PEV Consumer Behavior in Practice

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VAN015

Overview

Timeline

- Mid 2014
- Mid 2016
- 15% Percent complete

Budget

- Total project funding
  - $400,000
- $156K Funding received in FY14
- $244K Funding for FY15

Barriers

- Barriers addressed
  - Infrastructure: Show how consumers are using infrastructure in order to identify gaps
  - Constant advances in technology: Provide input to models in the rapidly developing PEV market. Calibrate models with in-use data.

Partners

- CARB is funding data collection
- DOE is funding analysis
- ORNL, NREL, Argonne will be able to use anonymized data
- Project Lead: Michael Nicholas, Gil Tal, Thomas Turrentine

Relevance and Objectives

- Plug-in technology is new and there is little real understanding on how people are actually using their vehicles and more importantly what factors explain their usage.
  - Travel needs
  - Other vehicle availability
  - Access to charging
  - Battery size
  - Vehicle Switching
- Understanding how people are using their cars gives policy makers the tools to predict and affect outcomes to achieve policy goals
- Can we expect plug-ins to replace ICE (Internal Combustion Engine) vehicles? What role do ICE vehicles play within the household?

- Is eVMT important as a metric? What does eVMT represent?
  - GHG reduction?
  - Local criteria pollutant reduction?
  - Gasoline replacement?
  - Energy security?
  - Technology advancement?

Relevance and Objectives (cont.)

Our role

- Provide stakeholders and policy makers analysis to help make informed decisions and have informed discussions
- Analyze cause and effect under different policy goals

The household as a unit of analysis

eVMT share 42% Total 19,000 Miles	eVMT share 42% Total 19,000 Miles	eVMT share 72% Total 11,000 Miles	eVMT share 68% Total 19,000 Miles
PHEV 8,000 eMiles 3,000 gas Miles	BEV 8,000 eMiles	BEV 8,000 eMiles	BEV 13,000 eMiles
ICE 8,000 Gas Miles	ICE 11,000 Gas Miles	ICE 3,000 Gas Miles	ICE 6,000 Gas Miles

Relevance and Objectives (cont.)

