Analysis of Incentives and Policy Impacts on the Market for Alternative Fuels and Vehicles

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SA058

Overview

Timeline and Budget

•Project Start Date: 10/1/2013
•FY15 DOE Funding: $50,000
•FY16 Planned DOE Funding (if applicable): $50,000
•Total DOE Funds Received to Date: $112,000

Barriers

- Barriers addressed
  - Future Market Behavior
  - Unplanned Studies and Analyses
  - Market Transformation Analyses

Partners

- Argonne National Laboratory
- Thanks to:
  - John Axsen, Simon Fraser U.
  - Robert Graff, DVRPC
  - Zhenhong Lin, ORNL
  - Marc Melaina, NREL
  - Amgad Elgowainy, ANL

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Relevance

- This project supports Argonne National Laboratory's analyses of future markets for hydrogen and fuel cell technologies for the DOE Fuel Cell Technologies Office.
  - *Understanding and modeling the transition to low-GHG energy for motor vehicles and the role of public policies in the transition.*
  - *Estimating the impacts of ARRA and other policies on the early markets for non-automotive fuel cells (FY 2015).*
  - *Assessing the effectiveness and efficiency of policies for promoting low-GHG energy vehicles and fuels (FY 2016).*

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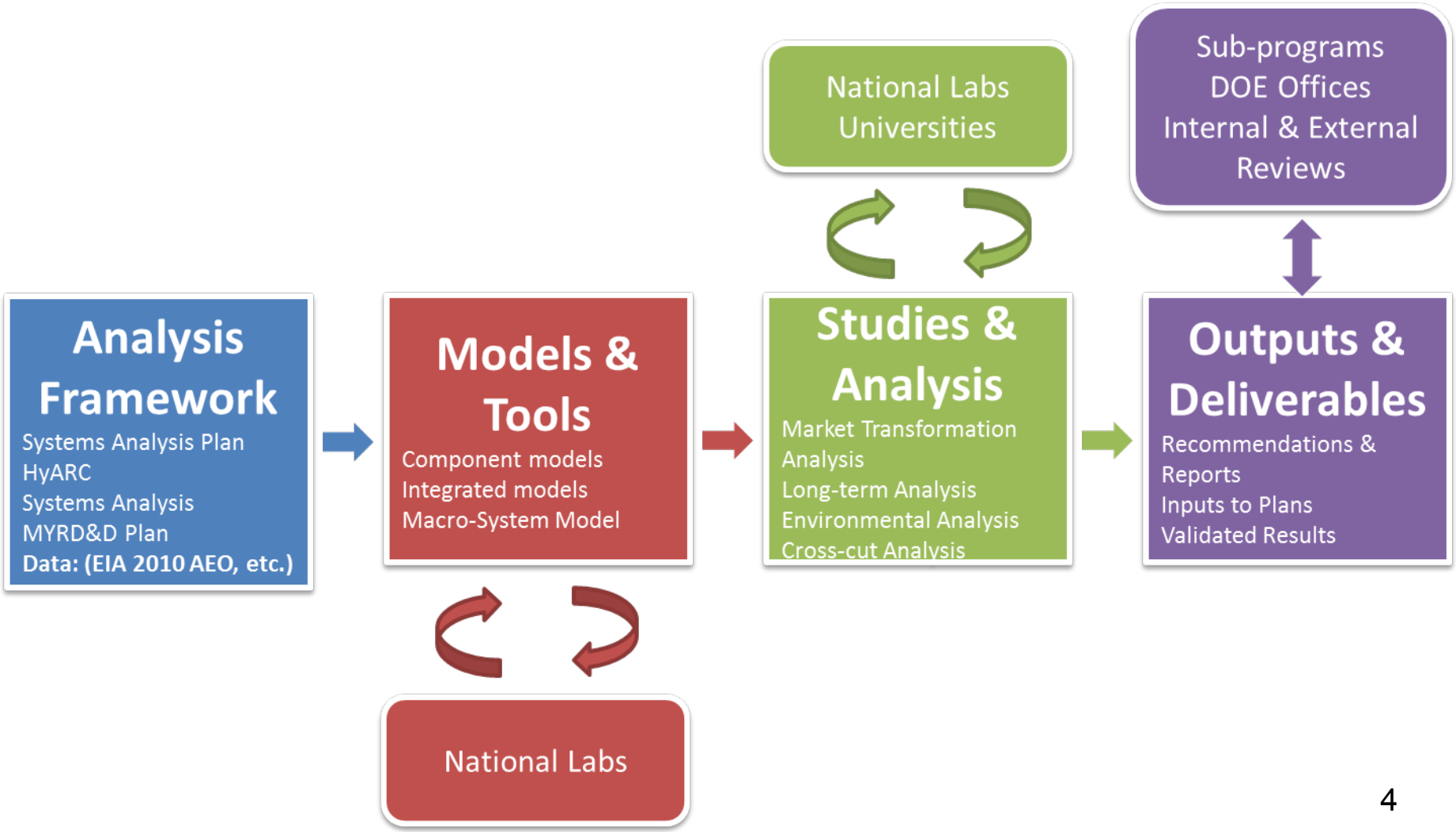
Evaluations of past policies to promote alternative fuels and vehicles can inform the transition to hydrogen.

