ALTERNATIVE TRANSPORTATION FUEL INVESTMENT RISKS DUE TO TECHNOLOGICAL AND PETROLEUM PRICE UNCERTAINTY

Marc Melaina, Brian Bush and Yongling Sun

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Presentation Overview

Motivation and Problem Statement
• Investments during ZEV transition

Analytic Approach
• Top-down and bottom-up model integration
• SERA, ADOPT and SEDS models
• Financial assessment capability

Relevant Scenario Studies
• California Statewide Assessment
• National Electric Vehicle Assessment (NEVA)
• H2USA National Scenarios

Role of Policy Mechanisms in reducing investment risk
• Preliminary result: incentives for a hydrogen station network
Motivation and Problem Statement

- Investments during ZEV transition
Motivation: Why ZEVs?

• Vehicle electrification with low-carbon electricity and hydrogen is a key option for sustainable transportation
  
  o Reduction Goals: Carbon, petroleum, criteria emissions
  
  • Biofuels, nuclear, and carbon capture are other key options
  
  • High ZEV fuel economies (FE) must be accompanied by electricity and hydrogen with low fuel carbon intensities (FCI)
  
  • Liquid biofuels may leverage existing fuel infrastructure.
  
  • Biofuels may play a larger role with medium- and heavy-duty vehicles, as well as aviation, rail, marine and other sectors

Source: Melaina and Webster (2011)
Problem Statement: Shared Stakeholder Risk

• Zero emission vehicles (ZEVs) require new fuel supply infrastructure (electricity and hydrogen)
• Value of ZEVs to consumers is dependent upon availability, quality, and price of fuel
• Market transition period: Infrastructure investments must materialize before strong fuel demand is established
Analytic Approach

- Top-down and bottom-up model integration
  - SERA, ADOPT and SEDS models
  - Financial assessment capability
Analytic Approach

General approach is bottom-up, with top-down aspirations

Main models

• SERA: Scenario Evaluation and Regionalization Analysis
• ADOPT: Automotive Deployment Options Projection Tool
• SEDS: Stochastic Energy Deployment System

Other key attributes

• Integration of:
  o Large empirical data
  o Stakeholder input
The Modeling Landscape: Three General Types

Different types of models are good at addressing different questions; each type has limitations.

Aspiration is to expand our bottom-up modeling framework to represent market and policy outcomes more realistically.

What types of integration between model types might inform a transition to ZEVs?
The Modeling Landscape: Methodology Examples

Market Equilibrium

System Dynamics

Economics

Thermo-chemical (Aspen)

Behavior

Engineering
The Modeling Landscape: Engineering Model Drawbacks

Rosy cost estimates
*Learning rates apply into the future*

Black Box
*The model has 1000 variables*

Too objective
*Sound analysis, speculative inputs*

Economics

Behavior

Engineering
The Modeling Landscape: Economic Model Drawbacks

Heterogeneous and irrational actors

*National network of fast chargers*

Regressions and rising above

*How might EVCS complement future retail business models? What if batteries are made in China?*
Scenario Evaluation and Regionalization Analysis (SERA)

SERA overview

High level of geographic detail (any level of resolution)
Full supply chain for hydrogen; data exchange with grid model results
Typical optimizations are on fuel cost, but other metrics can also be optimized
SERA scenario development sequence

1. Construct local scenarios for early market infrastructure clustering and vehicle rollout.
2. Tune nationwide scenarios to observations and lessons learned in local early market evolution and planning.
3. Refine methodology for locating and sizing stations within urban areas.
4. Develop methodology for locating FCEVs at households within urban areas.
5. Refine methodology for optimizing the choice of hydrogen production and delivery infrastructure.
6. Compute cash flows and delivered costs for hydrogen.
Automotive Deployment Options Projection Tool (ADOPT)

- **ADOPT’s choice model**
  - Uses a logit function
  - Competes all makes, models and trims
  - Validates well with historical sales

- **Attribute trade-offs**
  - Non-linear preferences
  - Preference changes with income
  - Validated with historical sales

- **Vehicle options**
  - Includes all existing makes, models, trims
  - Captures changes in fleet vehicle options
  - Match historical trends

- **Policy implications**
  - CAFE drives fuel economy
Choice Model: Attribute Trade-offs

Non-linear preferences
- Going from 100 miles to 200 miles range is more important than going from 500 miles to 600 miles range

Preferences change with income
- Higher income consumers are less influenced by cost and more influenced by performance and size
- Income, and thus preferences, change over time

![MSRP Equivalent Value by Characteristic](chart.png)
Model Calibration/Validation

- One set of coefficients were tuned to match historical sales for many different locations

- 63005 (Saint Louis, MO)

Percent HEV Sales

Sales By MPG
(listed by max in bin)

Sales By Acceleration
(Max Bin Accel Time (secs 0-60 MPH))

Sales By MSRP
(listed by max in bin)

Sales By Class

Fuel Economy (MPG)

Annual Sales

Vehicle Price (MSRP)

Annual Sales

Annual Sales

Annual Sales

Actual

Model

Actual

Model

Actual

Model

Actual

Model

Actual

Model
The Modeling Landscape: Behavior is key for transitions

*Consumer perceptions and use of vehicles is highly uncertain, and may evolve over time with new vehicles*

Complexity, barriers

*How many additional e-miles will be driven with investments in corridor charging?*

Lack of empirical data

*Early adopters have done X*

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Economics

Behavior

Engineering
Integrating SERA and ADOPT: local markets

Geographic market segmentations have been developed based upon analysis of early adopter behavior and income

