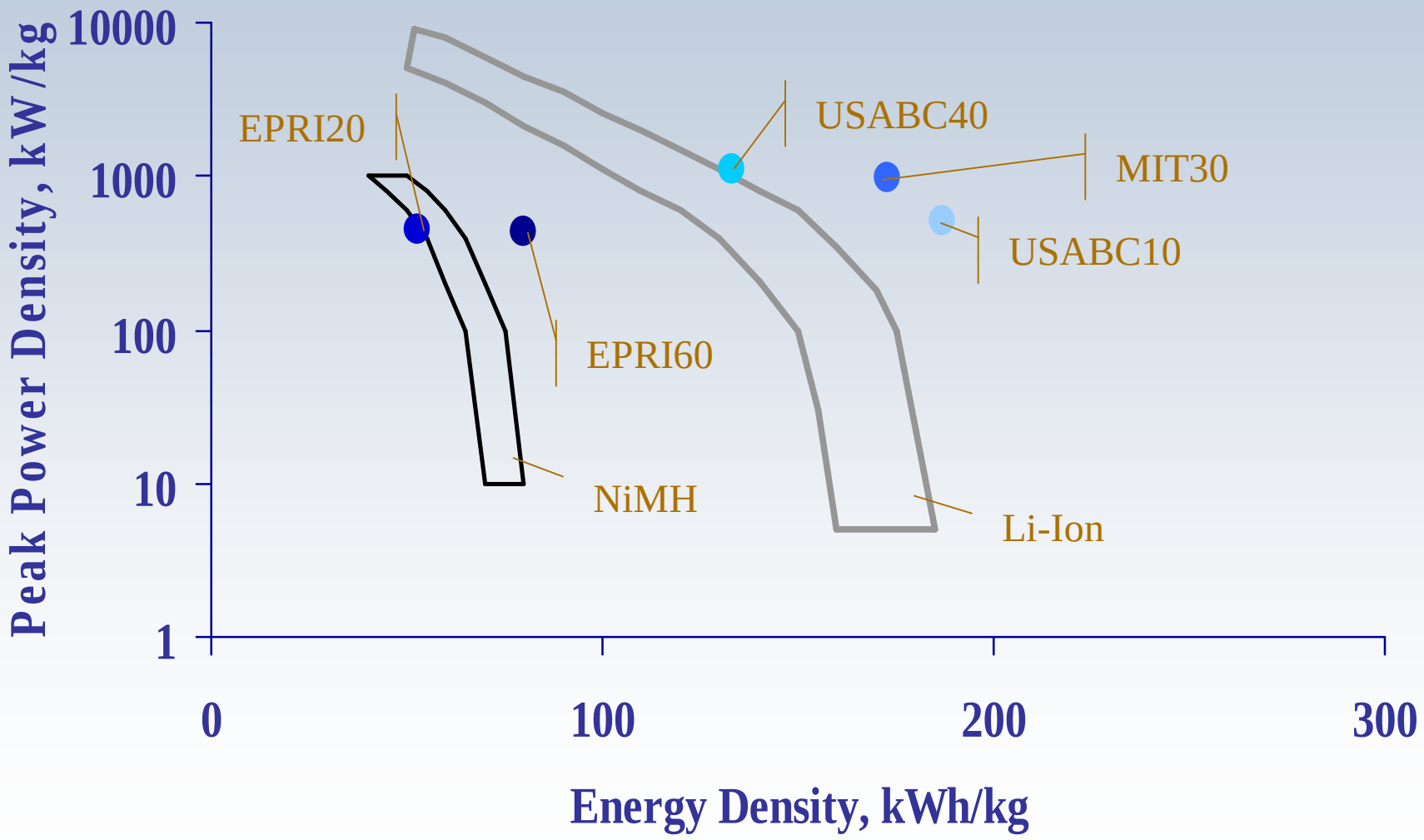
The time it takes to form positive values starts from first drive.