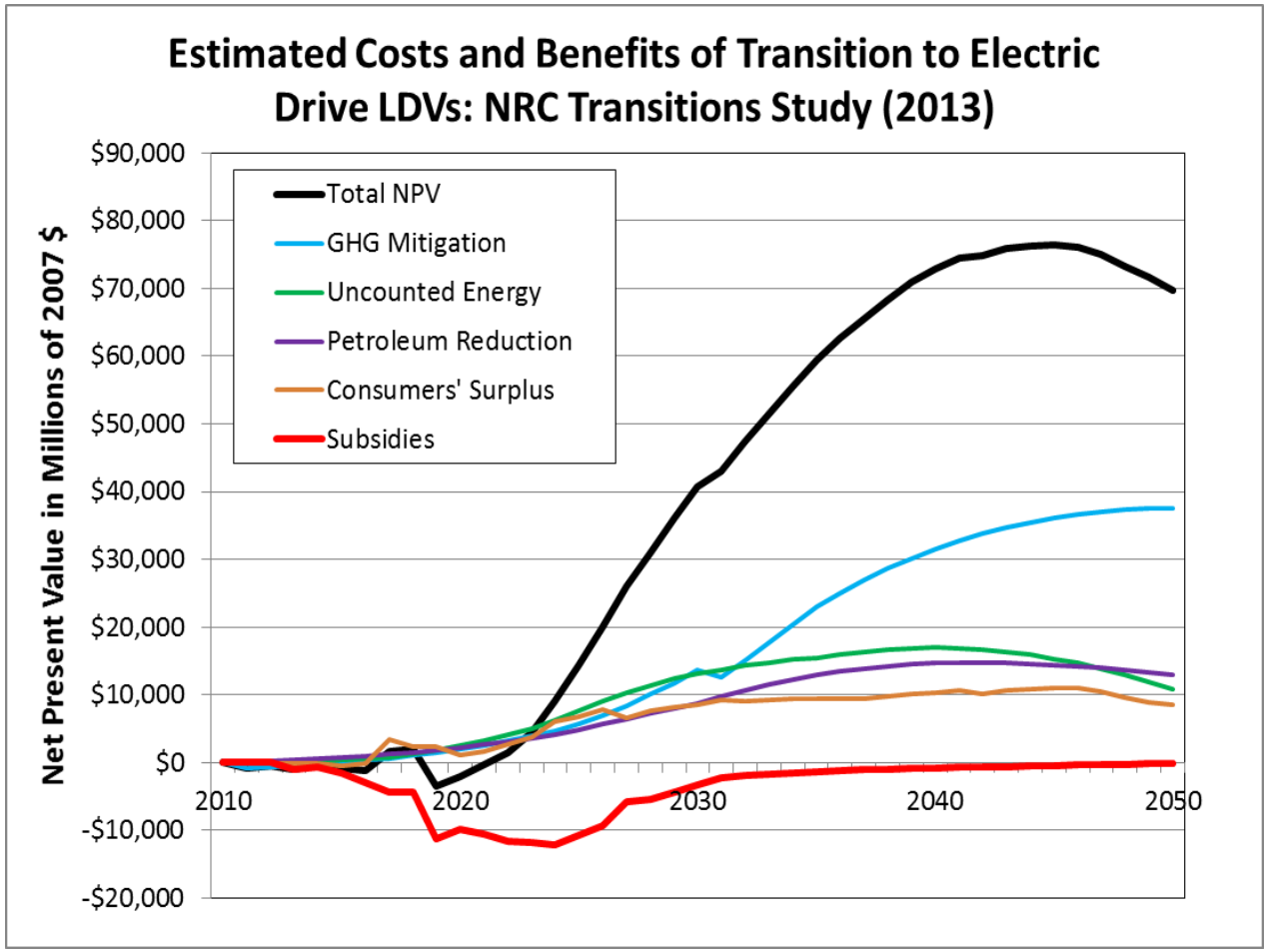
UT Baker Center's "Research and Analysis for Hydrogen Systems".

