DRIVE THE FUTURE:

BATTERY ELECTRIC VEHICLE PROJECT

South Bay Cities Council of Governments

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Table of Contents

Table of Figures

Tables

1. Introduction

This is the Final Report for the demonstration of full speed Battery Electric Vehicles (BEVs) in the South Bay Sub-Region of Los Angeles County. The project was sponsored by the South Bay Cities Council of Governments (SBCCOG) and funded by the South Coast Air Quality Management District (AQMD). It has been branded as the *Drive the Future* project.

This demonstration complements the previous SBCCOG/AQMD demonstration of slow speed vehicles (in the form of neighborhood electrics). The two projects together form a unique experiment of real world, on-the-road driving with the most environmentally beneficial vehicle technologies available. These projects will contribute to market acceleration strategies because the participants were chosen to represent the general population, rather than Electric Vehicle (EV) advocates or "early adopters."

Commonly Used Acronyms
EV: Electric Vehicles
BEV: Battery Electric Vehicles (full battery and long range)
NEV: Neighborhood Electric Vehicles (shorter battery range and slow speed)
ZEV: Zero Emission Vehicle (includes, BEV, NEV and Fuel Cell vehicles)
PHEV: Plug-in Electric Vehicles

Purpose

The primary purpose of this demonstration is to learn what policies and initiatives, especially at the local level, can accelerate the private market for battery electric vehicles (BEVs) in the South Bay sub-region of Los Angeles County and similar regions elsewhere in California. The imperative to advance BEV deployment is based on several factors, including the urgent need to:

- Improve air quality: Meeting the federal health-based ambient air quality standards for ozone (smog) by 2023 and 2031 as well as the fine particulate matter (PM2.5) air quality standards. ARB staff estimates meeting the 2031 ozone standard will require oxides of nitrogen (NOx) emission reductions of up to 90 percent compared to 2010 levels.
- Achieve State of California carbon reduction targets: AB 32 and subsequent Executive Orders issued by Governor Brown ask local jurisdictions to voluntarily reduce GHG emissions to 1990's levels by 2020, 40% below 1990 carbon levels by 2030 and 80% below 1990 levels by 2050. The transportation sector generates between 40% and 60% of local carbon emissions, depending on the city.
- Comply with State of California carbon reduction targets through land use-transportation coordination: SB 375 requires Metropolitan Planning Organizations (MPOs) to develop a Sustainable Communities Strategy (SCS) every 4 years as part of the Regional Transportation Plan. The SCS must show how carbon emissions will be reduced from automobiles and light trucks by 8% of 2005 levels by 2020 and 13% of 2005 levels by 2035.
- Support the State of California's ZEV Action Plan (updated in April, 2015): Accelerate the market of zero-emission vehicles in order to reach 1.5 million ZEVs on the road by 2025.

- Protect residents from oil market instability and escalating gasoline prices: South Bay residents pay about $1 billion annually when gas is priced at $4/gal. An increase to $6 or $8, would cause hardships for many households and damage every other sector of the regional economy.

All of these factors are consistent with the national and global efforts to pursue a low carbon future for the planet. Electrification of the transportation sector is an essential component of that future. Burning fossil fuels as the basis for ground mobility is not sustainable.

South Bay Context

The South Bay is a mature, built-out, auto-dependent suburban area, much like many other places in Southern California. Despite having pockets of residential density among the highest in Los Angeles County, the South Bay sub-region is transit-poor in terms of both bus services and rail infrastructure. If the South Bay was a single city, it would have the population of Portland, Oregon but with 50% more residential density and without Portland's transit infrastructure and dominant downtown.

The housing stock in the South Bay is about evenly split between single family and multi-unit dwellings. Much of the South Bay was built between the 1940s and the 1960s. Both of these facts are relevant to the BEV market because charging infrastructure and cost allocation in multi-unit dwellings are more complicated than in a single family home; and because older buildings will have less abundant electrical infrastructure than 21st Century housing.

The South Bay sub-region consists of 15 incorporated cities, unincorporated areas, and parts of the City of Los Angeles. There are 3 primary geographic districts (coastal, inland, and peninsula) where all of the 15 incorporated cities are located; and a 4th district consisting of areas of unincorporated County and City of Los Angeles.

Transit mode share in the South Bay for the work commute trip is 5.5% (vs the County average of 7.4%) and less for non-commute trips. Bus service is not very frequent and there is minimal rail infrastructure with only incremental expansion planned over the next 20 years.

Sustainable South Bay Strategy

The dominant state and regional policy strategy for reducing greenhouse gas (GHG) emissions is a land use strategy– by adding residential and mixed-use density along the major arterials that serve as transit corridors -- will not likely be effective in the South Bay. Nor would it be politically feasible.

Recognizing the potential conflict between State policy and South Bay conditions, the SBCCOG initiated a research program in 2004 that was designed to identify a land use and transportation strategy that would reduce GHG emissions, criteria pollutants and gasoline consumption without relying on large investments in public transit and increases in residential density.

The research program focused on the interaction between the built environment, destination locations, household travel patterns and household mode choice in 8 neighborhoods (4 with centers and 4 along commercial corridors). The key findings included:

- All neighborhoods are some form of horizontal mixed use
- Trip lengths are very short for most households
- Mode choices were either driving or walking
- Commercial areas that attracted the most visitations from adjacent neighborhood were compact with more businesses per acre.

The findings suggested that relatively short range zero emission vehicles (ZEVs) could satisfy a high percentage of mobility needs. Demonstration projects of two range-limited zero emission vehicles, first NEVs (neighborhood electric vehicles) and now BEVs, were conducted in order to validate or disprove, through deployment and use, that such vehicles could be a good fit in the South Bay. The NEV project demonstrated that 25 MPH, 25 mile range vehicles fit the South Bay travel patterns and help residents satisfy local needs while achieving substantial carbon reductions. This report extends the analysis to the full speed, longer range BEVs.

The NEV demonstration findings along with the results of complementary projects became the basis for an integrated transportation – land use strategy referred to as the Sustainable South Bay Strategy (SSBS).

The Board of Directors of the SBCCOG adopted the SSBS in October, 2010 as the basis for:

- The sub-region's contribution to the regional Sustainable Communities Strategy
- The land use and transportation chapters of a sub-regional Climate Action Plan, and
- As a guide to land use planning and transportation policy for cities interested in becoming more sustainable.

SSBS Summary

With no changes in the development pattern, the South Bay can dramatically reduce its carbon footprint when households drive zero emission personal vehicles that match their actual mobility needs. Our findings in the eight- neighborhood study and confirmed by the NEV Demonstration were recently re-confirmed by the Baseline Conditions Report in Metro's South Bay Mobility Matrix produced by Cambridge Systematics in 2015. Most trips in the South Bay are too long to walk, too short for public transit, and perfect for limited range ZEVs.

There are two transportation strategies in the SSBS – converting the existing fleet of internal combustion engine (ICE) vehicles to some form of electric; and reducing the number of vehicles per household through the growth of the mobility services market.

The fuel mix of new vehicles is primarily a function of the private market, especially consumer decisions. Local governments have some influence through infrastructure investments, regulations that affect the

electrical infrastructure in commercial and residential building renovations, administrative processes, and public information/education.

The promise of the mobility services market is that, over time, the need for privately owned vehicles will decline. The growth of the market for these new services is somewhat speculative at this time because government regulations are unsettled. Assuming that unsurmountable barriers do not appear, ride share, car share, bike share, van pools, and demand-responsive short haul transit should help reduce the number of vehicles needed by a household. To have an environmental impact, these new services will need to be cleaner than the private vehicles that they displace.

The land use strategy in the SSBS consists of consolidating destinations so they are optimized for walking and short range vehicles. Currently, destinations are unevenly distributed consistent with cheap and plentiful automobility.

The "centers" strategy will retrofit the many post-war suburban housing tracts with a functionally robust compact commercial center within half mile of every residence. This is complemented by converting the over-built and underperforming commercial corridors into housing at the lowest density possible within the prevailing real estate market.

Conceptually, each center will be a compact, mixed commercial development located on the corners of major intersections. The centers would serve the commercial and service needs of the adjacent residents and of the neighborhoods within a couple of miles. This could include day care, pharmacy, grocery store, shared meeting space, coffee shop, bakery, dentist, shoe repair, shared work center, and more.

Centers can be *enhanced* through an innovative facility called an "Access Hub" that will coordinate the mobility services and provide access to technology, some of which will offer virtual access to other places (for example through distance education, tele-medicine, and e-government). The combination will attract a higher percentage of all trips taken by residents in that neighborhood, thereby reinforcing the value of the neighborhood center and helping to build a viable neighborhood economy.

The result of this retrofit will mean walking mode share should increase due to more destinations appearing within one-half mile from home. And the mode share of limited range vehicles should also increase as adjacent neighborhood centers come to include many more destinations within a few miles of every home.

Battery Electric Vehicle Demonstration Project

Battery electric vehicles (BEVs) are essentially a new product in the automobile marketplace. Unlike most private goods, there is a substantial public interest in consumer acceptance of BEVs. Failure to proliferate at a brisk pace will have several significant economic and environmental consequences.

The SBCCOG demonstrated that NEVs, a type of BEV specialized in hyper local trips, could produce significant economic and environmental benefits. Importantly, the project identified several factors key to increasing the deployment of NEVs

This demonstration was designed to find out the extent of the economic and environmental benefits that BEV use can produce, and the key factors to accelerating the market for them.

This report on the BEV Demonstration begins by reviewing how the study was conducted. The project is then placed in the context of previous attempts to understand the dynamics of BEV use. This is followed by an analysis of the transportation data that the project produced – volumes of use, destinations, charging, and economic-environmental benefits. The report closes with a quantitative assessment of the challenges to meeting the various economic and environmental goals and a set of recommendations to address those challenges.

2. Project Design and Operations

Overview

The "Drive the Future" study focused on the experiences of South Bay residents driving a zero-emission vehicle for a period of approximately two months. Participants in the study tested a vehicle from a family of zero-emission Plug-in Electric Vehicles (PEV) - vehicles powered solely by battery alone – Battery Electric Vehicle (BEV).

The BEV Demonstration Project was branded "Drive the Future" for marketing purposes and it used a version of the heart logo that had been previously developed for the NEV Demonstration (branded the LUV Project for local use vehicles).

The active BEV demonstration period ran for 24 months, between December, 2012 and December, 2014. The approach replicated the NEV Demonstration program. Applicants were screened using selection criteria and when chosen were loaned a BEV to drive as they wished for a two month period. GPS technology was used to establish household travel patterns before introduction of the BEV and after they received the BEV. The quantitative and qualitative results from both the GPS destination data, driver's logs, surveys as well as the experiences of the participants captured through focus groups form the basis of this report. The GPS provided a stream of data that included location, time, speed, and route. Miles driven, locations where stopped (destination area), dwell time, and in the case of the Leafs, charging behavior, are some of the performance variables collected. GPS data were supplemented by pre and post surveys (completed online before and after completing their BEV rotation) that asked for a list of frequent destinations as well as feelings, perceptions and market aspects regarding electric vehicles and charging.

Additionally, participants were asked to record logs for each trip; identify the exact destinations; where they parked; and the BEV charging information (where they charged, what type of charge and any other information that might be relevant i.e. how much they may have paid or if there were any specific issues). Lastly, participants were asked to attend a formal "end of study focus group" where they were "debriefed" (along with other participants in their study cohort) to learn about their experiences, observations and concerns following their time in the study.

Research Design: Vehicle Technology

BEV and ICE Vehicle GPS Monitoring

The initial fleet consisted of 2 leased Nissan Leafs, 1 leased Honda Fit and a BMW loaned to the project by the AQMD which had leased it. The AQMD replaced the BMW with another Honda Fit in May, 2013 when the AQMD's lease ran out.

A "Pre-Post" design was used for gathering GPS data. Every ICE vehicle in participating households was equipped with a GPS device two weeks before the BEV was placed. The purpose was to establish the "normal" driving pattern before adding the BEV. The monitoring of the Household ICE vehicles (via GPS)

continued for two weeks after the BEV placement in order to gain insight into the role of electric drive in a predominantly ICE household. Household members were free to choose any car in the household fleet for each trip purpose. Thus, with only a few exceptions, the BEV never fully (100%) replaced any one ICE vehicle in the study.

Sample Size

After 2 years, the total number of households with usable ICE GPS data was 46 and the total number of household with usable BEV data was 47. Two selected participants dropped out of the study after receiving their BEV. In one instance, the participant stated that he "was expecting a new car" and that he "did not like the way the car looked". In another instance, the participant was called away for a family emergency (across country) and, subsequently experienced a damaged vehicle that was later broken into (robbed). The household data collected from these two households was dropped from the study.

