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

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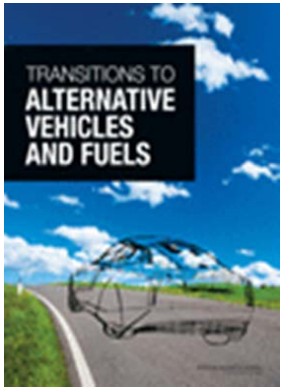
McNutt & Rodgers' (2004) review of alternative fuel (AF) policies provides lessons that remain valid today

- **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.

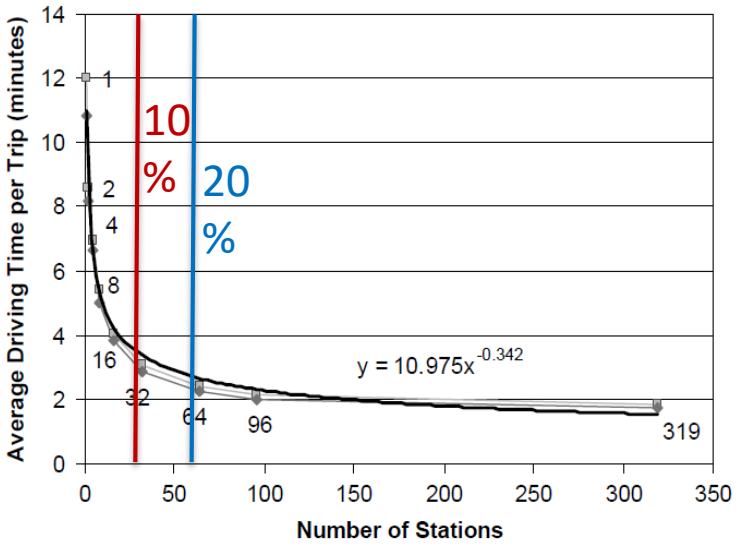
Creating an energy transition for the public good is a new challenge for public policy.

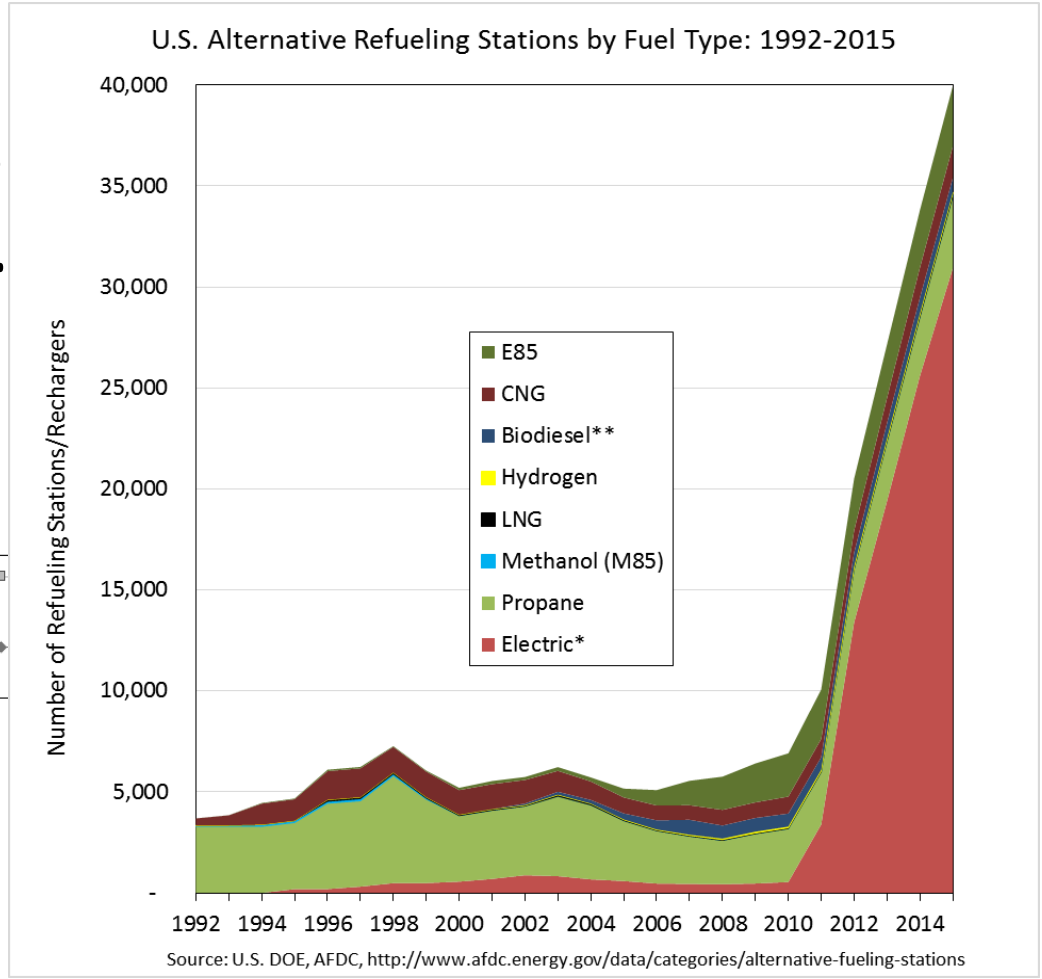
- Multi-decadal time scale
- Technological & market uncertainties
- Multiple market issues, strong positive feedbacks
- Initially Costs>Benefits, later Benefits>>Costs
- Large scale energy transitions need a complex, multi-dimensional policy strategy, to…
  - Co-evolve demand and charging infrastructure
  - 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.