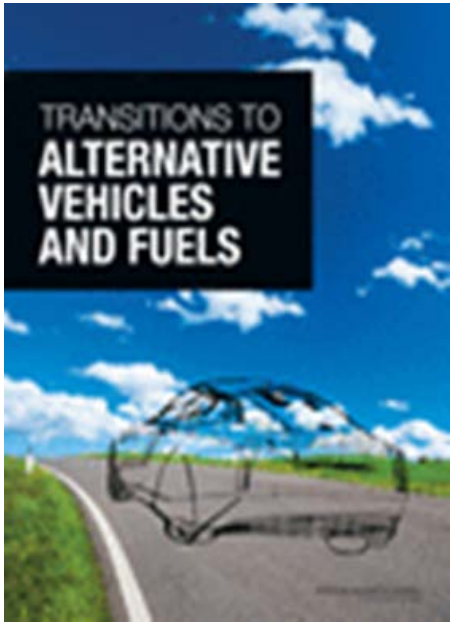


Approach

- This year's work addressed:
  - Critical review of policies to promote alternative fuels and vehicles
  - Comparative analysis of costs of alternative fuel refueling infrastructure
- Public policies must address the barriers to large-scale system transition (a new challenge for public policy):
  - Reduce the costs of vehicles
    - Economies of Scale
    - Learning by doing
    - Technological progress
  - Reduce the costs of refueling
    - Scale economies, Learning by doing (LBD), technological progress
    - Codes, standards, ordinances
    - Increase fuel availability & utilization
  - Increase the value of the vehicle & fuel
    - Decrease majority risk aversion
    - Increase awareness & familiarity
    - Increase diversity of choice
    - Enhance public perception

Energy transitions: Take decades, are uncertain, have strong positive feedbacks, are complex.





LDV =Light-Duty Vehicle

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.

Reviewing the recent (2000-2014) evidence.

- Much of the recent "revealed preference" evidence comes from studies of hybrid vehicle sales (1999-2014).
- Fuel availability was not an issue.
- Revealed preference studies of Plug-in Electric Vehicle (PEV) sales are less numerous and recharging availability is less critical than hydrogen refueling availability for a Fuel Cell Electric Vehicle (FCEV).
- Evidence for FCEVs comes mostly from "stated preference" surveys and simulation.

Reduce vehicle cost
Studies of hybrid sales offer relevant insights.

- 3% to 20% of hybrid sales in 2006 due to the federal income tax credit (Beresteneau and Li, 2011).
- Subsidies at time of purchase worth ten times future tax credit (Gallagher and Muehlegger, 2011).
- Behavioral economic theory predicts immediate rebate worth 2X a future tax credit (Khaneman, 2011; Diamond, 2009; Axsen, 2009).
- The complexity of the federal tax credit for hybrids weakened its impact (Cahill, 2015).
- Size (salience) matters: only incentives above $1,000 had a statistically significant impact on sales (Jenn et al., 2013).
- International studies: financial incentives most important factor in PEV sales (Sierzchula et al., 2014; Mock and Yang, 2014).