More Experience Leads to Positive Experiences (for many drivers)

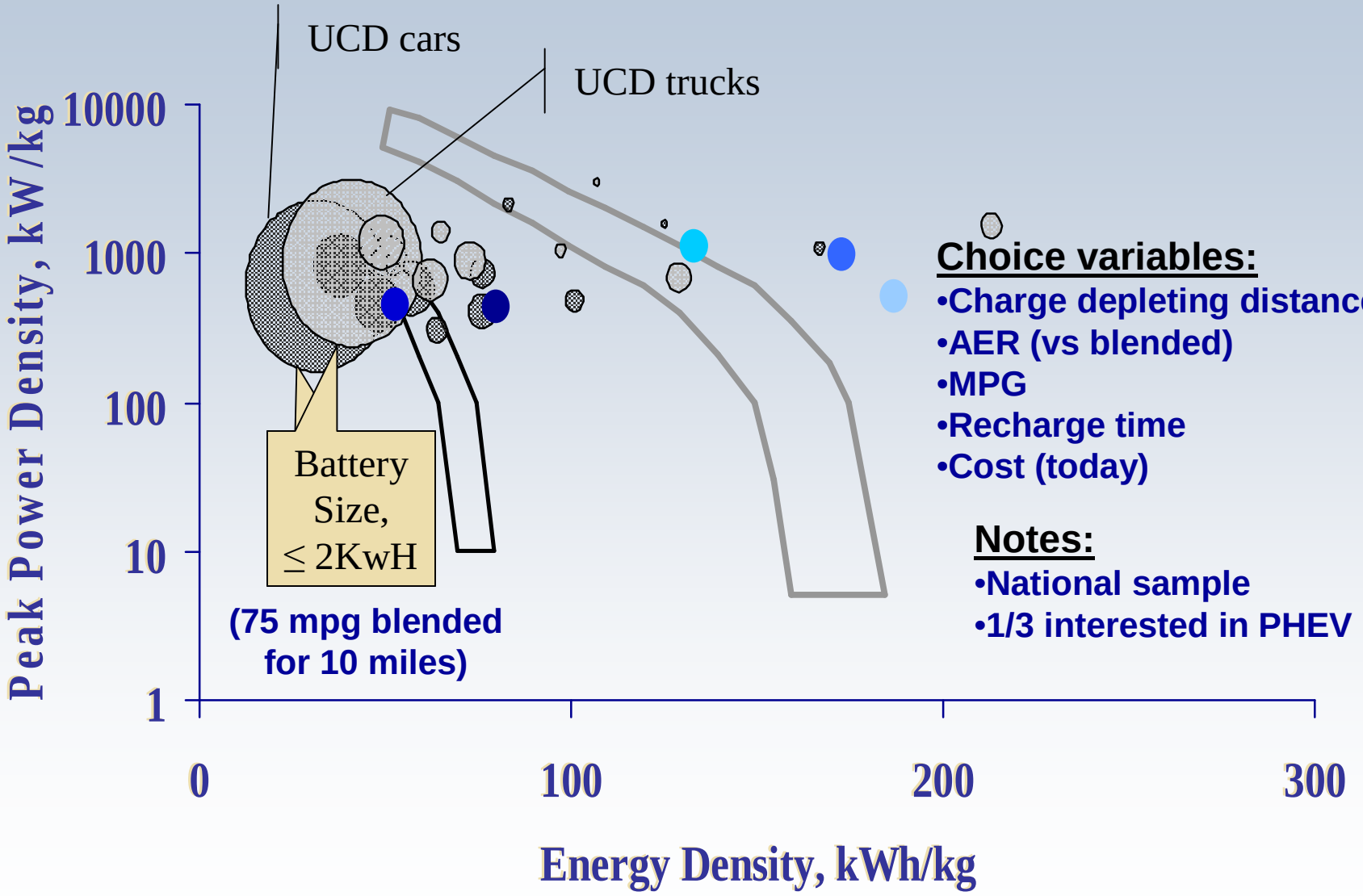


How Critical Are “Advanced” Batteries?

Experts Believe Major Battery Improvements are Necessary



Car-Buyers Prefer Very Small Batteries for PHEVs



Source: Kurani et al, 2010 (ITS-Davis PEV Center)

If we frame PEVs in terms of their positive attributes (and not in terms of problems), do we need higher-performing “advanced” batteries?

Goal should be cost reduction, not performance improvement?!

… also need to think of new low-energy EVs!

USV/NEVs from GM/China

Tentative Conclusions

- Current “expert engineering” thinking leads to PEV failure
- Success will come from framing PEVs more positively
  - Derive benefits from unique EV attributes (iPod example)
  - Many drivers willing to adapt (sometimes eagerly)
- Public charging is low priority
- No business model for public charging (except for employers and retailers)
- Successful PHEVs will have very small batteries
- Existing battery performance adequate for high market penetration by PHEVs (cost reduction would expand market)
- **Much more research on consumer behavior is needed!**