Light Duty Vehicle Electrification
Discussion on Trip, Vehicle, and Consumer Characteristics

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Outline

1. Motivation
2. Literature Review
3. Proposed Work
4. Outlook / Outreach
Outline

1. Motivation
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4. Outlook / Outreach
Automobile, Mobility … Why Not Just “Cars”? 

Mobility = Mobility Device + Mobility Consumer

or: Mobility = Transportation + Enjoyment
Different Levels of Vehicle Electrification

Conventional
- ICE Powered Vehicle (CV)
  - Fast refueling
  - Long range
  - No e-drive

Electrified
- Hybrid Electric Vehicle (HEV)
  - Fast refueling
  - Long range
  - Minimal e-drive

- Plug-In Hybrid Electric Vehicle (PHEV)
  - Fast refueling
  - Long range
  - Often e-drive

- Battery Electric Vehicle (BEV)
  - Slower refueling
  - Shorter range
  - Only e-drive

- Fuel Cell Vehicle (FCV)
  - Fast refueling
  - Long range
  - Only e-drive
NHTS – Average Daily Mobility Behavior

Cumulative Daily Distance / Total [%]

Source: Pike Research, US DOT, Volkswagen Research Lab
Compiled by M. Buckner, Lico Technology
Consumer Choice: Average vs. Extreme Case
Outline for a Proposed Research Project

1. Analyze National Household Travel Survey and additional sources, identify similar mobility behaviors, define categories by actual needs, and set assumptions for perceived consumer needs
   **Goal:** quantification and categorization of mobility behavior

2. Describe and categorize vehicle types by level of electrification and build impact simulation model with mobility behavior as input
   **Goal:** simulation model to calculate environmental impact and personal autonomy

3. Apply database and model and calculate environmental impact and autonomy when consumer and vehicle categories as defined under 1-2 are matched to reach optimum for environment and mobility
   **Goal:** characterization of optimal vehicle fleet composition

4. Determine vehicle purchase and operating cost to quantify consumer burden when transitioning to optimal fleet composition, take into account additional (practical, emotional, economical...) factors, and consider measures to mitigate financial burden
   **Goal:** recommendations for a more sustainable vehicle fleet composition and how the optimal mix can be attained through incentives, if necessary
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Existing Work Overview – Types of Studies

- **Attitude Study (AS)**
  Analyze responses from consumers regarding their views of EV technology.

- **Travel Behavior and Constraints Analysis (TBCA)**
  Evaluate range needs of consumers and estimate corresponding market share.

- **Revealed Preference Study (RPS)**
  Analyze decision making and consumer behavior regarding EV purchase.

- **Stated Preference Study (SPS)**
  Provide economic valuations where transaction or market data is not available.

- **Reflexive / Integrated Stated Response Study (R/ISR)**
  Similar to SPS, but constraints and choice sets placed to identify further preferences.
<table>
<thead>
<tr>
<th>Publication</th>
<th>Authors</th>
<th>Type</th>
<th>Results</th>
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<tbody>
<tr>
<td>Testing electric vehicle demand in ‘hybrid households’ using a reflexive survey (1996).</td>
<td>Kurani, Turrentine, Sperling</td>
<td>R/ISR</td>
<td>Households with more than 1 vehicle can adapt to a single limited range vehicle. Purchase of EV most strongly linked with defining purpose of vehicle and household life cycle.</td>
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<td>Joint mixed logit models of stated and revealed preferences for alternative-fuel vehicles (2000).</td>
<td>Brownstone, Bunch, Train</td>
<td>SPS, RPS</td>
<td>Market share of 75 mile EVs will be: 2.1% (sub-compact); 2.3% (sports car); 0.6% (compact pickup); 0.6% (minivan).</td>
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<td>Attitude of European Car drivers towards EVs: a survey (2012).</td>
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<td>Testing electric vehicle demand in ‘hybrid households’ using a reflexive survey (1996).</td>
<td>K. Kurani, T. Turrentine and D. Sperling</td>
<td>Interactive Stated Response (ISR)</td>
<td>Many households with more than one vehicle can adapt to a single limited range vehicle. This represents up to 18% of light duty CA market with vehicles with 40 to 150 miles of range. Purchase of EV is most strongly linked with defining purpose of vehicle and household life cycle.</td>
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**Existing Work Example 1**

**Fig. 1.** Average daily mileage distribution. Histogram of daily mileage during 1 mile is not tabulated in the histogram. The black line shows the sum of days.

Existing Work Example II

Figure 1 GPS Data Representation of Daily Distance Traveled

Figure 3 Maximum Possible Single-vehicle Household Adoption Rates for BEVs in Seattle

Source: Khan, Kockelman; “Predicting the Market Potential of Plug-In EVs Using Multiday GPS Data”; TRB Annual Meeting; 2012
Chain of Study Steps – Focus of this Work

- Assumption
- Analysis
- Interpretation
- Conclusion
Outline

1. Motivation
2. Literature Review
3. Proposed Work
4. Outlook / Outreach
Trip, Vehicle, Consumer Characteristics

Trip Characteristics
1. Length
2. Predictability
3. Alternative

Vehicle Characteristics
1. Affordability
2. Range
3. Perks & Appeal

Consumer Characteristics
1. Consideration
2. Rationalism
3. Flexibility
Trip, Vehicle, Consumer Characteristics

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Consumer Characteristics
1. Consideration
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3. Flexibility
**Trip Characteristic: Length**

**Definition:** Distance between start and destination

**Challenge:** No information about what road, urban / rural setting, vertical profile, (charging) infrastructure

**Need:** More information about trip specifics

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### Extreme 1

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### Neutral / Moderate

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### Extreme 2

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actual trip length in miles

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Trip Characteristic: Predictability

- Describes how much consumer knows about trip characteristics and how they compare to vehicle specifications.