Non-financial incentives can also be effective but are location-specific.

- High-Occupancy Vehicle (HOV) lane sticker worth $1,200 to $4,000 in CA (Blanco, 2009; Wood yard, 2007).
- HOV access increased sales in VA but not 5 other states (Gallagher and Muehlegger, 2011).
- Non-HOV incentives were not statistically significant (Diamond, 2009).
- HOV access, exemption from emissions testing and annual fee reductions boosted PEV adoption but public charger availability, home charger subsidies, license fee exemptions and free parking did not Jin et al. (2014).

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 say incentives increase likelihood of PEV purchase (Krause et al., 2013).
- Majority say at least 18% of the vehicles on the road must be PHEVs before they would consider buying one (Krupa et al., 2014).
- 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 vehicle cost
Lessons from the literature

- Subsidies available at time of purchase have at least twice the impact of future tax credits.
- Subsidies must be large enough to get the consumers attention.
- Simple is better than complicated.
- Non-financial incentives are important but are situation-specific.
- Individuals concerned about energy security and climate change are 40-70 times more likely to consider a PEV but do not expect to pay more for one.

Reduce the cost of refueling. Fuel prices matter.

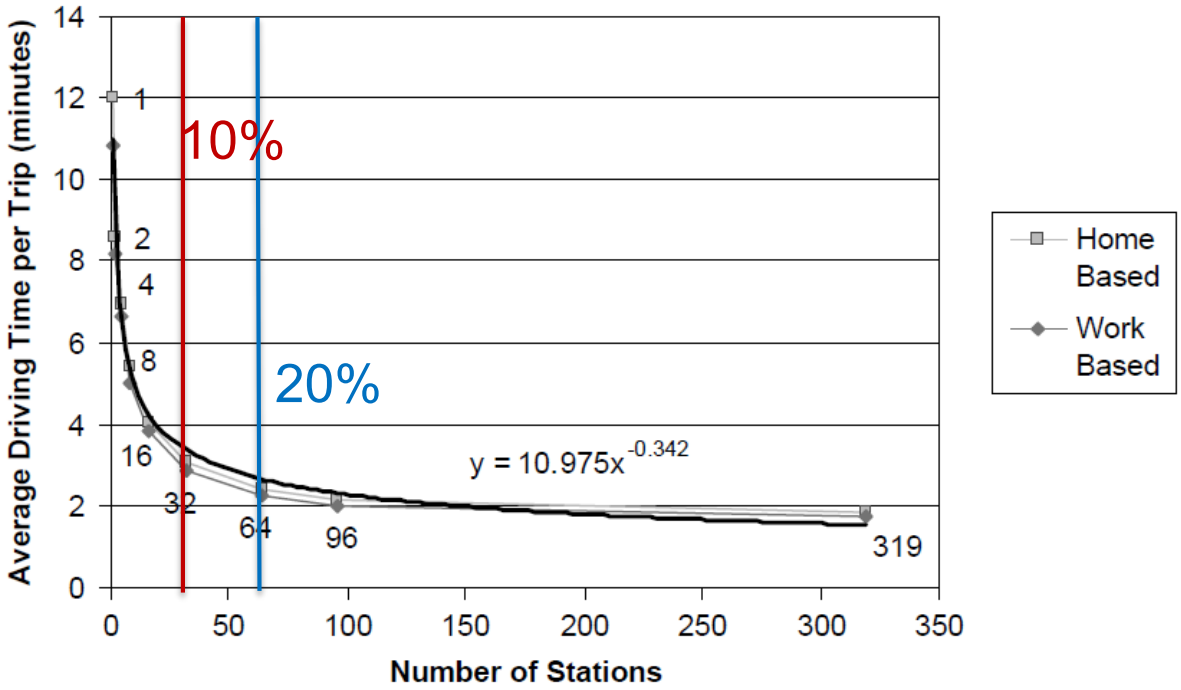
- Higher gasoline prices increased HEV & BEV sales (Vergis and Chen, 2015).
- Price of electricity were negatively correlated with BEV sales.
- 86% say fuel savings important to likelihood of buying PHEV (Krupa et al., 2014).
- Hybrid buyers willing to pay only ½ present value of fuel savings (Gallager and Muehlegger, 2011).
- Those considering purchasing a PHEV willing to pay only $1,858 for $500/year in fuel cost savings, a 3.7 year payback (Krupa et al., 2014). Majority (not interested in a PHEV): 1.6 year payback.
- Results are consistent with other evidence on willingness to pay for fuel savings (Greene et al., 2013).