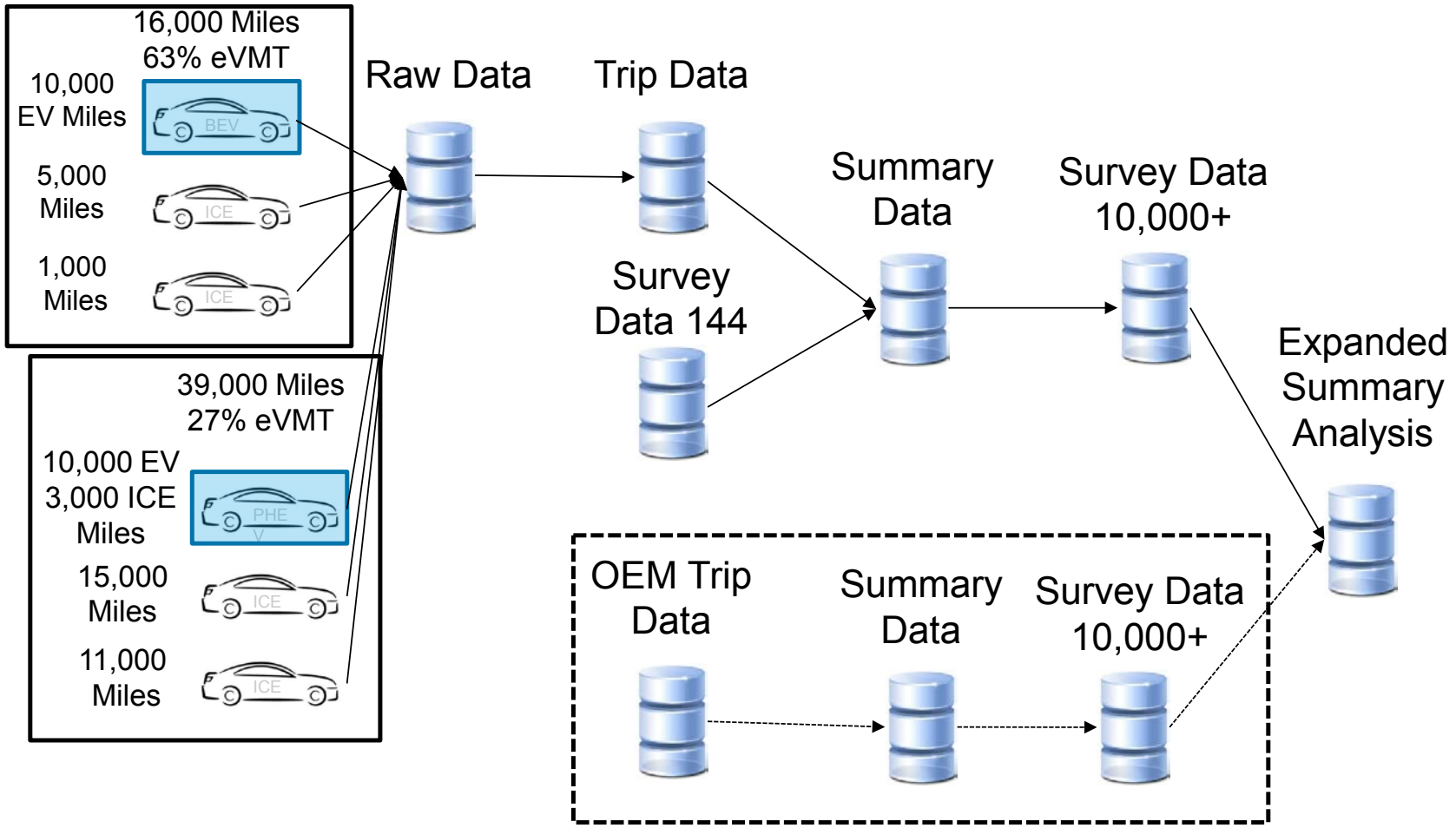
Why can't we just use data from Automobile Manufacturers (OEMs)?

- OEM data pros
  - Absolute numbers
  - Large number of observations
- OEM data cons
  - Selection bias/inconsistent sampling
  - Inconsistent metrics
  - No information on driver or household
  - No information on travel in other cars
  - Limited ability to explain differences between vehicles

- Survey data pros
  - Large number of surveys (UCD has done 20,000+)
  - Household context captured
  - Qualitative data explains motivations
  - Other vehicles detailed
- Survey data cons
  - Self reported, inaccurate memories

Relevance and Objectives (cont.)

Combining Survey Data with In-use data Increases the Value of Each Individually. OEM data usage is speculative, but possible.