Data Collection: Challenges and Variations in Collecting ICE and BEV GPS Data

The collection of GPS data was facilitated through the hardware and software provided by FleetCarma and consisted of a logger with on-board software that plugged into the vehicle's On-board Diagnostic (OBD) port, a modem and an antenna – all linked together with cables. Information about the vehicles' travel (and, in some cases, engine emission information) was communicated through the car's OBD to the modem where it was relayed via cell phone technology to a web based portal for manipulation and reporting for the study. On the surface, the equipment and accompanying software appeared to be "plug and play" however over the course of the study it was discovered to be not quite that simple – especially for the ICE cars. Issues arose that both resulted in the loss of some data as well as the need to "clean" and account for data that was imprecise or skewed because of the technology.

There were three general types of issues that affected the collection of GPS data: faulty equipment; software issues; and, installation or participant damage. In terms of faulty equipment there were instances where the connection to the modem broke or was defective. These types of instances were rare and the loss of data was recognized after a period of time when the technology did not report as expected. Most breakage occurred in ICE vehicles and as each breakage was identified it was fixed. In almost all instances, equipment installed in the BEV cars functioned properly.

In terms of software, it was discovered that not all cars communicate the same. Software configurations for BEV vehicles were developed and worked without the need to reconfigure. In terms of ICE vehicles this was not the case. Rather, because of the age of the car, make or model of the vehicle, software needed to be customized so that the GPS technology would work as expected. Initially, this issue was identified through the collection of poor data – not being received or communicated via local cell phone technology; or, upon receiving the data it was lacking in some aspect. As these issues were identified software upgrades or "fixes" were applied and data was able to be collected as anticipated. Additionally, this issue changed the protocol for installing GPS units into ICE vehicles with time spent configuring the software prior to the installation of the units in the cars.

Lastly, in the case of some ICE vehicles, the data collection broke down as a result of equipment being either willfully or mistakenly unplugged from the car. Often the location of the OBD port is exposed and as a result the unit can be dislodged. In other instances, the cables (used to connect the various pieces of GPS system became loose or exposed through movement of legs and arms resulting in lost data.

Research Design: Participant Selection

The participants were drawn from two pools of applicants. The first group consisted of the residual applicants from the NEV demonstration project. There were over 250 people who remained on the NEV waiting list when the projected was completed; of these, a large percentage of former NEV drivers were interested in participating in the BEV project. Additionally, other applicants were found through direct advertisement via the South Bay Cities Council of Governments' (SBCCOG) on-line and public outreach events. These individuals "signed-up" via an on-line application found on the SBCCOG web site. Lastly, as the project unfolded, individuals applied from having seen the decaled BEV cars in their neighborhoods or around the South Bay. As in the NEV project, the vehicles themselves, with decals identifying them as part of the Drive the Future project, proved to be effective marketing tools.

Participant Recruitment

Over a two year period the BEV study sought to recruit a representative sample of households that lived in the South Bay. The characteristics of the study and the demographics of the region, however, did not allow for a completely "true" sampling of households (by any metric) within the South Bay. Rather, given the relatively small sample size, passive recruitment (self-selection) of applicants as well as the variation in both terrain and demographic characteristics of neighborhoods and households, the research team created a matrix of characteristics to select participants that was a "rough approximation" of the characteristics of households within the region. These characteristics included: geography, income, housing type and the available electrical wiring (within the home) as well as attempts to select participants from as many of the 15 South Bay Cities and other political areas that make up the South Bay sub-region.

Target Goals

Target goals were defined to select participants based on a combination of one or several of the following characteristics: geography, income, housing type and the available electrical wiring (within the home). The following chart describes the BEV study's recruitment targets by total households that participated in the study:

Table 1: Selection Criteria matrix for BEV Study (Goals vs Actual)

Criteria	Goal	Total Participants Selected	Target Goal +/-
Inland	17	14	-3
Beach	14	20	6
Peninsula	17	13	-4
Low Income (15-50k)	2	5	3
Middle income (50-150k)	30	31	1
High income (150k+)	16	12	-4
Single Family Home	24	29	5
Dwelling w/ Shared Walls - Apartment/Condominium	24	17	-7
110 only wiring	24	39	15
220 wiring available in parking area	24	10	-14
Former LUV participant	6	7	1

General Characteristics of Participants by Geography, Income and Housing Stock

The South Bay of Los Angeles County is a geographically unique area of the region. Three specific geographic areas were identified to be studied: Palos Verdes Peninsula, Beach Cities and Inland Cities. These geographic areas were selected because of their topographical as well as geo-political characteristics.

The Palos Verdes Peninsula is a hilly location that has a unique topography of neighborhoods that are, generally, more affluent and a terrain that can be rather steep. The 5 mile climb to neighborhoods at the top of the Peninsula was an important study aspect to examine range anxiety. Steep terrains deplete the battery more rapidly. Within the Peninsula, steep terrain was always the last part of a trip returning home. From a consumer perspective, this area is seen as a burgeoning market for electric cars due to the relative affluence of those that live on the Palos Verdes Peninsula.

The Beach Cities are defined as El Segundo, Manhattan Beach, Hermosa Beach and Redondo Beach. Each of the areas has a border on the water with topography that includes both hills and flat areas. These cities host a range of incomes from high (near the beach) to lower further inland as well as a mixture of housing stock that includes both single family homes, apartments and condominiums. Importantly, the Beach Cities are an area within the South Bay that (like the NEV study) presented opportunities to test the SBSS themes. That is, presence of a "downtown" or city center like Riviera Village or downtown Manhattan Beach as well as density of housing presented an opportunity to test

whether participants from this area stayed local – a condition that would allow comparison to the findings of NEV drivers who (similarly) were able to use an NEV for most of their daily trips.

In contrast to Beach Cities, Inland Cities (Inglewood, Hawthorne, Gardena, Lawndale, Carson, Torrance, Lomita) are less dense in terms of housing and they are geographically more flat. These areas have a mixture of housing stock as well as incomes. Having a selection of participants from the "Inland" cities would, it was thought, test travel choices (surface versus freeway); destination patterns and the viability or interest of those that lived in (relatively) less affluent communities.

Variations in Target Household Characteristic Goals

Participants were recruited from a pool of applicants. The result of this process was a pool of applicants that were skewed in numbers towards the Beach Cities, middle to higher incomes and those that lived in single-family homes. Attempts were made to select cohorts of households that had a broad cross-section of characteristics of geography, income and type of household. However, this was not always possible and categories within the study became a challenge to match.

For example, we set a target goal of 17 households who lived on the Palos Verdes Peninsula (PVP) however the total number of participants that took part in the study from PVP was 14. There were many PVP applicants with single family homes and fewer who lived in apartments or condominiums, which was another set target. The challenge became weighing housing type and geography.

Meeting housing type goals was also a challenge. Single family housing applicants were more abundant than those living in apartments and condominiums. Many denser housing structures did not have a place to plug-in and these applicants had to drop out.

Figure 1: Maps of Participants by Type of Residents

Red = Single Family Home
Blue = Dwelling with shared wall (Apartment/Condominium)

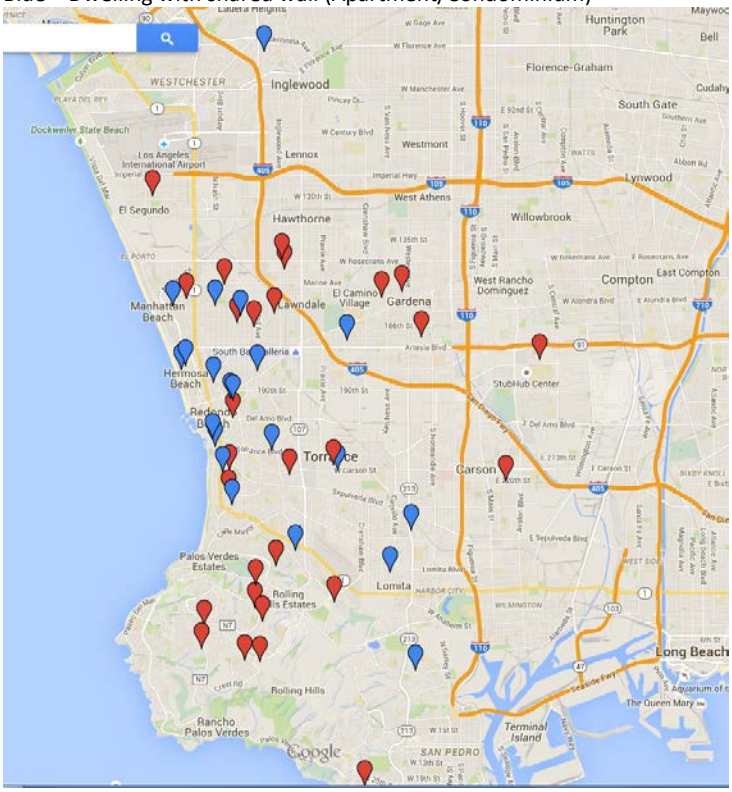


Figure 2: Maps of BEV Participants by Type of Residence and Topography

Red = Single Family Home
Blue = Dwelling with shared wall (Apartment/Condominium)

3. Previous Research

The literature review revealed that there has been no other electric vehicle demonstration study conducted that is similar to ours. Studies fall into several categories. Many studies have assessed consumer preferences and barriers to electric vehicle purchases. Others have looked at how electric vehicles are driven but they differ from Drive the Future in that they examine individuals who have purchased vehicles or 'first adopters,' and or analyzed data on an aggregate scale. Several pilot studies exist that test electric vehicles within municipal or corporate fleets. By loaning out vehicles to a variety of residents within the South Bay, Drive the Future is the first study to include drivers that more similarly reflect the wider purchasing market. It also analyzes data on a micro-scale or on-the-ground driving patterns such as routes taken, destinations accessed and in-depth charging behaviors.

Consumer preferences and barriers to purchase is an important aspect to consider as it can inform policy makers and manufacturers on steps to take to better place electric vehicles in the market. Egbue and Long 2012 conducted an on-line survey of prospective owners of EVs. Their sample of 481 individuals revealed that the cost and performance of vehicles such as battery technology and charging infrastructure are major challenges influencing the desire to purchase EVs even amongst the environmentally concerned (Egbue & Long, 2012). The authors mentioned that a media campaign could help promote EVs.

No studies were identified that extensively examined the travel behavior of EV drivers on a micro-scale. The largest EV demonstration to date, The EV project, run by ECOtotality North America focused on macro charging and driving patterns.

ECOtotality was awarded over $100M for the EV project from the United States Department of Energy in 2009.[1] Over the course of the project through 2013, ECOtotality deployed over 15,000 charging stations in 18 cities located in the states: Oregon, Washington, California, Arizona, Tennessee, Texas and the District of Columbia. Partners included Nissan North America and General Motors/Chevrolet. Existing EV drivers in these cities who qualified to participate were given a residential charger at no cost along with installation services. Idaho National Laboratory was contracted to perform the data analytics.

The EV Project collected and analyzed data to characterize vehicle use in diverse topographic and climatic conditions, evaluated the effectiveness of charge infrastructure, and conducted trials of various revenue systems for commercial and public charge infrastructures. In exchange for allowing the collection of vehicle and charge information, participants received a Blink wall mount charger at no cost, and in select locations, up to a $400 credit toward the installation. This information included data from both the vehicle and the EVSE, including energy used and time and duration of charger use.

For the duration of the project, a quarterly report on driving and charging statistics was produced. The last report was dated August 2013. Statistics for the reports were aggregated to protect the privacy of the drivers. The final aggregate statistics reveal that over 2.9 million gallons of gasoline were avoided by the project from around 8,300 drivers, 762 of them in Los Angeles. Other statistics included the number

[1] http://www.theevproject.com/

of public level 2 charging, number of quick charges, percentage of home and away-from-home charging, distance driven, number of trips, average trip distance, and average distance between charging events for the entire study area and for the different urban areas. It should be noted that the drivers for the EV project represented a segment of the population that was willing, able and enthusiastic about driving EVs as they had already purchased their vehicles. Therefore, the study only highlights first adopters.

The demonstration project by ECOtotality is the largest US study to date. Other demonstration studies have mainly been conducted through municipalities and universities in partnership with auto dealers. Cities and universities provide good test beds for EVs as they can be incorporated into the existing fleets and universities provide a bounded neighborhood setting. Demonstration examples from 2010 include a joint project with Energy Systems Network (ESN) and Indianapolis to deploy 50-100 plug-ins within city state and corporate fleets; a small fleet demonstration partnership with Honda Fit EV and Accord plug-in hybrid along with Stanford, Google and the city of Torrance; and the USPS electric vehicle conversion project (NWV Markey Discovery, 2011).