Reduce the cost of refueling: Fuel availability

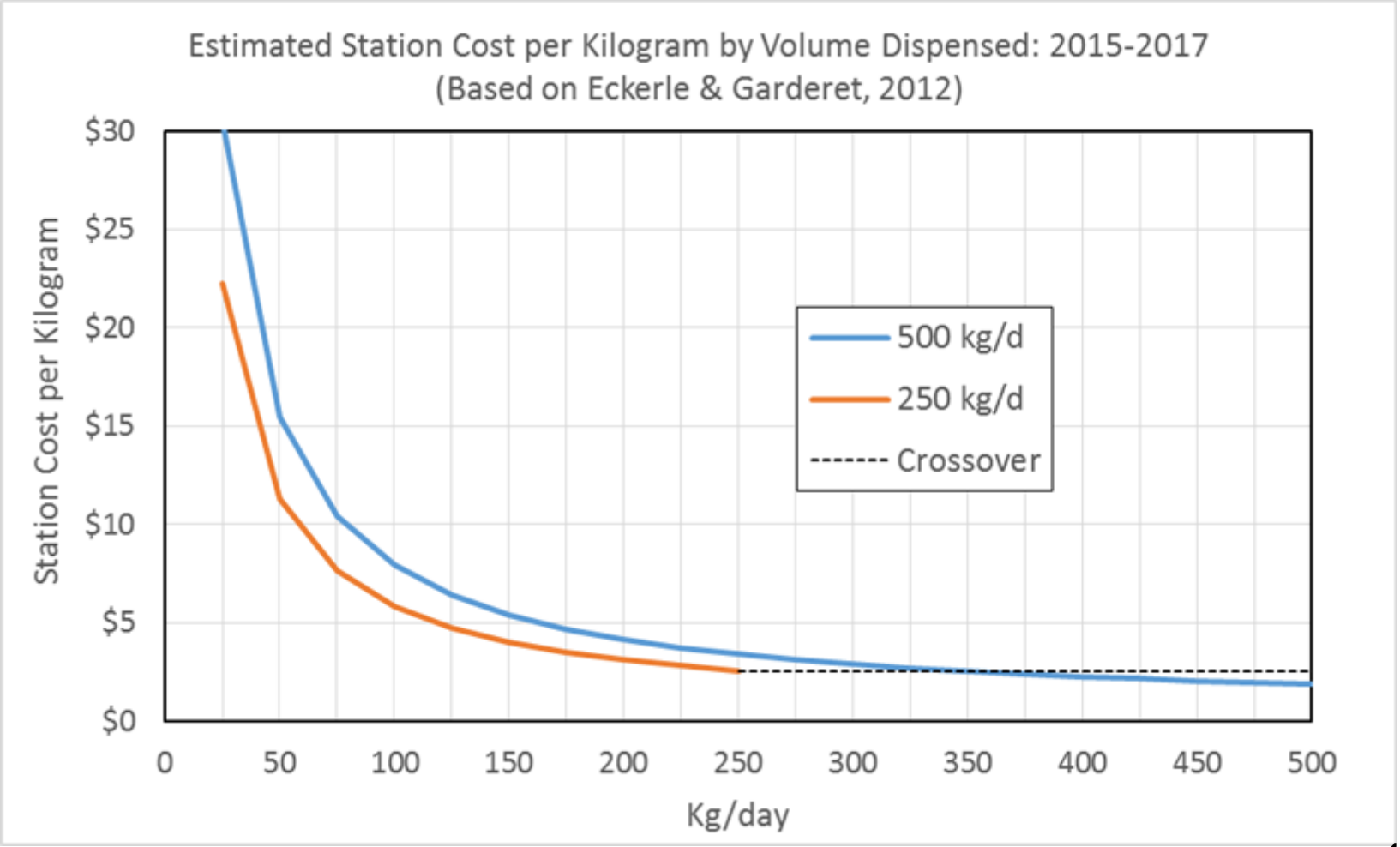
- US survey: availability of 1% to 10% like price increase of $4,250 to $16,000 (Melaina et al., 2013).
- Those not interested in Alternative Fuel Vehicles (AFV) more worried about fuel availability than early adopters.
- PEV owners do 75%-80% of recharging at home; (INEL, 2014).
- Awareness of public recharging only 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).