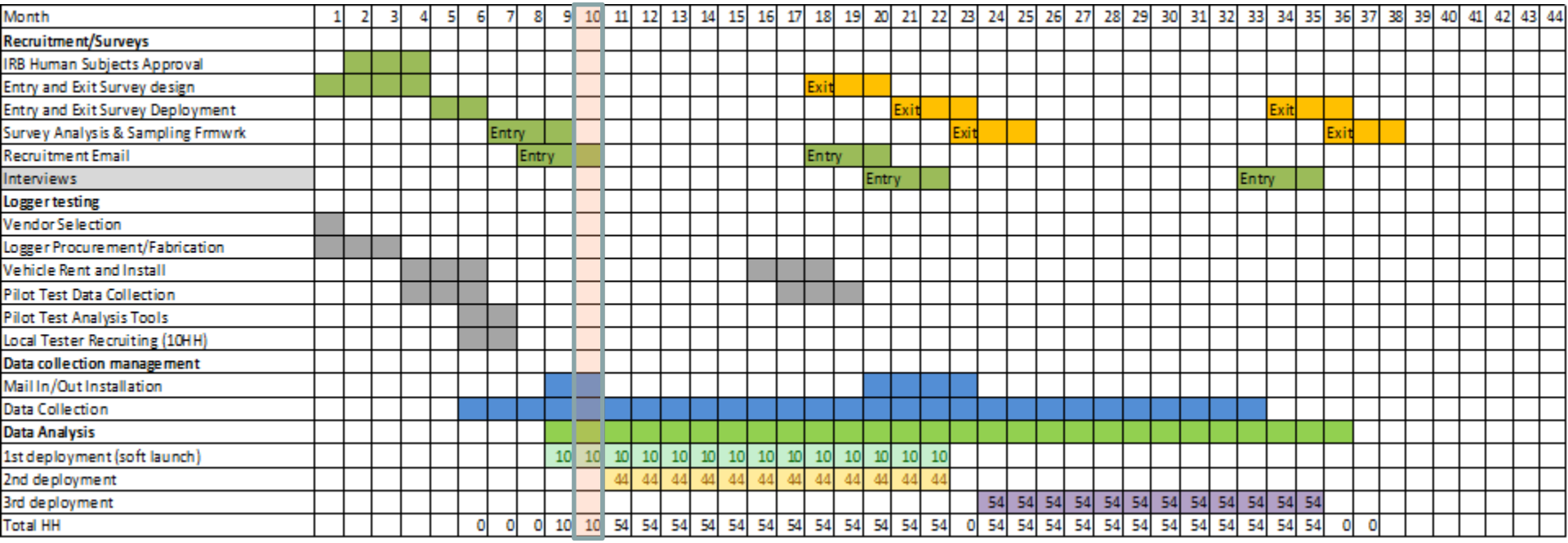


Relevance and Objectives

- Provide most in-depth study of PEV usage and charging dynamics. Inform policy on battery size/vehicle architecture/consumer behavior interaction
- 30,000 person survey to inform data collection
- Data Collection: Monitor **all** vehicles in PEV households. PEVs: Leaf, Volt, Prius Plug-in, C-Max, (BEVx?, Tesla?)
  - 144 households
  - Monitor OBD driving and charging parameters along with location
  - Determine PEV household travel dynamics. How is the PEV used compared to other cars? EVMT impacts?
  - Determine charging frequency and location. L1, L2, QC location.

Milestones

- **DOE funded data analysis portion. Started with another household data set**
- **CARB funded data collection effort is progressing**
  - **Loggers procured and in test households getting data**
  - **Recruitment survey has been deployed**



