PEV Charging Infrastructure:
What can we learn from the literature?

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McNutt & Rodgers’ (2004) review of alternative fuel (AF) policies provides lessons that remain valid today

• **The incumbent vehicle and fuel technology** will be difficult to displace, in part because it **will adapt and improve** to compete with alternatives.

• Niche markets will not grow into mass markets unless alternative vehicles and fuels offer **compelling advantages to consumers**.

• Consumers make vehicle choices based almost entirely on **private not social benefits**.

• **Low energy density fuels** that require more frequent refueling impose real costs on users and are an important barrier to mass market adoption.

• A successful transition is likely to require **disincentives for continued use of conventional fuels** as well as incentives for alternatives.

• Unregulated and unsubsidized private sector investment in refueling infrastructure was rarely built in advance of market development and when it was, the financial results were disappointing.

• **Coordination between the automobile and energy industries is vital**.

• **Scale matters a great deal** in the automotive and fuel industries. Low volumes in early markets are a large financial barrier.
Creating an energy transition for the public good is a new challenge for public policy.

- Multi-decadal time scale
- Technological & market uncertainties
- Multiple market issues, strong positive feedbacks
- Initially Costs > Benefits, later Benefits >> Costs
- Large scale energy transitions need a complex, multi-dimensional policy strategy, to...
  - Co-evolve demand and charging infrastructure
  - Reduce vehicle costs (Technology, Learning, Scale, Diversity)
  - Overcome consumers’ unfamiliarity and risk aversion
  - Create an efficient institutional infrastructure
EVSE is different.

Less critical but still important: 75-80% of charging at home. Value of $100s to $1,000s. Need 10X charge points? Is low utilization a problem? Appropriate analytical tools.

DOE AFDC: 13,335 electric stations 32,728 charging outlets
How can we do it?

• There’s more than one way.
• Multi-dimensional policies
  – Many costs decrease exponentially
  – Societal, institutional learning
  – Research, development, demonstration, deployment
• Durable policies
  – ZEV mandates + subsidies & incentives
  – CAFE/GHG standards
  – Highway user fees on energy
  – C-tax, cap and trade (?)
• Monitor, measure, adapt and persist.
THANK YOU.
Backup slides.
The complexity of the transition problem appears to require a comprehensive policy strategy addressing all major barriers because of:

• Consumer behaviors that aren’t “economically rational”
  – The majority’s risk aversion to novel technologies
  – Lack of information and unfamiliarity
  – The tendency of markets to undervalue energy efficiency

• Important non-market processes, including changing government codes, standards and ordinances

• Positive and negative external costs and benefits
  – “chicken or egg” network external benefits
  – Technology “spillover” effects

• Strong positive feedbacks create tipping points.

• Uncertainty and long time constants for change require persistent, adaptive strategy.
Word of mouth, advertising, reviews and ratings, dealer experience

• Public knowledge of PEV policies ranged from 0.3% to 5.5%.

• 4 out of 5 said incentives increased likelihood of PEV purchase (Krause et al., 2013).

• Most say opinions of others would have little influence on likelihood of buying a Plug-in Hybrid Electric Vehicle (PHEV) (Krupa et al., 2014).

• Majority say at least 18% of the vehicles on the road must be PHEVs before they would consider buying one.

• Target policies to areas where early adopters are most concentrated (Skerlos and Winebrake, 2010; Green et al., 2014).

• New car dealers influence sales but the evidence is based on customer satisfaction surveys rather than sales impacts.
  – PEV buyers rated the dealer experience lower than conventional vehicle buyers (Cahill et al., 2015).
  – Sales personnel misperceived the value of time spent selling a PEV.
Reduce the cost of refueling: Fuel availability

• Importance varies greatly by vehicle technology.

• One US survey: availability of 1% to 10% like price increase of $4,250 to $16,000 (Melaina et al., 2013).

• Those not interested in Alternative Fuel Vehicles (AFV) more worried about fuel availability than early adopters.

• PEV owners do 75%-80% of recharging at home; INEL, 2014).

• Awareness of public recharging weakly related to interest in PEVs (Bailey, 2015).

• Value of recharging networks in San Francisco and Seattle, $1,000-$2,000 per BEV. Other cities, $100-$1,000 (Lutsey, 2015).
Early alternative fuels infrastructure requires support. What works best?

- Low utilization and uncertain future demand makes investment unattractive in early markets (Eckerle and Garderet, 2012; Brown et al., 2013; Botsford, 2012).

- Requires capital and/or operating subsidies to create 3-5 year payback (IPHE, 2010).

- ARRA provided $400 million for vehicle electrification, increased the AF infrastructure tax credit to 50% or $50,000.

- With 50/50 ARRA funding, EV Project installed 12,000 level 2 chargers (residential and public) and 100 DC fast chargers.

- The 12,552 public charging stations in the U.S. (AFDC, 2016) have very low utilization rates (Green et al., 2014).
  - Sites with at least 3 events/week averaged 4-7 per week (INEL, 2014)
  - Most sites had fewer charging events.
  - NRC (2015) EV Barriers Committee: federal government should refrain from further investment until relationship between infrastructure and PEV adoption are better understood.