A final study worth mentioning is the UC Davis MINI E Consumer Study. This study tracked the experiences of 120 private households in greater Los Angeles and New York/New Jersey that leased full electric conversion MINI Es during the study period of June 2009 to June 2010. A total of 450 private households and public fleets participated in the MINI E demonstration in the US including the e SBCCOG as one of the participants. It should be noted that electric or not, the Mini is a 'fun' vehicle.[2] Study findings revealed that all drivers found the car fun to drive and practical for daily use meeting 90% of daily needs. Most of the drivers drove less than 40 miles a day and found home charging easy to use. 71% of drivers said they were more likely to purchase a BEV that they were a year ago while only 9% said they are less likely.

Tom Turrentine, UC Davis Plug-in Hybrid & Electric Vehicle Research Center Director, said, in personal correspondence, that the study highlights three new and potentially significant ways that drivers value BEVs. First, the MINI E meets drivers' desire for a vehicle that is both environmentally friendly and fun to drive. Drivers loved the vehicle's quick acceleration and quiet operation. Second, limitations of range and longer recharge times may be outweighed by a whole new set of activities and benefits discovered through their lifestyle exploration. Third, drivers like to develop their clean driving territory. Drivers start talking about the MINI E as a special way to explore their region. They of course can go anywhere in their gas car, but they like to talk about where they can go in their MINI E.

While range is often held up as limitation of BEVs, the MINI E's range of around 100 miles was acceptable to most drivers most at that time. The often referred to term of "range anxiety" was not a primary issue for MINI E drivers who became experts on the capabilities of their vehicles during their lease. The exception was very cold weather on the East Coast in winter 2010, which demanded extra energy for heating.

[2] http://phev.ucdavis.edu/project/uc-davis-mini-e-consumer-study/

4. Transportation Analysis

Will full speed electric vehicles with an 80 mile range fit the driving patterns of South Bay households? There were good reasons to believe that they would. The initial SBCCOG research on the eight neighborhoods, the NEV Demonstration, and the Baseline Condition Report produced for LA Metro by Cambridge Systematics as part of the South Bay Mobility Matrix all found that our trips are relatively short. Most trips in the South Bay are less than 3 miles. The longest trips are generally no further than downtown Los Angeles, about 20 to 25 miles away.

When "interpreting" the results of the BEV Demonstration, it's important to remember that even in 2015 we are still in the pioneer days of electric drive. The charging infrastructure is not developed – in residences, employer parking lots or in public areas. The options of car sharing and ride sharing have been advancing quickly but have not yet affected the driving culture to the extent that drivers are comfortable with their access as an alternative if their range-limited vehicle is not appropriate to a particular trip.

In other words, the driver reactions in this demonstration provide insights into the "pioneer experience" of driving an electric vehicle and this experience should continually evolve as the infrastructure and other contextual elements improve.

The questions we were able to answer include: How much are BEVs used? What are they used for? What factors impact the household use of BEVs?

Baseline Household Driving

The data on BEV use should be interpreted within the broader context of household driving behavior by the participants. And that pattern is relatively "un-patterned."

Over the two-week period before the BEV placement, participating households averaged 43.4 miles driven per day in a gasoline fueled vehicle (see table below). The daily driving ranged from a low of 7 miles to a high of almost 103.

This variation in household driving could be related to a number of factors including the number of drivers in the household, age of driver, number of vehicles available to the drivers, number employed, occupation of household members, work site location, number attending school, school aged children and after school activities, physical health, and more.

Commonly Used Acronyms
EV: Electric Vehicles
BEV: Battery Electric Vehicles (full battery and long range)
NEV: Neighborhood Electric Vehicles (shorter battery range and slow speed)
ZEV: Zero Emission Vehicle (opposed to EVs as EVs include hybrids)
PHEV: Plug-in Electric Vehicles

Many households included two generations of drivers. Age-related driving patterns were examined only in terms of over/under 55 because of the special interest in the mobility of seniors. Households where the primary driver was over 55 averaged 43.4 miles per day while those where the primary driver was

younger than 55 averaged 42.6 miles per day. No difference – at least in baseline ICE driving. This did not hold true for BEV driving.

Table 2: BEV Average VMT, Standard Deviations, Max and Min

	Average HH VMT		Average Vehicle VMT	
	Pre	Post	Pre	Post
Inland	44.64	24.20	23.83	13.50
Beach	45.50	30.65	23.10	15.82
PVP	37.74	19.05	26.28	12.21
Over 55	43.42	27.09	25.31	14.50
Under 55	42.60	25.56	23.53	14.39
Apt/Condo	34.61	23.28	20.92	14.09
House	50.72	28.93	27.03	14.80
Mean	43.40	26.30	24.19	14.47
SD	23.31	19.86	10.86	9.17
Mean +1SD	66.71	46.16	35.05	23.64
Mean -1SD	20.09	6.44	13.33	5.30
Max	102.84	91.40	51.42	45.70
Min	6.99	0.41	6.99	0.41

There was a slight difference in average miles driven per day depending on where the participant lived. Those in beach cities were almost identical to those in the inland cities (45.5 miles per day VS 44.6). The surprise was that the lowest average miles per day (37.7) were driven by participants from the PVP. The average, 15% lower than the beach cities total, was a surprise because the lower density development pattern of the PVP as well as its remoteness from job centers is usually associated with slightly longer trip lengths and more driving in general.

The baseline ICE vehicles for PVP households tended to cluster around the average. Only one household was outside one standard deviation. This is in contrast to the PVP households' BEV driving (discussed below).

Single family detached VS multi-family buildings including condos – did reflect a significant difference. Multi-unit households averaged 31% fewer miles than single family households with a difference of 51 miles per day VS 35. One possible explanation could be that multi-family buildings are often located closer to employment centers than single family tracts.

Household Driving with BEV in the Fleet

Was there an impact on average driving volume when a BEV is added to the household fleet? Not on average in our sample. Households averaged 43.4 miles per day during the monitoring period before

the BEV was introduced and 45.6 during the monitoring period with the BEV in the fleet (26.3 ICE, 19.3 electric)(see table above and below).

At this grain of analysis it appears that BEVs became a new option and their use simply substituted electric miles for gasoline miles. Average daily household driving might have declined or the proportion of electric miles might have increased had the project required participants to not drive one of the household's ICE vehicles during their two month trial. That condition would have resulted in greater reliance on the BEV, more realistically approximating a real life scenario of BEV acquisition. As it was, households had the "safety net" of their existing ICE vehicles for whenever the BEV trip looked too risky.

While on average the baseline household driving volumes were approximately the same as the driving volumes with a BEV added, there was considerable variation in how individual households reacted. Some households drove much more and some much less.

Household BEV Driving

The table below shows the basic BEV usage data. The clearest observation is that 39,420 electric miles were driven over the 18 month demonstration period. Assuming all of them replaced an ICE vehicle (averaging 24 MPG, slightly above the national average of 23.6), 1,640 gallons of gasoline were displaced. At an average cost of $4/gallon, this collectively saved participants $6,570 (minus the cost of the electricity, which is a relatively modest amount).

Table 3: ICE Pre Average VMT, Standard Deviations, Max and Min

	Average Daily VMT
PVP	25.53
Inland	37.25
Peninsula	17.24
Average over 55	15.34
Average under 55	21.30
Average House	19.81
Average Apt/Condo	19.17
Mean	19.52
Standard Deviation	10.53
Mean + 1SD	30.05
Mean - 1SD	9.00
Max	49.74
Min	2.95

The daily electric VMT averaged 19.3 miles per household with a wide range of 3 to 50. There were a total of 16 "extreme" cases – defined as those households whose average daily miles was 2 standard deviations from the mean. Ten were less and seven more. Of the seven that averaged more than two standard deviations above the mean (more than 30 miles per day), 4 were from the PVP, including the household with the single highest average, 2 were from Inland Cities, and one from the Beach Cities. Of the ten that averaged two standard deviations less (less than 9 miles per day), 6 were from the PVP, including the household with the single lowest average, 1 from a Beach City and 3 from Inland Cities.

It is difficult to conclude that location had a significant impact on BEV driving. Recapping the PVP as an example, there was a strong central tendency in the baseline driving pattern with all but one of the 10 households average daily VMT lying within 1 standard deviation of the mean. When driving a BEV, all 10 households were 2 standard deviations from the mean. Worse, 6 were low and 4 high, including the household with the highest daily average in the project.

The ranking by averages also changed when driving a BEV. Households from the Beach had the highest baseline daily average and the lowest BEV daily average. Inland households went from second but near the top of ICE baseline averages to having the most average BEV miles. PVP averages rose from being the lowest average driven in an ICE to second in BEV miles.

In contrast to the ICE baseline where there was no real difference in the over/under 55 age categories, there was a significant age difference when driving a BEV -- 21 miles per day for under 55 VS 15 miles per day for those over 55. This seems consistent with the stereotype that acceptance of new technologies declines with age.

There was essentially no difference in average daily BEV driving by housing type. This also was a change from the ICE baseline in which there were significantly more average daily miles by single than multi-family home dwellers.

Interpretation

While numbers are essential, they do not tell the entire story. A "profile" was developed to qualitatively describe each household's experience with a BEV. This section interprets the data through the lens of the profiles.

The BEV data are organized into 5 parts. The average VMT per day was 19.26 and three households were almost exactly on the mean, ranging from 19.3 to 19.8.

The second and third groups were those with a daily average VMT that was one standard deviation above the mean (13 households) and one standard deviation below the mean (14 households).

The fourth and fifth were "extreme" cases with averages within two standard deviations above (7 households) and below (10 households) the mean.

Low Extreme Households

Based on the numbers alone, it would appear on the surface that these 10 of 47 households (21%) did not find much use for the BEV. That was not entirely the case. For eight of the ten households, destinations were simply local resulting in relatively few miles driven per day.

In one example, BEV usage averaged 6.3 miles per day while ICE vehicles in the household together averaged a comparable 7.9 miles per day over the two weeks before the BEV placement.

In other words, most of the low usage volume is related to the actual low mobility needs of the drivers. In three cases the BEV was used for the journey to work where the work site was 3 miles or less from home. In fact, there was near universal endorsement of a BEV as a second local car for purely local trips.

However, there were other factors that could have contributed to the low usage volume.

The most significant other fact was the ICE vehicle "safety net." We are unable to verify the use of ICE vehicles when a BEV would have sufficed because the ICE monitoring lasted for only two weeks after the BEV was introduced to the household. However, when commenting on their BEV experience several households mentioned that they would not drive a BEV to such distant destinations as Palm Springs or Big Bear Lake. Even the Music Center in downtown LA would be considered risky by some.

Not all of those concerns are unfounded. BEVs have properties that work against their use for trips that require extensive freeway driving. Freeway speeds tend to drain the battery and reduce the range more than local streets. Freeways often are free-flowing which results in little braking meaning that the batteries are not re-generated as they would be during local driving.

Problems with home charging can also affect risk tolerance. Charging in single family homes does not receive the same level of concern as charging in multi-family buildings. Yet, two of our low extreme households, despite living in single family homes, had charging issues. In one case the Level 1 outlet in the garage was not grounded; in another there was no way to park the car near the existing outlet inside the garage. In that case, the only available outlet was outside in the driveway where the drivers were concerned that the exposed charging cable would invite theft. For that reason the household did not typically charge overnight.

Low volume drivers were more likely to find fault with the vehicle itself. For example, headlights don't automatically turn off, and in one case drained the auxiliary battery causing panic that the vehicle was dead.

Low volume users were generally less engaged with the vehicle's potential. They tended to not use the onboard amenities and seldom used public charging requiring a membership. They did use super convenient external charging like at Costco, worksites or dealerships. All are hassle free options except when the charging stations are occupied or out of service.

Using amenities like air conditioning, heater, radio, or lights also reduces the range. These would normally be used on longer trips. Skittish drivers would, for example, suffer the discomfort of heat rather than engage the air conditioning and risk reduced range.

Another barrier mentioned by this lower extreme group was that the gauge that displays remaining battery life often appears erratic. This causes uncertainty about the actual remaining range and therefore uncertainty about one's wellbeing. And, in some cases the cargo area was too small for an intended use.

Propensity to purchase a BEV is another dimension. Virtually every participating household was motivated by an interest in evaluating the technology for a future purchase. Many expressed concerns for the environment. Of the ten in the lower extreme group, only one expressed an interest in purchasing a BEV or a hybrid following the two-month trial.