Approach: Recruitment and Surveys

Sent invitation by mail

Fill out survey

Want to participate

Chosen households

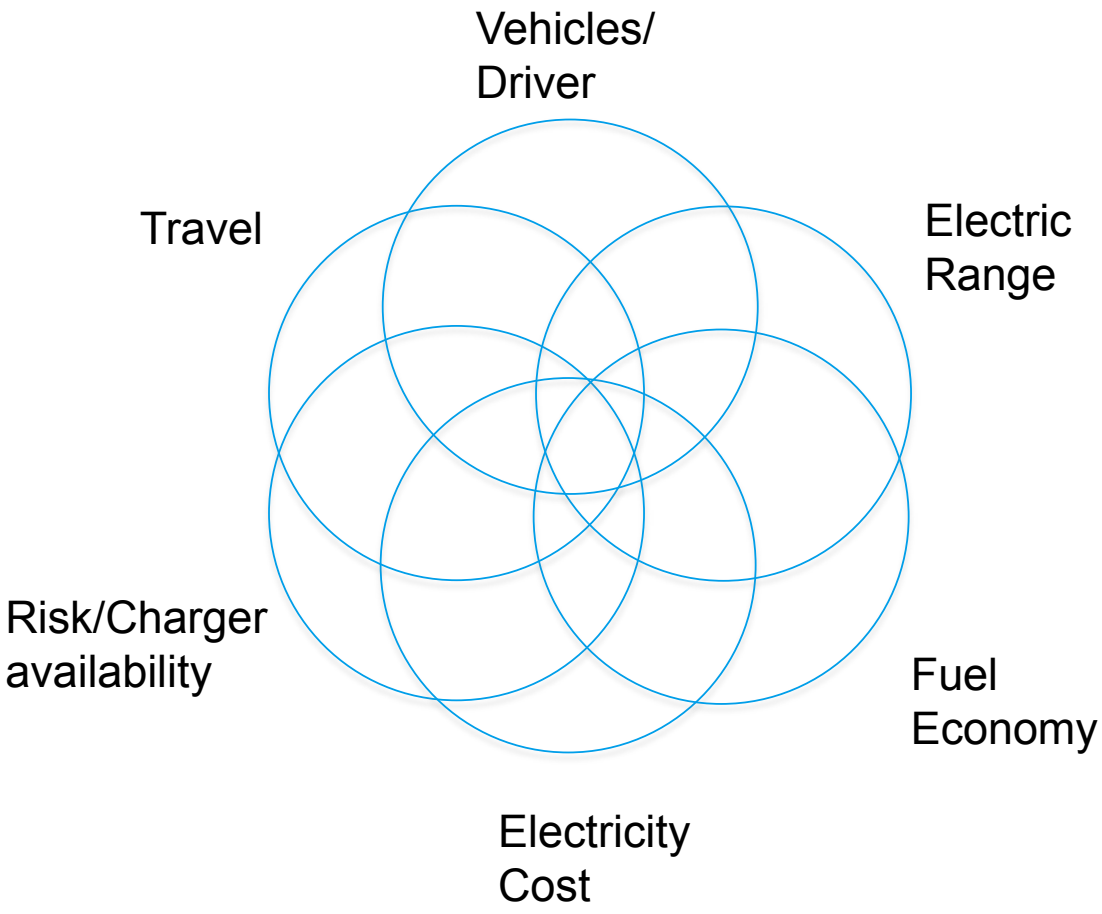
- Use the 37,000 person survey to characterize the market and recruit respondents
  - 144 households selected from the sample
  - Favor households with newer than 1996 vehicles (OBD II)
  - Incentive is $350
  - Select for geography variation

Approach/Strategy

- Use second by second data on battery state of charge, location, charging, efficiency, temperature etc to construct:
  - Vehicle profiles to highlight the differences between BEVs and PHEVs of varying size
  - Household fleet profiles in miles per year by vehicle
  - Trip profiles on distance and energy use
  - Charging profiles to see the difference that charging makes in travel choices

Approach/Strategy

- Electric Miles Variation Has Multiple Explanations. Defining What Matters and to What Extent Determines What is Possible With Policy