How much fuel availability is enough?

- Minimum for first adopters is 15% to 20%, according to a modeling analysis by Gnann and Plotz (2015).
- Fuel availability is a major concern for majority until availability reaches 10% to 20% (Sperling and Kurani, 1987; Greene, 1998; Liu and Greene, 2015).
- The time cost of access decreases exponentially with the number of stations (Nicholas, Sperling and Handy, 2004). (Where the "elbow" is.)
- Clustering of stations can substantially alleviate availability costs in early market (Ogden and Nicholas, 2010).



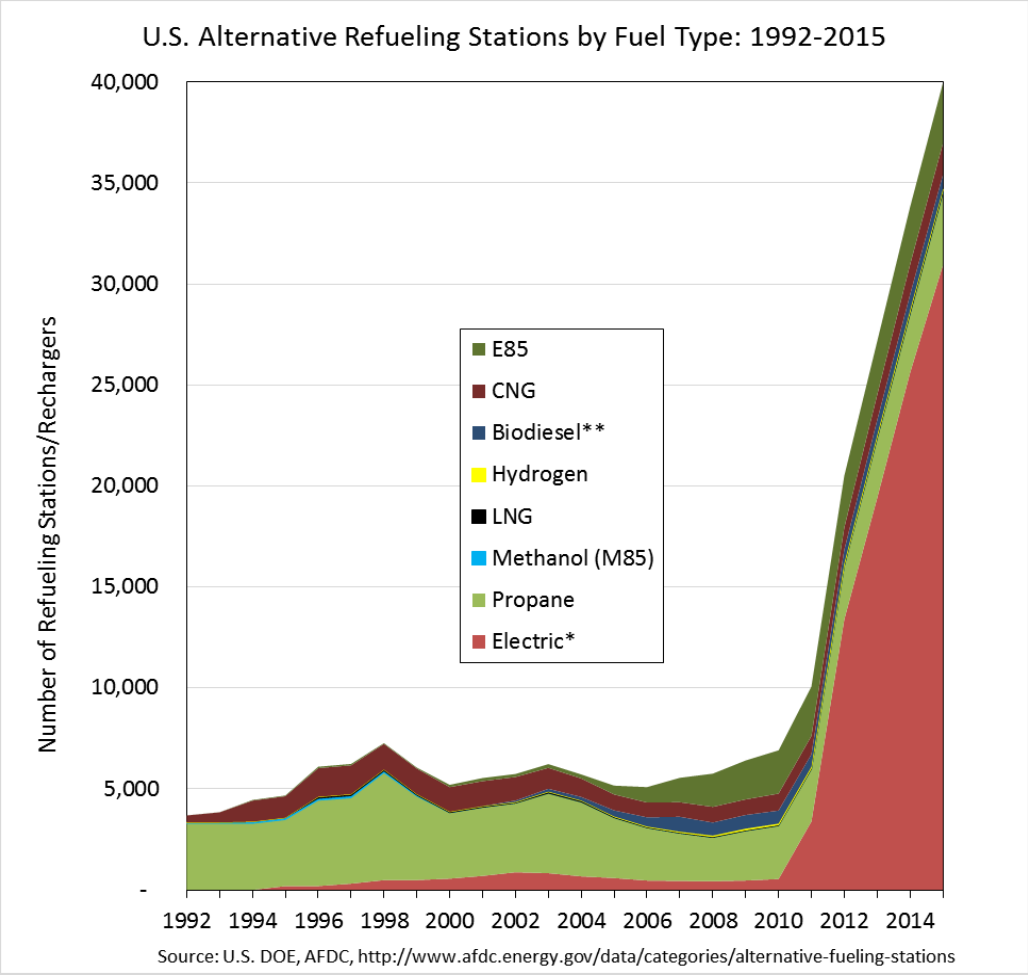
Business models for early AF refueling infrastructure are problematic because it appears that capacity must exceed demand for the vehicle market to grow.