In one case, parents had range concerns not shared by the daughter for whom the car was intended and, despite her preference for the BEV, her parents actually purchased an ICE vehicle for her to drive.

Most felt that a plug-in electric vehicle such as a hybrid would be a better fit because of the extended range capabilities – even though their predominant travel pattern was local and, in two person households, there was already access to an ICE vehicle for those regional trips when they come up. One household typically purchases only used vehicles with a $7,000 maximum regardless of fuel type.

Single person households have a difficult time committing to a range limited vehicle, although most BEV leases come with days of free rental car options for just those cases when extended range is necessary. Again, there is a hassle factor that most people want to avoid and the lack of publicity about these extended range options.

Security is very fragile for all participants but especially within this group. One incidence of severe anxiety will affect vehicle use and in two cases convinced the drivers that only a PHEV would make sense.

Average Use Households

Three families drove very close to the mean miles per day of 19.3. In all cases, they shared the same local destinations of the low extreme group with the exception that there was generally a little more distance in their commute to work, in one case almost 13 miles to Century City.

A closer look at their stories shows primarily a different attitude from those in the bottom group. This is manifested in two ways.

This group tended to not exclude the trips at or near the range limits whereas the lower group tended to just use an ICE vehicle when there was a risk of having to charge remotely. For example, regular trips to parents in Pasadena were handled by charging at the destination. In another case, the daughter was more adventurous and drove to Long Beach and Disneyland

And they "engaged" more with the vehicle and its characteristics. As a group they were more willing to plan their trips including charging options. They were more likely to use the onboard amenities. One household replaced their Level 1 service with Level 2.

High Extreme Households

This group of 7 households averaged between 30 and almost 50 electric miles per day. A primary difference in driving pattern was that the distance to work and work related travel was much greater. Round trip commutes were in the 30 to 40 mile per day range.

The second reason for the relatively high volume is that this group took those longer, more "risky" trips that tested the range or flat-out required a stop for charging where the other groups decided to take in an ICE vehicle. There are several examples of the primary driver setting out to boldly explore the range limits of the vehicle by driving to distant places where a charge would be needed to return – and sometimes without a plan for locating that charge, relying instead on chance and persistence.

This group actively used smart phone apps to locate public charging opportunities and membership in ChargePoint and other networks. They pursued free charging at places such as at Costco, downtown Manhattan Beach, or various sites in Hermosa Beach.

This group also reported letting the vehicle change their driving habits that carried over to ICE vehicles. For example, they drove more slowly on freeways in order to preserve energy or took surface streets to more destinations.

Like the other groups, a significant anxiety event can discourage continued driving. One household was on a path to become the highest volume user when a call came to pick up a child from school and the BEV was at the worksite in Orange County and not fully recharged. In this case another family member took care of the child but the experience meant that the BEV was thereafter reduced to the role of an adjunct vehicle used for local errands, much like with the lowest volume group. In the end, this family finished last in the high-use group.

VMT Reduction Possibility

Total VMT increased in 26 of the households after the BEV was introduced to the family. This makes intuitive sense in that it is a natural instinct to drive a new car to see what it's like, show it off and for some people, to test its limits. There are many examples of limit testing – in one case a PVP household drove all the way to Santa Monica Place in order to experience the vehicle's range limits and understand the ease or difficulty in charging remotely in a public place.

It is more difficult to understand why 21 households actually drove fewer miles after receiving the BEV. There are several possible reasons – the relatively few days of data collection from ICE vehicles distorts the average; a serendipitous event; or the possibility that the range limited vehicle influenced driver choices, inspiring the BEV driver to choose closer destinations or more trip chaining and car-pooling.

Serendipity is present in at least one of the cases. The household averaged 69 miles per day in two ICE vehicles. After the BEV, total household miles dropped to 40 miles per day – 27 electric and 13 ICE. One driver essentially replaced her ICE vehicle with the BEV and drove the same routes with the same frequency as before. The second household member changed her night school schedule around that

time and stopped driving every day to Long Beach from Torrance. That accounted for the drop of 30 miles per day in driving.

Another possible example of VMT reduction was the household that averaged 73 miles per day in ICE vehicles. This dropped to 27 miles per day after addition of the BEV which was driven 29 miles a day. The overall reduction of 18 miles per day by the household was accounted for by a change in driving pattern. Each adult had been driving their own SUV independent of one another running errands, dropping kids to after school activities and driving to work even though they worked in the same facility. The BEV and its zero gasoline costs inspired them to not drive both SUVs everywhere in order to double the savings. In order to save as much gasoline as possible, the family began to carefully plan their routes forsaking the independence that the two ICE vehicles provide. This family was not from a wealthy zip code so the dollar savings may have made the inconvenience worthwhile.

VMT reduction in some households because of vehicle range limits is not out of the realm of possibility. If increased freeway capacity can induce traffic; and if increased residential density can reduce VMT, perhaps local vehicles can reduce VMT as well. Finer grained GPS data would be necessary to evaluate that hypothesis.

Findings

The high, medium and low mileage groups all shared the practice of using the BEV for the myriad short trips that are common to the South Bay. It's fair to say every driver found utility in the BEV for local transportation.

However, multiple drivers and multiple vehicles in a household created a situation which is more complex than originally imagined. The distinction that we have commonly used in the Sustainable South Bay Strategies (SSBS) is that BEVs are perfect for use as the "second car" in a household. The model is that the first is a the long distance car, used for the commute to work, recreational travel, and generally for those infrequent trips to the outer reaches of the region or for inter-region travel. The second car is local travel such as shopping, dropping kids to school, entertainment, meals out, etc.

In the old days, Dad would have driven the primary vehicle and Mom the secondary. This household travel dynamic is as outdated as the gender roles.

Many households have two working adults, each with commute travel. In some cases, one or more of the jobs is very close to home. Both adults run local errands. Single-person households have no second car. In the end, there is lots of local travel, but it's not routinely assigned to one local car.

Sometimes there is a real "second car" and sometime two "first cars." This changes the "second car" category and complicates the value proposition. Drivers may well become disappointed when the new car cannot be used for the range of each person's travel needs. In other words, in some cases there are only mobility needs of individuals, not of the household. The household with the most electric miles

driven, more commonly engaged in the process of sharing the BEV on the basis of each day's travel demands.

The project produced a rich data base including routes, speeds, trip legs, dwell times, charging behavior, and destinations in terms of land use and specific businesses expressed as NAIC codes. This is a resource that can be used in other plans, projects and policies by the SBCCOG, SCAG, Metro and possibly others.

The age distinction we recorded was over or under 55 and applied only to the applicant or the primary driver, but not in households with multiple drivers, where there is usually a mix of ages. Anecdotally, in households with two driving-generations, the children were more willing to accept and even test the vehicle's limits than the parents.

There were two significant factors at play as the households moved from low to high. The first was distance to the work site and travel for work such as making off-site sales visits.

The second was the personality characteristics of the drivers.

The personality differences can be expressed by three terms that relate to individuals' acceptance of BEV technology, those that were: equivocators, engagers and those that embraced the vehicles. These descriptions are more like caricatures that don't fully capture the complexity between our drivers, but are a starting point for further discussion and research.

Equivocating – the households with the fewest electric miles driven were more tentative in their relationship with the vehicle. The majority of their trips were in fact local but there were other opportunities such as the occasional trip to the outer reaches of the region that they either avoided making or used an ICE vehicle to take. They typically did not fully inhabit the vehicles by using the onboard amenities like blue-tooth and GPS. None of them acquired charging network tap cards. Planning for charging away from home and to routes and destinations was too much of a hassle. There was little tolerance for hassles themselves and the fear of hassles. The threshold for anxiety was low and actual anxiety would turn one or more of the drivers in the household against the vehicle.

Engaging – the middle group saw the vehicle as more friendly than scary, more cooperative than challenging. They also avoided some of the high risk destinations but were more willing to plan and route so as to remain secure on longer trips.

Embracing – the top group fully embraced the strengths and weaknesses of driving electric. They were more adventuresome, even motivated at times to find the limits to the vehicle. They were more willing to plan. They adopted aspects of the electric culture by subscribing to charging networks, identifying public opportunities, changing their driving styles, and just flat out having fun driving their electric car.

There are real destination differences between high and low volume drivers. Beyond that you might say that at the high end, the drivers managed the vehicle and at the low end the vehicle managed the drivers.

What accounts for these differences is a mystery at this level of analysis. It is not purely residential location, profession, or housing type. Age could be a factor in so far as those under 55 drove about 25% more electric miles than those over 55. In terms of the qualitative information we collected, younger individuals tended to embrace the technology more than the older drivers. Again, we seem to be dealing with personalities.

Purchasing a $20,000 to $30,000 vehicle for limited or specialized use was not perceived as a good value proposition. In general, expectations were high for BEVs, perhaps in some small part because they appear as a "normal" car.

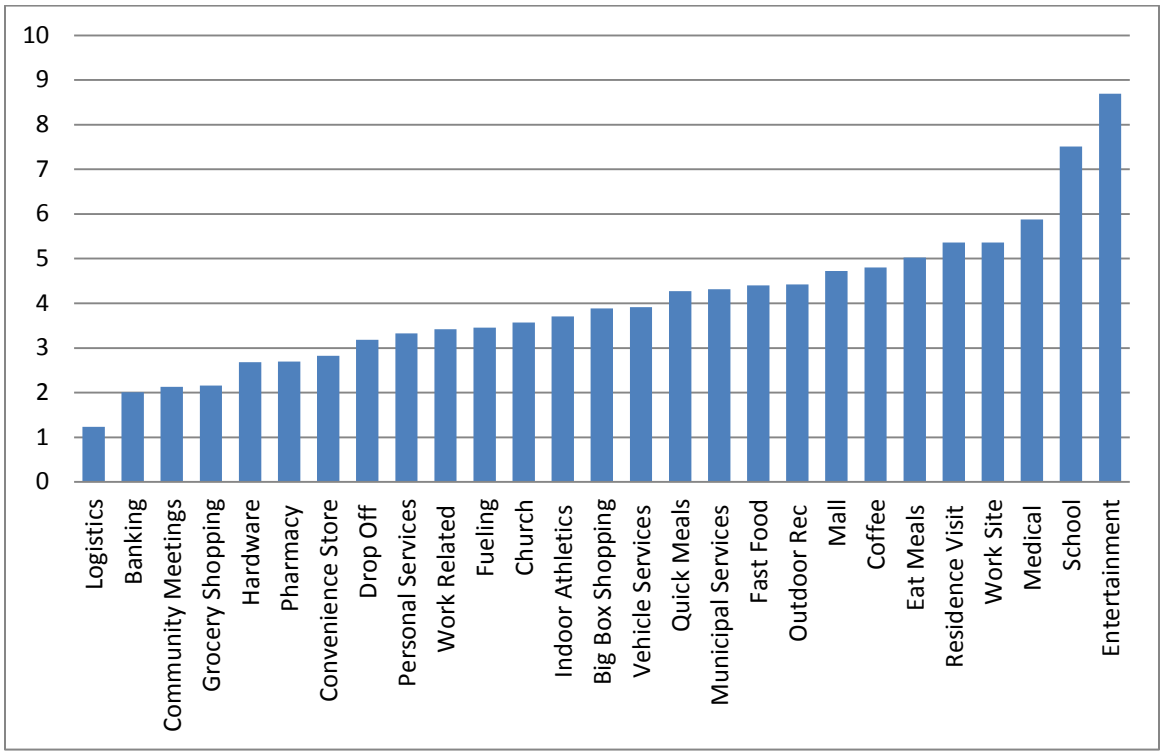
The environmental and economic benefits related to substituting BEVs for ICE vehicles are potentially substantial. See the Environmental Impacts Section for details.

Destinations

Distance to destination makes or breaks BEVs as a viable option for personal mobility. Sub-regions that are relatively compact make good markets for BEVs. The South Bay is built out with many horizontal mixed-use neighborhoods resulting in many destinations being within a few miles of most origins. BEVs should be a viable option for South Bay residents.

The following two graphs illustrate the destinations accessed in ICE vehicles before the BEV was introduced. The first shows the average distance to 27 destination types and the second shows the relative frequency of trips made to those same 27 destinations.