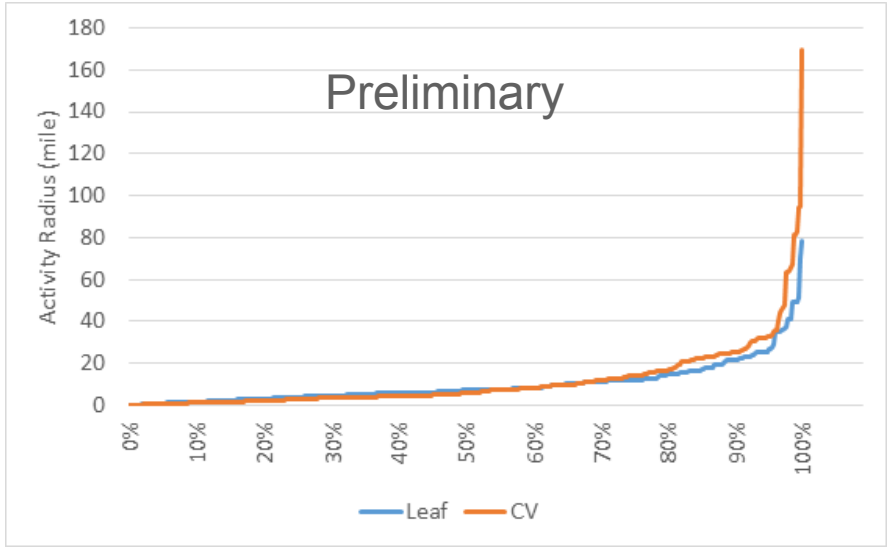


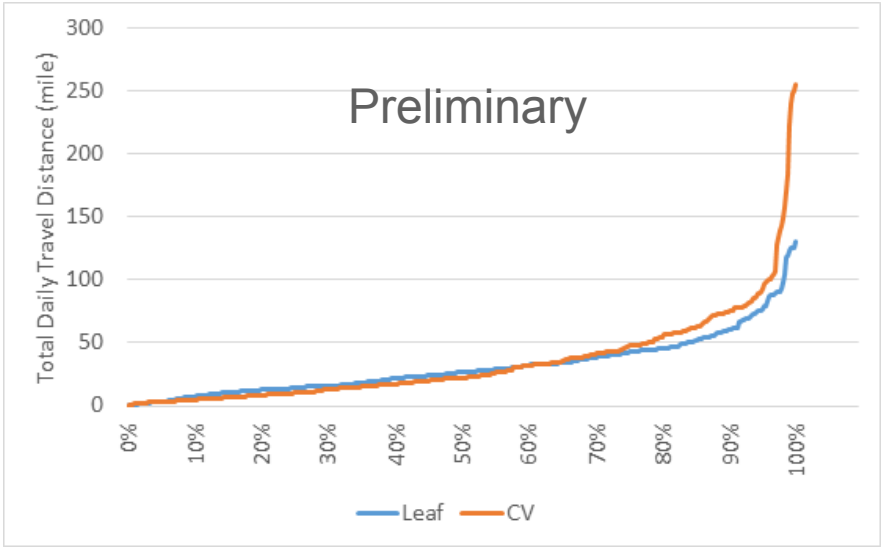
Technical Accomplishments and Progress

- Preparatory analysis begun with 78 1-week Caltrans Travel Survey GPS households. Leaf HH subsample vs ICE HH.
- Helping prepare for 1-year ARB project data.
- Data collected from ARB project will be more complete than Caltrans GPS data
  - 1 year time period to investigate infrequent trips and seasonality
  - SOC information included to investigate the role of battery size in travel behavior, range buffers, cold weather, etc
  - Charging location and frequency information included to investigate the role of infrastructure in travel behavior and eVMT
  - 4-6 models instead of just one. PHEV and BEVs are included
  - Complete survey data will be linked to data collection to explain the why behind travel and charging behavior

Technical Accomplishments and Progress

- Maximum Leaf activity radius is 81 miles. 90% are < 25 mi
  - Relevance: People may not stray far from home in a BEV. How does this limit a BEV's usefulness? Will we see exceptions in 1-year data?
- Maximum Leaf total daily miles is 125. 90% are < 60 mi. Half of the Leaf HH drove their Leaf more then their ICE
  - Relevance: HH have many idle ICE vehicles. 60% of HH drive the Leaf more miles than their ICEs. Leaf is preferred but limited in range





Technical Accomplishments and Progress

Travel differences Leaf vs. ICEs within HH

- Average distance is about equal between EV and **all** HH ICEs on weekdays. (some idle ICEs)
- Average distance on weekends is lower in Leaf
- Median distance is higher with EV on weekdays

	ALL ICE VEHICLES		LEAF	
WEEKDAY	Weekday	Weekend	Weekday	Weekend
MAX NO. TOUR	14	5	7	7
AVG. NO. TOUR	1.73	1.43	1.67	1.71
MEDIAN NO. TOUR	1	1	1	1
MAX. TRAVEL TIME (MIN)	289.75	256.55	229.11	166.39
AVG. TRAVEL TIME (MIN)	65.18	55.45	69.24	49.71
MEDIAN TRAVEL TIME (MIN)	52.62	37.00	61.77	40.13
MAX. DAILY DISTANCE (MILE)	254.98	183.92	130.93	107.92
AVG. DAILY DISTANCE (MILE)	35.45	32.22	34.24	23.52
MEDIAN DISTANCE (MILE)	24.19	16.64	28.65	16.15
MAX. SPEED (MPH)	93.50	89.50	87.60	88.40
AVG. SPEED (MPH)	32.63	34.87	29.67	28.39
WEIGHTED AVG. SPEED (MPH)	28.75	29.88	28.59	25.37
MAX. NO. STOP	17	16	21	19
AVG. NO. STOP	4.00	3.99	3.81	3.91
MEDIAN NO. STOP	3	3	3	3
N	313	90	323	116

Preliminary

Travel differences Leaf HH vs. non-Leaf HH (ICE and Leaf vs ICE and 2nd ICE)

- ICE HH use main ICE intensively
- Leaf HH is used more than the second ICE in an "ICE-only household (shift travel?)