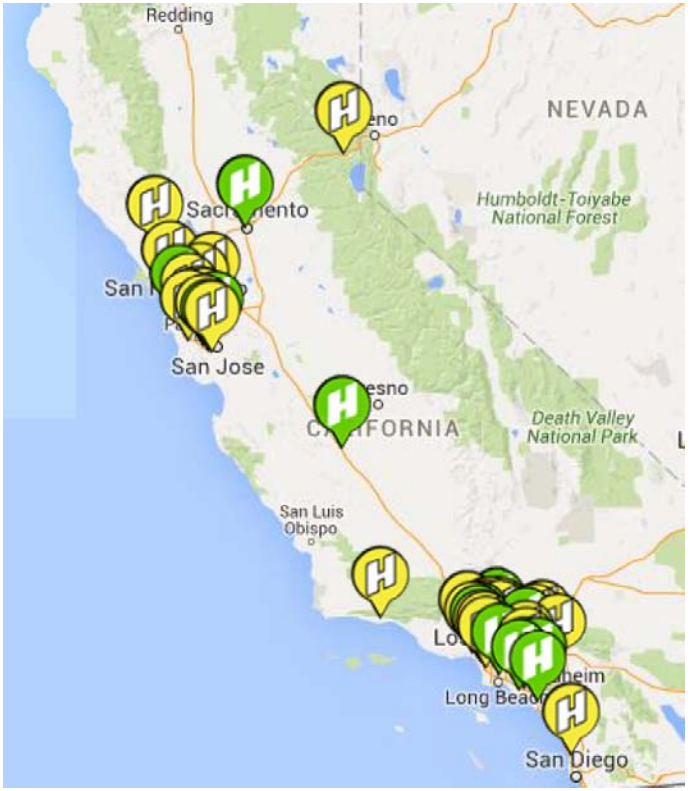


Early alternative fuels infrastructure requires support. What works best?

- 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)
  - NRC (2015) EV Barriers Committee: federal government should refrain from further investment until relationship between infrastructure and PEV adoption are better understood.

Investment in Electric Vehicle Service Equipment (EVSE) has far exceeded all other alternative fuels infrastructure. But a combination of state subsidies, ZEV mandates and other incentives is building a hydrogen refueling network in CA.





14 Open, 27 to open in 2016.
As of 4/8/2016.

Early alternative fuels infrastructure: Institutional issues also matter.

- DOE's Clean Cities EV Readiness Project examined planning and regulatory issues at all levels of government.
  - State planning toolkit for local governments and agencies
  - Local coordinating councils
  - Workshops with local leaders
  - Panel of experts at state level to assist localities
  - Comprehensive program of education and outreach for public and governments

- Low cost incentives at community level:
  - Waive or reduce EVSE permitting fees
  - Streamline permitting procedures
  - Real estate or sales tax incentives

The complexity of the transition problem requires 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

- 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.

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

Accomplishments and Progress: Responses to Previous Year Reviewers' Comments

- We received a number of valuable comments from reviewers on last year's project evaluating the impacts of the ARRA on the non-automotive fuel cell industry.

- The comments helped improve the research and will be reflected in the doctoral research of UT Industrial Engineering graduate student Girish Upreti.

- Girish Upreti received the ***2015 Bernard S. Baker Student Award for Fuel Cell Research*** for his work contributing to last year's project https://fuelcellsworks.com/news/ut-industrial-engineering-graduate-student-girish-upreti/ .

- However, that project was completed and is not continued in FY 2016.