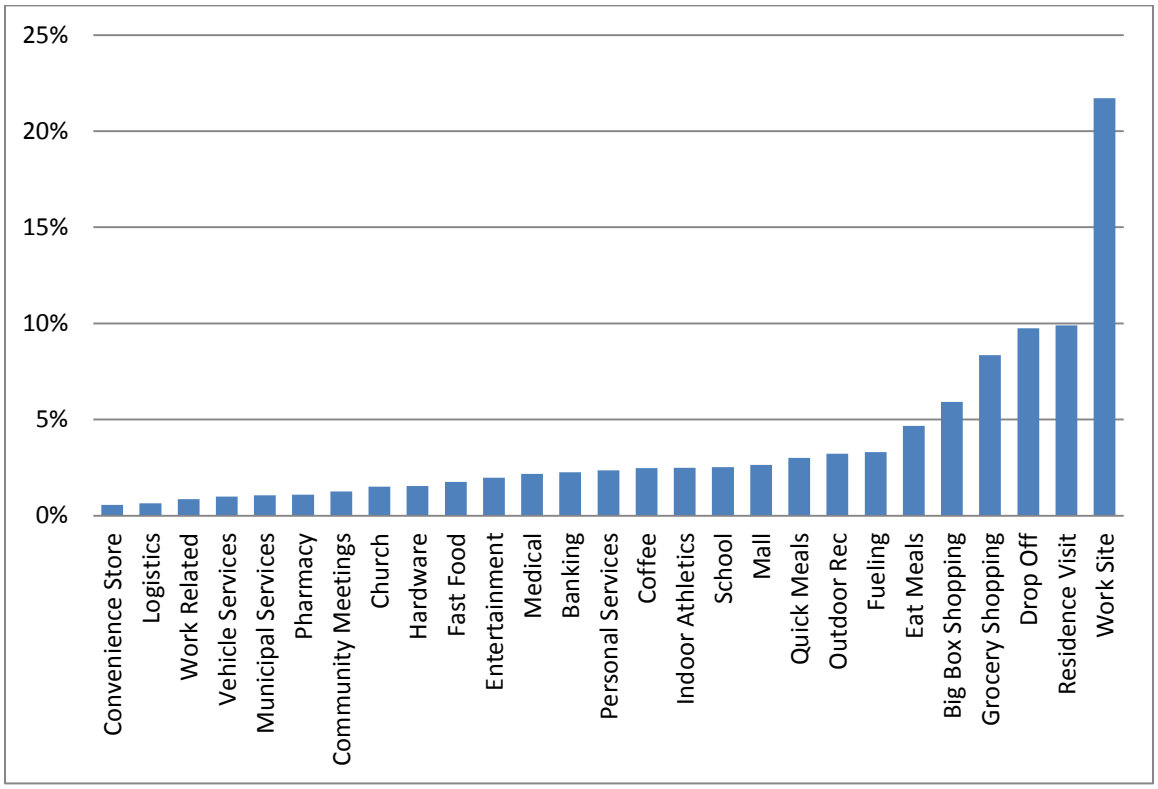
Figure 3: Pre ICE Destinations by Distance from Home



According to these data there were no destinations that averaged more than 9 miles from home. Entertainment destinations were the farthest from home followed closely by schools. Driving a relatively long distance to an entertainment venue makes intuitive sense. The neighborhood movie house has been eclipsed by large scale entertainment centers and regional attractions.

The Category 'School' did not include taking teenagers to junior high school (those trips are "drop-offs" and are frequent but short). Driving to a school occurred, for example, when attending a community college or taking night classes at a university. The journey to work is generally considered to be the longest trip a household takes. The average distance from home to work amongst our participants was only around 5 miles and was the fourth highest average.

Figure 4: ICE Pre Percent of Trips by Trip Destination



The journey to the work site was the most common destination, although it made up only a little more than 20% of all trips in the Baseline. This is consistent with various published estimates of the journey to work which range from 20% to 30% of all trips depending on the location. For example, the American Association of State Highway and Transportation Officials estimates roadway travel, commuting constitutes 28% of household vehicle miles of travel (AASHTO, 2015).

A target for converting ICE miles to electric miles would be those trips that are both relatively long and relatively frequent. Driving to the work site would be the best to convert since the commute is the most common and the 4th longest followed closely by residence visit (such as visiting family) which is the second most frequent trip with the 5th longest average. Going out to eat is the 5th most common and 6th

longest. For all the rest, destinations with relatively high frequency tend to be reached at relatively short distances, and vice versa.

The following two charts show the destination distance and frequency for BEV driving when it was added to the household. BEV usage was dominated by the journey to the work site with almost 25% of all trip destinations, a greater percentage than the approximately 21% of ICE vehicle destinations. The average distance to the work site was about the same regardless of fuel type, gasoline or electricity. This suggests that many ICE miles were converted to electric miles for the journey to work.

Residence visit was also a frequent destination when driving a BEV and similar to ICE driving in frequency and distance. The work site and residences visited (whether family or friends) are in both cases fixed locations. If that's where a driver is headed there is no choice to choose a closer option. The driver option would be to drive the ICE vehicle rather than the BEV. That the frequency and distance for the BEV are roughly equivalent to ICE patterns again suggests electric miles have substituted for ICE miles.

When driving to eat meals, the third target destination, the profile was similar to the ICE vehicle. In eating meals, BEVs were driven a little more often and to destinations a little less distant, on average. Since there tends to be a number of restaurant options for most households, drivers have apparently chosen closer options than they do when driving an ICE.

Figure 5: BEV Percent of Trips by Trip Destination

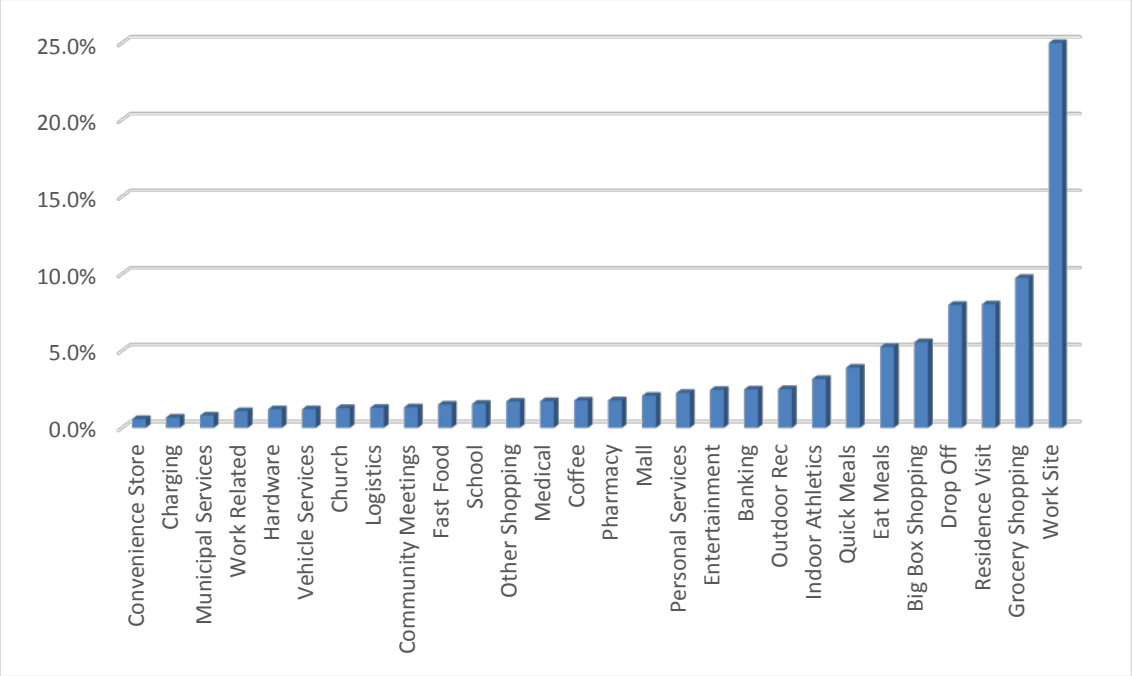
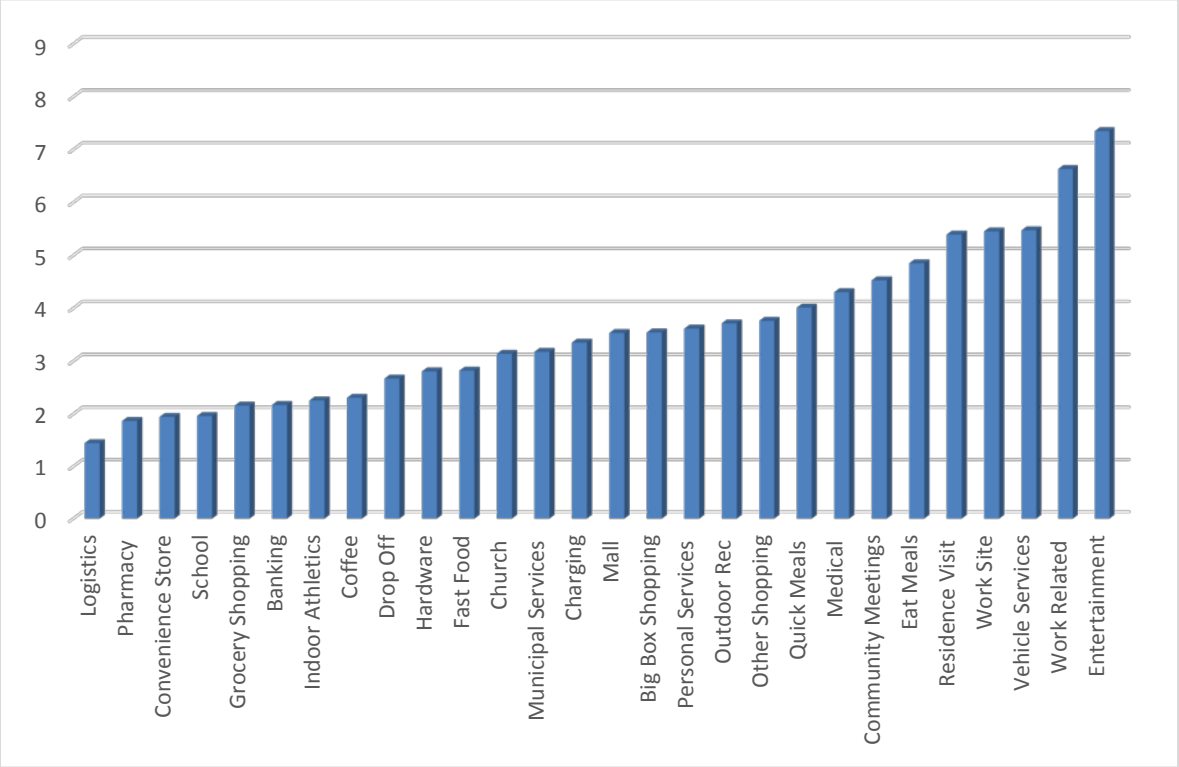


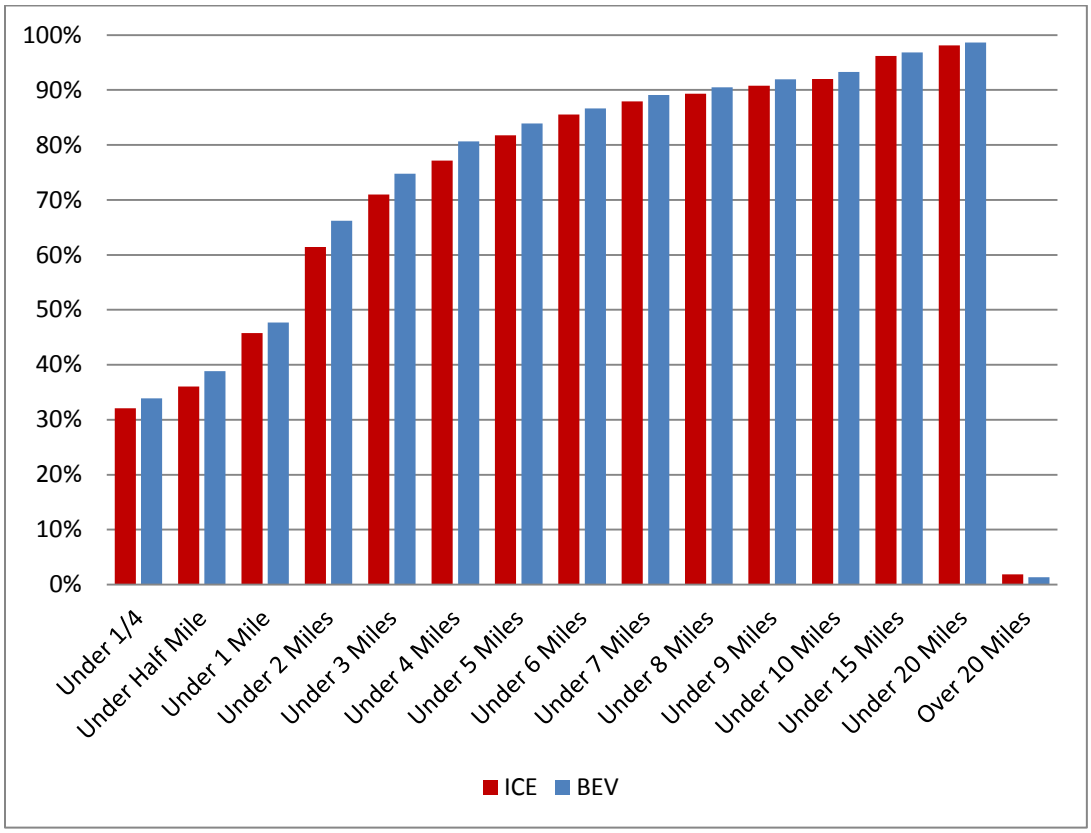
Figure 6: BEV Destinations by Distance from Home



The following graph shows that the BEV was driven to destinations that were almost exactly the same distance from home (DFH) in the same frequency as the ICE vehicles for the Baseline. In other words, the frequency pattern of destinations in terms of distance from home was almost identical between ICE and BEV. This is of course on average. There are likely many extremes just as in there are in the total VMT per day per household.