- Example: Consumer may have very consistent driving schedule, e.g. “to and from work is a 30-mile round trip” or may have 30-mile commute but “often needs vehicle at work to run errands”.

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<th>Extreme 2</th>
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<tr>
<td>complete trip detail known</td>
<td>duration of travel understood</td>
<td>length, profile, etc. unknown</td>
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Trip Characteristic: Alternative

- Considers other options instead of vehicle that is considered first option.
- Especially applies when EV cannot be used for trip because of limited range.
- Alternatives can be another household vehicle, rental car, carsharing, ridesharing, taxi, public transportation, biking, walking, or forgoing trip.

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<td>other personal vehicle, no applicable limitation</td>
<td>ride-sharing, public transportation</td>
<td>no alternative, trip cancelation</td>
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Trip Characteristics
1. Length
2. Predictability
3. Alternative

Vehicle Characteristics
1. Affordability
2. Range
3. Perks & Appeal

Consumer Characteristics
1. Consideration
2. Rationalism
3. Flexibility
Vehicle Characteristic: Affordability

- Compares actual cost of mobility option to actual financial situation of consumer.
- Example: “100 miles cost $50” may have different implication for someone with low dispensable income as opposed to someone with more financial flexibility.
- Additional “context” information needed.

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<td>free, no cost associated with using</td>
<td>acceptable cost with regard to financial situation</td>
<td>unbearable financial burden</td>
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Vehicle Characteristic: Range

**Definition:** Distance vehicle can travel on own power until needs to get replenish

**Challenge:** No information about how range is influenced by terrain, speed, auxiliaries, driving style, etc.

**Need:** More information about trip and consumer to determine “practical” range

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<td>-------------------</td>
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<tr>
<td></td>
<td>actual vehicle autonomy in miles</td>
<td></td>
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Vehicle Characteristic: Perks & Appeal

- Considers how much vehicle appeals to a consumer
- Also considers additional value that consumer benefits through certain vehicle choice.
- Especially for EVs includes free parking, access to HOV lane, etc.
- Also including the importance of styling, practicability, brand values, etc.

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<td>additional benefits and positive appearance</td>
<td>practical and fair</td>
<td>not extra benefits, negative appearance</td>
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Trip, Vehicle, Consumer Characteristics

Trip Characteristics
1. Length
2. Predictability
3. Alternative

Vehicle Characteristics
1. Affordability
2. Range
3. Perks & Appeal

Consumer Characteristics
1. Consideration
2. Rationalism
3. Flexibility
Expresses how much consumer cares about the external impact of his / her travel choice on others and how much his / her personal needs are covered.

Including vehicle’s impact on the environment and also personal needs like reassurance by others and the experience of pride.

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<td>caring about others &amp; environment</td>
<td>covering self, considering others</td>
<td>only caring about self, egoistic</td>
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Consumer Characteristic: Rationalism

- Describes if consumer is rather driven by practical or emotional factors.
- Example: consumer might see vehicle as means to get to a destination (= commodity) or might enjoy driving (= enjoyment).

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<td>practical behavior, non-emotional</td>
<td>balance of emotional and practical behavior</td>
<td>emotional behavior, non-practical</td>
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Consumer Characteristic: Flexibility

- Describes how carefully consumer plans vehicle travel or how risk-taking someone is.
- Also considers how well consumers deal with change.
- Example: consumer willing to “experiment” with the range information or already stressed out when fuel gauge in conventional vehicle goes below half-full.

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<td>risk neutral, change accommodating</td>
<td>risk seeking, change appreciating</td>
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Characteristics and Connections

- **CONSUMER**
  - Rationalism
  - Consideration

- **CONSUMER**
  - Flexibility

- **TRIP**
  - Length
  - Predictability
  - Alternative

- **VEHICLE**
  - Range
  - Affordability
  - Perks & Appeal

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- **longer travel distance** = higher transportation cost

- vehicle range > trip length

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**Necessary Match**

**Essential Influence**

**Significant Link**
Characteristics and Connections

CONSUMER Flexibility

TRIP Length

TRIP Predictability

TRIP Alternative

CONSUMER Rationalism

CONSUMER Consideration

VEHICLE Perks & Appeal

VEHICLE Range

VEHICLE Affordability

Necessary Match

Essential Influence

Significant Link
Outline

1. Motivation
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3. Proposed Work
4. Outlook / Outreach
Outlook – Combine Existing, Add Connection

1. Literature Overview
2. Comparative Study of Existing Work
3. Propose Integrative Approach
4. Categorize Commuters
5. Analyze data from SAC and SD
6. Propose Additional Surveys
Outreach – Questions for the Group

For a work titled
“Matching Consumer Expectations and Vehicle Specifications in Light of EVs”,
what about the following questions:

1. Does the 3x3 characterization of trip, vehicle, consumer cover the aspects pertaining
   to electric mobility insufficiently / sufficiently / completely?
   >> What is missing, redundant, confusing?

2. Would it be possible (make sense) to make the entire set of characteristics
   quantifiable?
   >> How can this be accomplished?
   >> Who would like to help? (anything from ideas … discussion … collaboration)