	LEAF HH		No LEAF HH	
	Most Used ICE VEHICLE	LEAF	Most Used ICE VEHICLE	Second Most Used ICE VEHICLE
AVG. DAILY TRAVEL TIME (MIN)	72.03	63.09	85.43	52.22
MAX. DAILY TRAVEL TIME (MIN)	289.75	229.11	789.39	535.24
AVG. TRAVEL TIME PER TOUR (MIN)	56.42	44.50	62.29	37.04
MAX. TRAVEL TIME PER TOUR (MIN)	280.98	193.23	789.24	535.24
AVG. DAILY TRAVEL DISTANCE (MILE)	42.65	31.12	51.40	25.88
MAX. DAILY TRAVEL DISTANCE (MILE)	254.98	130.93	851.64	342.10
AVG. TRAVEL DISTANCE PER TOUR (MILE)	35.13	22.82	38.89	18.75
MAX. TRAVEL DISTANCE PER TOUR (MILE)	250.13	130.78	851.55	342.10
AVG. SPEED (MPH)	33.83	29.52	35.80	29.76
WEIGHTED AVG. SPEED (MPH)	30.72	27.77	31.81	26.93
MAX. SPEED (MPH)	93.50	88.40	103.90	108.00
N	78	78	699	699

Preliminary

Technical Accomplishments and Progress

- How much travel could be shifted to the Leaf within the household?
- Scenarios examine when Leaf is idle and could be driven instead
  - Relevance: Leaf is driven fewer miles per day, but same total distance (on all days and all vehicles) as ICE vehicles. = ICEs sit in the garage and are used for longer distance trips.
  - Much travel is shifted, but 20% more travel could theoretically be shifted to the Leaf

	Avg. Travel Distance (Mile)		Total Travel Distance (Mile)	
	LEAF	ICE VEHICLE	LEAF	ICE VEHICLE
ORIGINAL	31.84	39.99	13788.61	13995.81
CASE 1	37.34	39.25	16166.96	11617.45
CASE 2	34.55	36.65	14958.15	12826.26
CASE 3	39.60	35.94	17145.03	10639.38
CASE 4	39.68	35.81	17183.34	10601.07

Preliminary

Collaboration and Coordination with Other Institutions

- This project uses data collected for the California Air Resources Board
  - ARB will be using these results of this study to review policy and goals
- Some expansion in vehicle types (Tesla, i3 Rex) may be possible with California Energy Commission funding.
  - More emphasis on energy profiles
  - Increase in sample size
- Currently coordinating with NREL, ORNL, Argonne and others to make cleaned data on focus households available for modelers
  - In-use data and summary results can be used to refine assumptions in models

Remaining Challenges and Barriers

- Data collection and data cleaning remain a looming challenge
  - Survey has been deployed to 37,000 owners.
  - Now working on automatic data cleaning. Enterprise data storage and filtering software is being implemented.
  - Data collection is progressing with test households. Successful data has been collected for all models.
- Preserving privacy per University regulations while providing useful data is a careful balance
  - Some data will be provided in second by second format
  - Some data will have to be pre-aggregated

Proposed Future Work

- Rest of FY15
  - Begin Year 1 data collection
  - Provide interim results
- FY16
  - Finish Year 1 data collection
  - Start Year 2 data collection
  - Provide final results

Summary Slide

- PEVs are a new and fast growing segment of the market. They are used in unanticipated ways and understanding these dynamics is important to planning for/modeling the future.
- Modelers and policy makers need better data to make decisions.
- Data from all vehicles in the household allows a more complete picture of true eVMT, not just what's available by studying only the PEVs. E.g. How much are the other cars driven in the household?