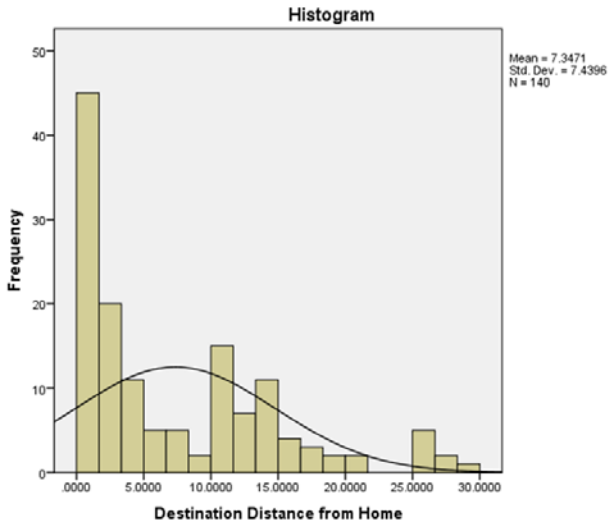
About 31% of the household ICE trips were to destinations ¼ mile or less from home versus 32% of the trips taken in the BEV. The biggest difference occurs on trips taken to destinations that were 3 miles or less from home which accounts for 71% of all ICE vehicle trips but 75% of all BEV trips. All but about 2% of ICE trips were to destinations less than 20 miles from home and for BEV trips it was 1%. In other words, the BEVs were driven in a very similar pattern to the ICE vehicles.

Figure 7: Distance Percentages for ICE Pre and BEV Trips (Distance from Home)

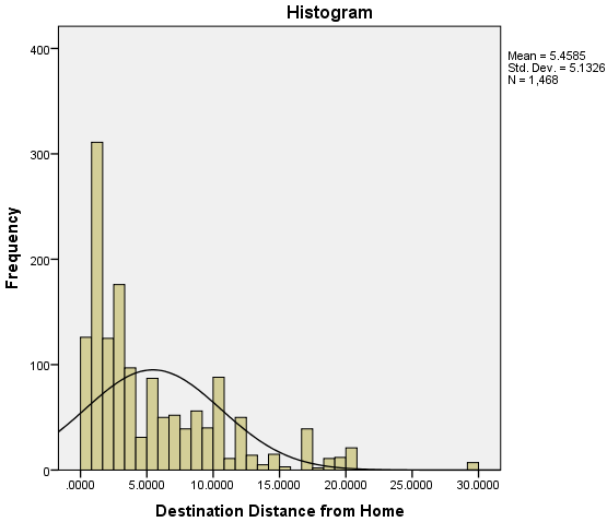


The following graphs show the distribution of trips to 4 of the 6 destinations that were farthest from home: Entertainment, Work Site, Residence Visit, and Eat Meals. In each category of destination, the bulk of the trips were made close to home skewing the distribution to the left. These distributions reveal interesting findings. Trips to entertainment produced the largest average distance from home. But the distribution reveals that around 46% of trips for entertainment were less than 3 miles. These same patterns are also apparent in the other destination categories. In each category of destination, the largest frequency of trips distances is relatively short. Thirty miles is about the furthest distance from home for those destinations with the largest frequencies.

Figure 8: Histogram Distance Distributions for Entertainment, Work Site, Residence, and Eat Meals

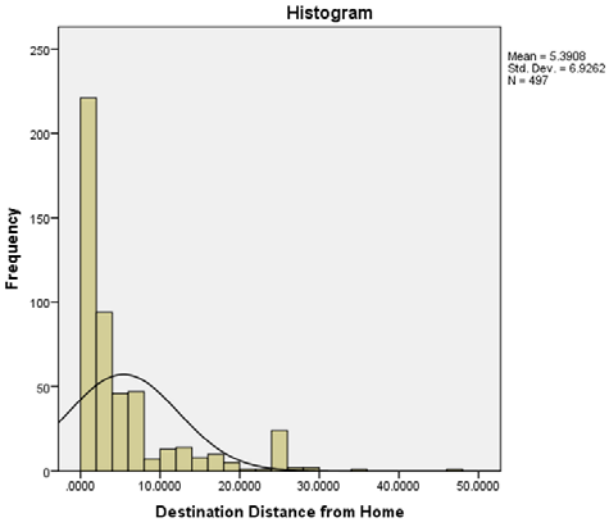


Entertainment

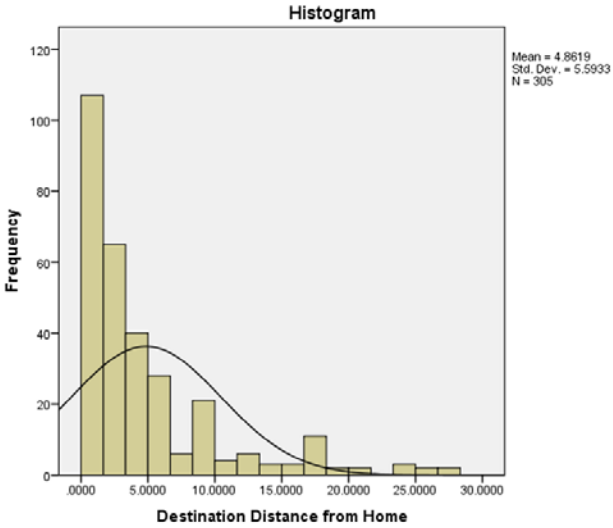


Work Site

Residence Visits



Eat Meals



Findings

The destination frequencies and distances for Baseline ICE driving and BEV driving are essentially identical. The distance to the work site is the same regardless of vehicle type – which is what would be expected – but the relative frequency of the trip was greater in the BEV.

Like with the VMT data, the destination analysis suggests that a BEV is completely substitutable for the ICE vehicles. The distances are well within BEV range, even the longest of them. The level of acceptance seems to return to the personality characteristics of the drivers.

Hot Spots

Introduction

"Hot spots" are clusters of destinations that are visited many times by several different households. Many visits from the same household do not constitute a hot spot.

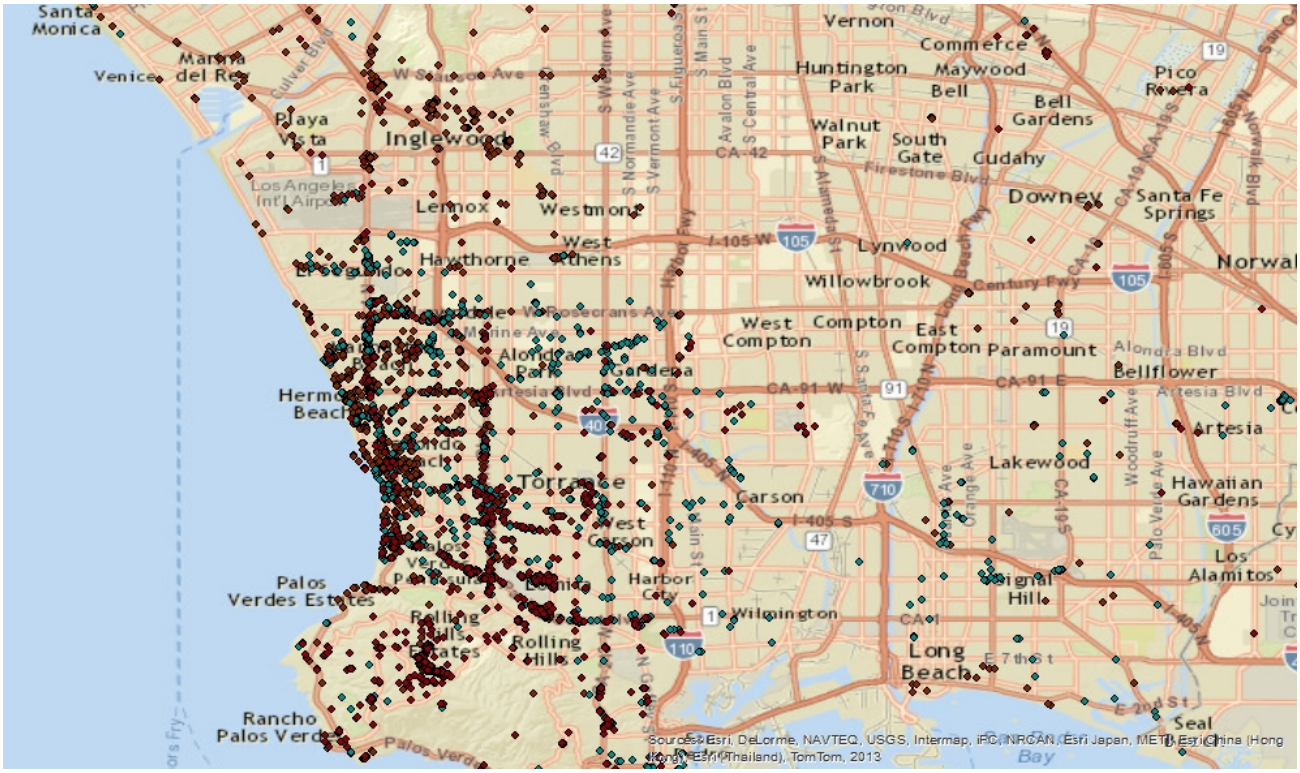
Hot spots are significant for two reasons:

- They are candidates for locating electric vehicle charging stations (EVCS)
- They provide clues about designing neighborhood centers that are part of the Land Use Strategy of the Sustainable South Bay Strategies (SSBS).

Concentration of demand by many vehicles may substitute for dwell time as a criterion for EVCS siting. The number, mix and density of BEV destinations that are the most "magnetic" can inform the development of future neighborhood centers.

The figure below shows all the stops made in a BEV by all participating households. Stops tend to follow major arterials and they are also clustered around some of the recognizable malls such as the Peninsula Center in Rolling Hills Estates or Del Amo Shopping Center in Torrance. While some BEV stops were made further inland in Downey, Lakewood and Long Beach, the sheer bulk of the BEV stops lie within the South Bay near to the driver's homes.

Figure 9: Stops by Beach, PVP and Inland Households



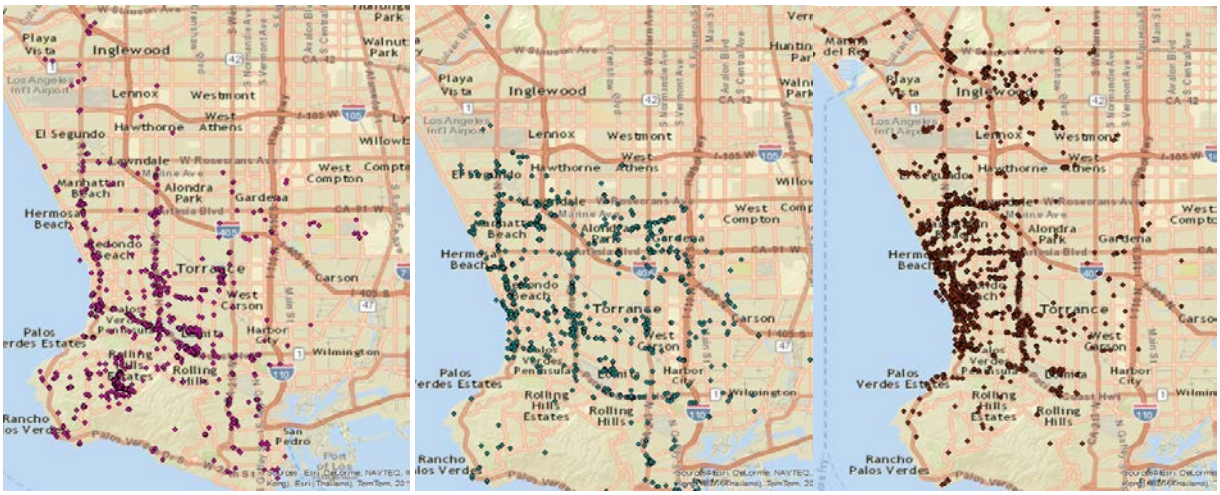
Methodology

Stops were first separated by the three areas Beach, Peninsula and Inland. This is because Peninsula stops are likely to be geographically separated from the other areas and Inland drivers may have different driving patterns than Beach drivers. The figure below shows three separate images for Peninsula, Inland and Beach stops. All three categories of drivers made similar stops around the major arterials in the South Bay. Peninsula drivers made more stops within the Peninsula and Beach drivers made more stops in general as there were more BEV drivers from this area.