Collaborations

- Given the nature of this year's project, collaborations consisted of peer review by external experts.
- Peer review of policy review and analysis:
  - Professor Jonn Axsen, Simon Fraser University
  - Mr. Robert Graff, Mgr. Office of Energy and Climate Change Initiatives, Delaware Valley Regional Planning Commission
  - Dr. Zhenhong Lin, Oak Ridge National Laboratory
- Peer review comparative refueling infrastructure costs:
  - Dr. Amgad Elgowainy, Argonne National Laboratory
  - Dr. Marc Melaina, National Renewable Energy Laboratory

These reviews greatly improved the quality of our analyses. However, any remaining deficiencies are the sole responsibility of the authors.

Remaining Challenges and Barriers

- Most published studies do not evaluate policies in the context of a large-scale energy system transition. This can lead to myopic assessments.
- Analyses of the cost-effectiveness of policies to promote alternative fuels and vehicles are very scarce.
- The complexity of the transition process and the importance of factors that are relatively poorly understood quantitatively (i.e., cost of majority risk aversion, value of fuel availability, etc.) limit our current ability to make definitive evaluations of policy strategies.

Proposed Future Work

- Publish comparative analysis of refueling infrastructure costs of alternative fuels and vehicles.
- Assist the Department of Energy and its National Laboratories in their participation in efforts to deploy hydrogen refueling infrastructure.
- Publish report on consumer behavior and the market adoption of advanced vehicle powertrains.
- Assist the DOE's National Laboratories in developing models for planning and policy evaluation of the transition to low-GHG energy for motor vehicles.

Summary

- Policies to promote low-GHG vehicles and fuels should be assessed in the context of a long-term, large-scale energy system transition.
- Such a transition is complex and requires decades to accomplish. The outcome is uncertain.
- A complex, multi-dimensional strategy comprised of durable, adaptable policies is needed.
- Published studies provide many useful insights but much remains to be learned about how to accomplish the necessary transition efficiently and effectively.

Technical Back-Up Slides

Publications and Presentations

Publications:

- Greene, D.L., “Policies for Promoting Low-Emission Vehicles and Fuels: Lessons from Recent Experience”, White Paper, Howard H. Baker, Jr. Center for Public Policy, The University of Tennessee, Knoxville, May, 2016, http://bakercenter.utk.edu/white-papers/ .
- G. Upreti, D.L. Greene, K.G. Duleep and R. Sawhney, “Impacts of the American Recovery and Reinvestment Act and the Investment Tax Credity on the North American non-automotive PEM fuel cell industry”, *International Journal of Hydrogen Energy*, published online January 21, 2016, at http://www.sciencedirect.com/science/article/pii/S0360319915313458 .
- and G. Upreti, 2015. “Impacts of the American Recovery and Reinvestment Act and Investment Tax Credit on the North American Fuel Cell Backup Power and Materials Handling Equipment Industries”, Baker Report 7-15, Howard H. Baker, Jr. Center for Public Policy, The University of Tennessee, Knoxville, December, available at http://bakercenter.utk.edu/wp-content/uploads/sites/4/2016/01/ARRA-Impacts-Study-Greene.pdf .
- Greene, D.L., *Alternative Transportation Infrastructure in the U.S.: Status and Challenges*, White Paper 1:15, Howard H. Baker, Jr. Center for Public Policy, The University of Tennessee, Knoxville, January, 2015, http://bakercenter.utk.edu//wp-content/uploads/2015/04/712949-White-Paper-Template.dlg_.alternative-transp.-115.pdf .

Publications and Presentations, cont'd.

Presentations:

- Greene, D.L., "Policies to Promote Alternative Fuel Vehicles: What can we learn from the literature?", a presentation to the Hydrogen and Fuel Cell Technical Advisory Committee, Livermore, California, April 6, 2016.
- Greene, D.L., "Why Hydrogen Fuel Cell Vehicles?", a presentation to the Pollution Probe Pathways Initiative Workshop, Toronto, Ontario, Canada, March 22, 2016.
- Greene, D.L., "Transportation and Energy: Managing an Energy Transition", a presentation to the Virginia Academy of Science Engineering and Medicine, 2015 Summit Meeting, November 5, 2015, Washington, DC.