Full integration will allow for ADOPT market share projections within each market, with optimal SERA alternative fuel build-out trends and price projections
Metro Coverage for Seattle

In earlier versions respondents had difficulty distinguishing between 2 & 3.
Stochastic Energy Deployment System (SEDS)

SEDS Overview

- Simulate the US energy markets based on costs and performance
- 13 interrelated modules
- Explore policies effects and R&D effects
- Allow risk and uncertainty analysis with probability distributions

Global oil market uncertainty within SEDS

The World Oil Market Model (WOMM) within SEDS receives U.S. oil demand and returns a global oil prices based upon uncertainty in the state of world.
WOMM generates market disruptions

Disruptions below are based upon AEO price trajectories

WOMM must be updated for future analyses.
See more on WOMM and SEDS documentation here: https://seds.nrel.gov/
Role of Investors in Transition: Where does the capital come from?

- There are many different types of investors, and they may play different roles across different stages of the ZEV transition period.
- How can they be engaged more fully into partnerships and projects?
Full financial analysis framework, multiple fuels

- Financial framework provides extensive analysis and reporting on a range of financial performance metrics of interest to investors. Deployed online as “H2FAST”:

The H2FAST user interface has been designed based upon feedback from reviewers with finance industry experience.

Key Finance Outputs

- Annual projection reports for:
  - Income Statement
  - Cash Flow Statement
  - Balance Statement

- Key Metrics:
  - IRR, EBITD, NPV, ROE, break-even price, payback

- Ratio analyses, for example:
  - Debt / equity
  - Debt Service Coverage Ratio

- Calculations adhere to international and generally accepted accounting practices

H2FAST is available at:
http://www.nrel.gov/hydrogen/h2fast/
Relevant Scenario Studies

- California Statewide Assessment
- National Electric Vehicle Assessment (NEVA)
- H2USA National Scenarios
Integration requires better understanding of investors

What types of integration can help us understand ZEV transitions?

What is Integration?
14 Meanings (Scraser and Sheate 2002)
1. Integrated information resources
7. Integration of business concerns into governance
11. Integration of stakeholders into governance
12. Integration among assessment tools
14. Integration of assessment into governance

Investment decisions must be understood within the context of:
• Technology improvements
• Stakeholder networks
• Price projections
• Financial outlooks
• Policy influences
• Potential or real partnerships
California Statewide Assessment

Assessment within context of Governors ZEV Action Plan goals
National Electric Vehicle Assessment (NEVA) PEV Scenarios

- Study examines the private and social costs and benefits associated with large-scale national deployment of PEVs
- Focus on fuel savings, GHG reductions, and macroeconomics (GDP and jobs)
- Social costs included, but air quality impacts are out of scope
- Some grid modeling included to examine impact of demand and time of day GHGs and prices

Results at Division level
H2USA Scenarios

- H2USA is a public-private partnership with 43 members (http://h2usa.org)
- Scenarios allow for analysis of sufficient and limited hydrogen coverage
- Cost penalties from discrete choice survey used for limited coverage (Melaina, Bremson and Solo 2012, USAEE Ann Arbor conference)
- Scenarios based upon possible influences of ZEV mandate on distribution of FCEVs across states and regions

Multiple rollout scenarios are of interest. The maps below illustrate one possible market growth scenario with urban area sequencing.
Hydrogen & Electricity Costs: fuel costs per vehicle mile

Central values for total fuel costs suggest BEV and PHEV costs 19-16% lower than FCEV costs, but sensitivities are skewed high.

**Key Assumptions for 2025**
- Cost of hydrogen delivered to the retail station: $3.00/kg[^B]
- Cost of electricity:
  - $0.11/kWh Resid. (Home)
  - $0.095/kWh Comm. (Public)
  - AEO 2012 Early Release
- Cost gasoline: $4.02/gal (AEO)
- Fuel Economies
  - FCEV: 59 mpgge
  - BEV: 113 mpgge
  - PHEV: 141/45 mpgge (e/g)
  - HEV: 49 mpg
  - ICE: 33 mpg

[^B]: 29

Role of Policy Mechanisms in reducing investment risk

• Preliminary result: incentives for a hydrogen station network
HRS Example

• Theoretical rollout of a network of hydrogen refueling stations (HRS)
• Public incentives for both upfront capital (early on) and operation of stations (later years)
• Results on private investor financial performance can be determined based upon last year in which incentives are offered
• Capital, incentives and earnings at right
Margin, Cash Flow

- A broad range of financial metrics are generated
- Can be used to gauge impact of incentives and influence on private investors
- Gross margin ($/fuel unit) and cash flows at right
- Incentives to 2020 provide stability in this example
- These metrics help inform the decision of when public funds may or may not continue to be required to establish a self-sustaining alternative fuels market
Conclusion: Integrated hybrid approach is needed

Model goal: improved representation of investor and consumer behavior underlying market outcomes

Today is the Benchmark
- Market status
- Short-term market perturbation potential
- “What’s around the next bend?”

Integrated energy modeling can help guide market development as it occurs

Market Takeoff, Business Case, Cost-benefit, etc.

Economics

Behavior

Engineering
Thank you!
References

- Melaina, Marc, Yongling Sun, and Brian Bush. 2014. “Infrastructure Costs Comparison for Hydrogen and Electricity.” SAE World Congress, Detroit, Michigan, April 2014.