Once the geographic areas were delineated, a "Hot Spot" analysis was performed using GIS software. Details of the statistical analysis are provided in the methodology section of the appendix. The analysis provided visual representation of geographic areas of ½ mile diameter where destinations were the most clustered.

Each Hot Spot is a circle with a ¼ mile radius around its center. The area is .2 of a square mile or about 128 acres. The destinations most frequented are distributed throughout each Hot Spot. There are some clusters within each Hot Spot but some destinations are just sprinkled around more or less isolated from the others. All are theoretically within walking distance of every other within the Hot Spot as the longest distances between any two destinations would be ½ mile.

Figure 10: Zoom Out of PVP, Inland and Beach Stops



Hot Spot Statistics

The following table presents the statistics of the highest performing clusters by area. There are 4 hot spot clusters for both Beach and Inland drivers, two hot spot clusters for Peninsula, Beach and Inland (referred to as PBI) drivers and 4 hot spot clusters for PVP drivers only.

Table 4: Top 10 Hot Spot Clusters

	Businesses		Destinations		Households
	Sum	Count	Sum	Count	Count
Beach and Inland 1	216	35	409	19	21
Beach and Inland 2	154	31	70	14	22
Beach and Inland 3	377	47	272	26	21
Beach and Inland 4	169	29	134	17	25
PBI 1	424	44	215	17	26
PBI 2	228	38	219	19	20
PVP 1	271	37	231	24	11
PVP 2	132	32	149	17	9
PVP 3	199	33	70	10	8
PVP 4	321	47	76	21	10

The table above lists total number of businesses and the count of distinct business types followed by the number of stops households made and the number of stop types. Finally it lists the number of total Households that visited the areas. For example Beach and Inland Hot Spot 1 has 216 businesses and 35 different business types, 409 stops were made by the households for 19 different stop types and 21

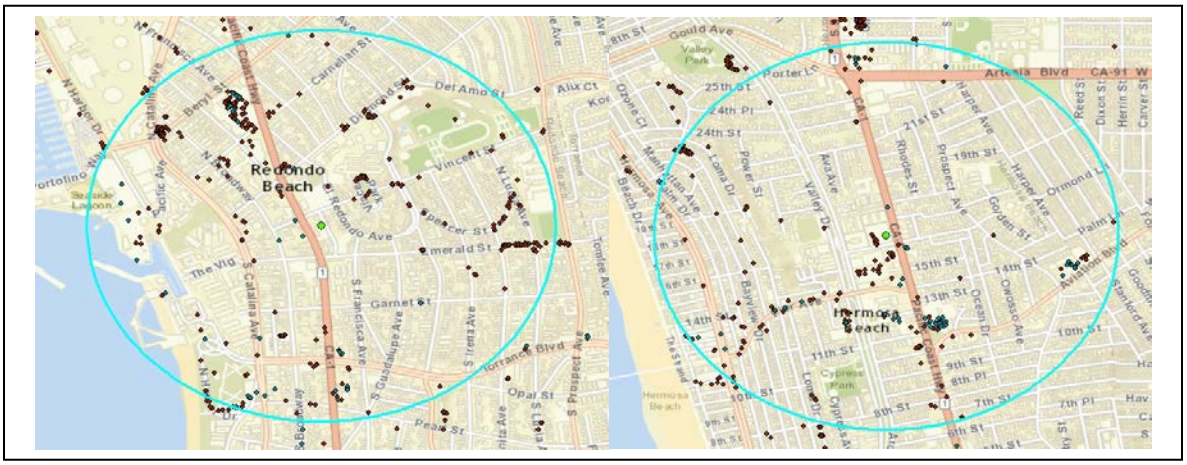
different Households visited this hot spot. The number of businesses within each hotspot range from 132 to 424 and the different types of businesses range from 29 types to 47. The number of stops made ranges from 70 to over 400 with a stop type ranging from 10 to 26. The number of different households ranges from 8 in the Peninsula Hot Spots to 26 in areas where all three household area types frequented.

The following goes into more detail surrounding each hot spot.

Table 5: Beach and Inland 1 and 2

	Sum	Count	Sum	Count	Count
Beach and Inland 1	216	35	409	19	21
Beach and Inland 2	154	31	70	14	22

Figure 11: Beach and Inland Hot Spots 1 and 2



The Beach and Inland 1 Hot Spot had the most number of stops within all the hotspots. 21 different families visited this site whose center is Emerald Street and PCH. This site is characterized by many schools, including two high schools, a middle school and a grade school. There is a Whole Foods in the area as well as pharmacies and restaurants and a UPS. Most of the visits to this site were to drop off students to school and residences with attached shopping trips. One of the drivers worked at Redondo Union High school and made adjacent trips to eat meals and get coffee.

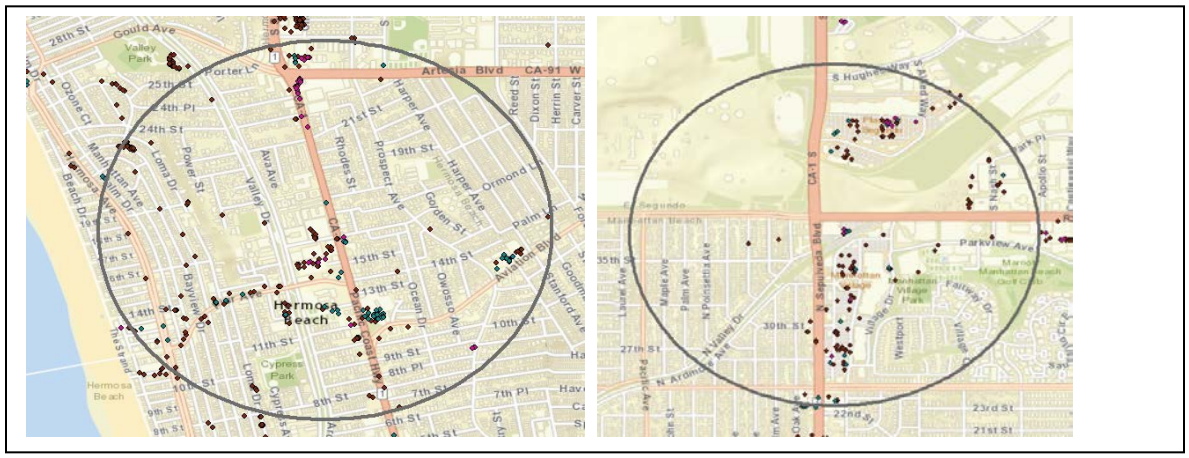
Beach and Inland Hot Spot 2 is characterized by the South Bay Galleria. 52 of the 70 stops here were made to the mall, grocery store and Big Box shopping.

Table 6: Beach and Inland 3 and 4

	Businesses		Destinations		Households
	Sum	Count	Sum	Count	Count
Beach and Inland 3	377	47	272	26	21

Beach and Inland	4	169	29	134	17	25

Figure 12: Beach and Inland Hot Spots 3 and 4



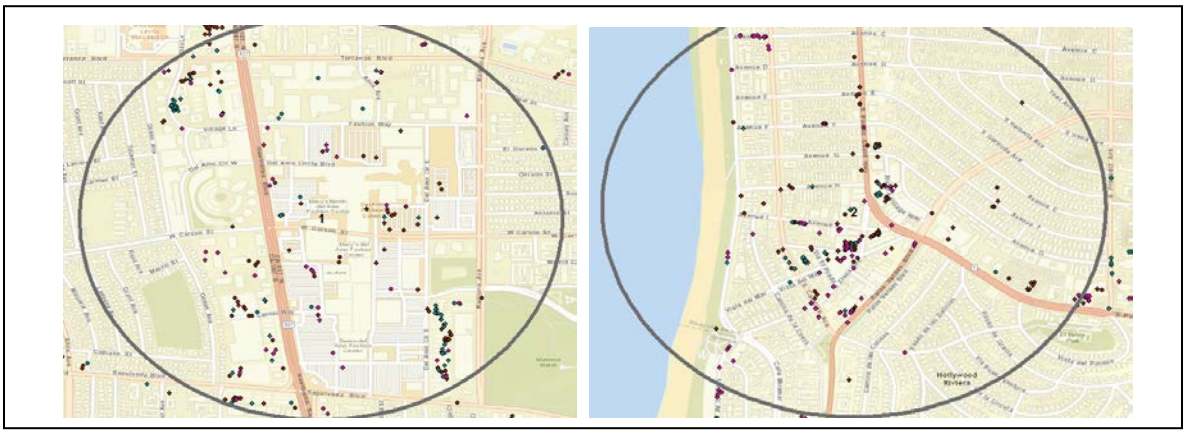
Beach and Inland Hot Spot 3 had the largest mix of stops at 26. There are 2 grocery stores in this location: A Ralphs and Vons kitty corner to one another. Within each of these grocery store complexes are a gym, restaurants and banks. Several drivers went to work in this site and the bulk of these stops constitute work trips. The rest are evenly spread between grocery, meals and gym.

Beach and Inland Hot Spot 4 is characterized by the Manhattan Village Mall. Like Hot Spot 2 the stops are evenly spread between grocery and the mall and the rest are for big box shopping, banking and eating meals.

Table 7: Peninsula, Beach and Inland (PBI) 1 and 2

	Businesses		Destinations		Households
	Sum	Count	Sum	Count	Count
PBI 1	424	44	215	17	26
PBI 2	228	38	219	19	20

Figure 13: PVP, Beach and Inland Hotspots 1 and 2



These are hotspots that were visited by the drivers from the three areas that are characterized by malls, grocery stores and big box shopping. The two hot spot sites roughly had the same number of visits with site 1 seeing more households and site 2 seeing a few more destination types.

Peninsula, Beach and Inland Hot Spot 1 is characterized by the Del Amo Mall. Nearby there is a Fresh and Easy, Ralphs, Target, Walmart and many banks. Most of the stops within this site were to Big Box stores and the Mall. There were a few trips to a worksite and to grocery stores. PBI 2 is the site of Riviera Village with many grocery stores: Trader Joes, Vons and Albertsons. It also contains many restaurants and gyms and is nearby the Beach. The largest amount of visits here were for grocery stores. There were trips to the gym and the beach and to eat meals.

Peninsula 1 through 4

Figure 14: PVP Hot Spots 1 and 2

Peninsula 1 Hot Spot contains the Peninsula Shopping Center which houses a grocery store, pharmacy, banks, Big Box stores, restaurants and gyms. There are municipal services nearby such as a library and there is also a well-visited church. It was the most visited by Peninsula residents. One family made visits to a nearby church and residential visits as well as grocery and other shopping. Several families including a retired couple made visits to the library, chaining grocery shopping and personal services.

Peninsula Hot Spot 2 is located on the lower right hand corner of the airport at Crenshaw and Pacific Coast Highway. There is a Trader Joes, Walgreens, gym, bank and coffee shops here. Most of the trips made were to the grocery store, coffee shops and Big Box shopping.

At Peninsula Center 3 which is off of Lomita and Crenshaw, there is a Vons, Home Depot, Lowes, Costco restaurants and banks. Most of the trips to this area were for Big Box shopping.

Peninsula Center 4 contains a Best Buy, Coffee Shop, Hawthorne Market, Office Max, restaurants, CVS, Michaels, Orchard Hardware, Sprouts and the Post Office. It constitutes the corridor from Hawthorne to Anza on Pacific Coast Highway. This site had an even mix of destinations visited.

Figure 15: PVP Hot Spots 3 and 4

Findings

The most frequently visited destinations in a BEV included the work site, grocery store, big box retailer, restaurants, and various drop-off places. It should be no surprise that Hot Spots are dominated by those types of destinations. For example, 75% of the stops in Beach and Inland 2 were for the South Bay Galleria (mall), grocery store and a big box store. Since mall dwell times averaged a little over an hour, the Galleria would be a likely place for EVCS deployment. However, overall, Beach and Inland #2 tied with PVP #4 for the least number of visits among the Hot Spots.

In contrast, Beach and Inland #1, centered at PCH and Emerald Street, was by far the most frequently visited Hot Spot. It has 4 public schools which account for many drop-offs, a grocery store, pharmacies, restaurants and a UPS store. However, it may not be a good place for EVCS placement since the drop-offs have no dwell time and only the restaurant stops averaged up to an hour of dwell time.

The balance between dwell time and popularity in terms of visits will need to be determined. The initial priorities can be established on the basis of most frequently visited and most minutes dwelling. Trials of EVCS deployment in public places need to be conducted and monitored in order to evaluate the initial siting criteria.

PBI #1 with 424 businesses representing 44 different business types (in terms of 3-digit NAICs codes), was the most destination-dense Hot Spot and also had the 3rd largest mix of types. Yet it was only the 5th most popular Hot Spot. The 8-neighborhood transportation study found that destination density (businesses per acre) and mix (number of NAICs codes present) were the determinants of trip capture by

the cluster. The walking mode from the adjacent neighborhood also increased with high density and mix.

The map of PBI #1 shows that outside of Del Amo Mall in the lower right corner, the other popular destinations are scattered throughout the Hot Spot. This highlights another component of the Land Use Strategy in the SSBS – magnetism of a cluster will increase if it incorporates the popular destinations at higher density in a "center."

Similarly, even Beach and Inland #1, the most popular Hot Spot would, according to the magnetism strategy, attract even more visits if the destinations were all concentrated at one or two intersections on a fraction of the 128 acres in the current Hot Spot.

NEV vs. BEV

Overview

Of the 47 households that participated in the BEV Demonstration, 7 of them also participated in the NEV Demonstration. Though 7 cases is a small sample, it does provide the opportunity to compare the use of the NEVs and BEVs vis a vis the ICE vehicles.

The most significant finding of the NEV Demonstration project was that slow-speed short range electric vehicles had great utility for the households who drove them. They were used to reach many frequented destinations including the work site in some cases. Since slow-speed short range vehicles are consistently left out of the discussion about "complete streets", we have labeled them the "neglected mode in sustainable transportation." In addition to NEVs, the category also includes Segways, e-bikes, electric skateboards, and innovations just now appearing such as the Solowheel.

In a similar way, the BEV Demonstration looked at the question of how zero emission technology in the form of bigger, faster, longer range, more expensive BEVs compare to the NEVs. What can a BEV do that an NEV didn't?

Commonly Used Acronyms

EV: Electric Vehicles
BEV: Battery Electric Vehicles (full battery and long range)
NEV: Neighborhood Electric Vehicles (shorter battery range and slow speed)
ZEV: Zero Emission Vehicle (opposed to EVs as EVs include hybrids)
PHEV: Plug-in Electric Vehicles

Emissions Reductions

In comparison to households' ICE vehicles both the NEV and BEV studies showed significant positive results in the percentage reduction of air pollutants and GHG emissions. In the NEV study the reductions were on the order of 20% and in the BEV study the reductions were approximately 40% - about double the reduction by NEVs. This makes sense since BEVs have three to four times the range of an NEV.

Destinations and VMT Comparison

In these seven cases, typically the BEV was driven for around two and half times more miles than the NEV. The low case was the household that drove only slightly more in the BEV than in the NEV, and this household drove relatively few total miles in general. The highest ratio was the household that drove the BEV for 4 times as many miles as the NEV.

Two of the former NEV households drove more BEV miles than ICE, about 1.5 to 2 times more. Three were the opposite and drove 2 to 4 times more ICE miles than electric. The other 2 drove about the same amount of electric and ICE miles, with slightly more ICE miles in both cases. This reinforces the observation that vehicle use is idiosyncratic amongst households.

Figure 16: Daily VMT by Vehicle Type

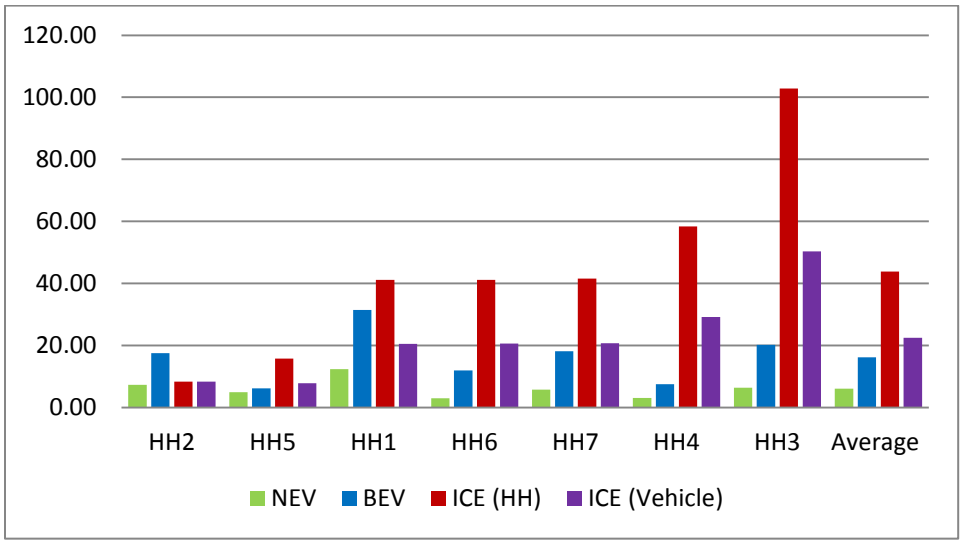
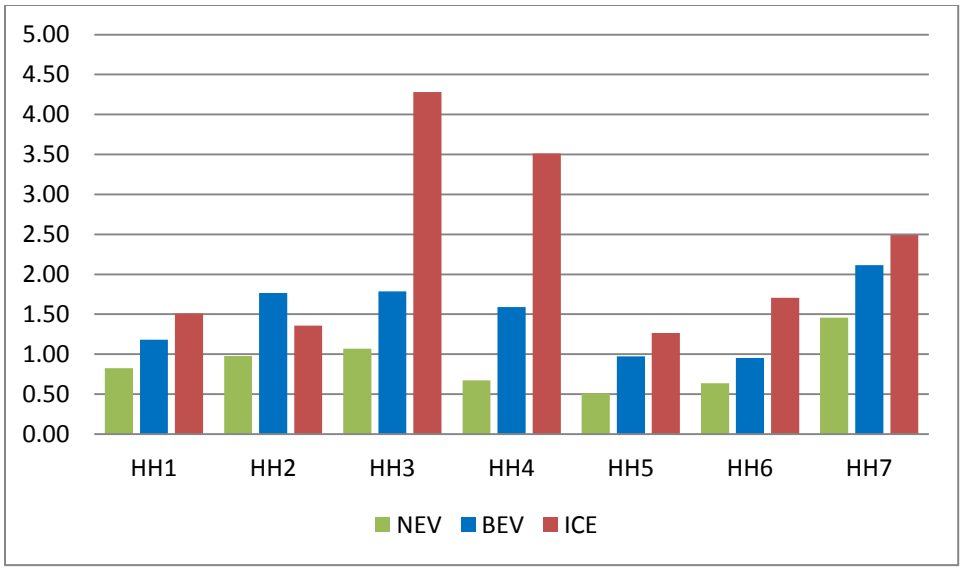


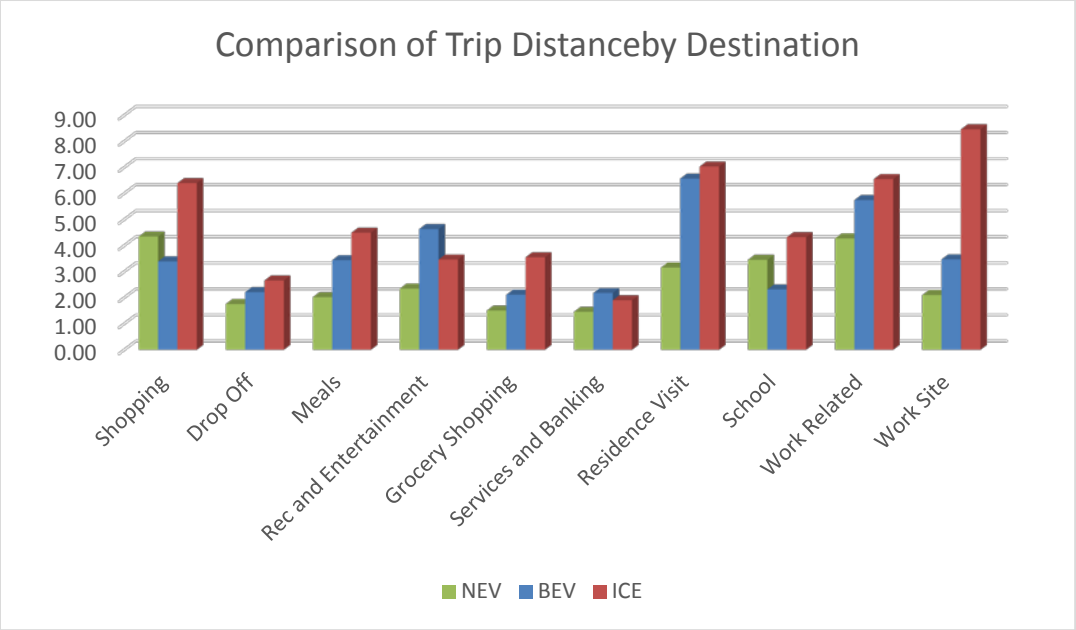
Figure 17: Average Trips Distance from Home by Vehicle Type


5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
HH1
HH2
HH3
HH4
HH5
HH6
HH7
NEV
BEV
ICE

Destination by distance for the group

For these 10 destinations that are a combination of the most distant and most frequent of all BEV drivers, the distances across the vehicle types followed approximately similar patterns. ICE vehicles were used to reach the most distant destination like work site, services/banking and residences. The others were more balanced but with BEVs being used for most of the closer destination types.

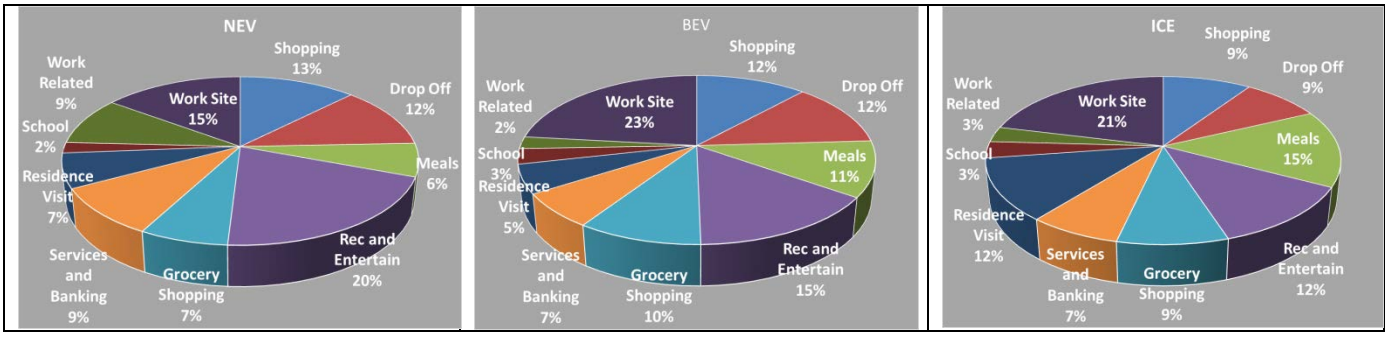
Figure 18: Comparison of Trip Distance by Destination



Destination Frequency

The following pie charts show the percent of trips taken to various destination categories. There is not much difference in vehicle use for trip purpose. Visiting other residences and going out to eat were the most significant. The BEV was used more than the ICE by these 7 households for the trip to work. Drop-off was a significant trip category in the NEV Demonstration and the BEV was used similarly, the ICE vehicle less often.

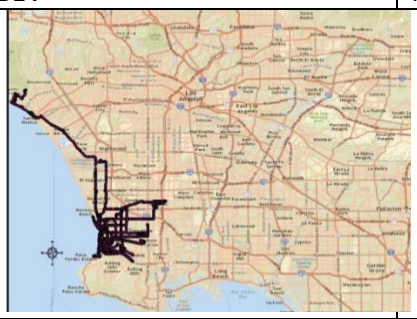
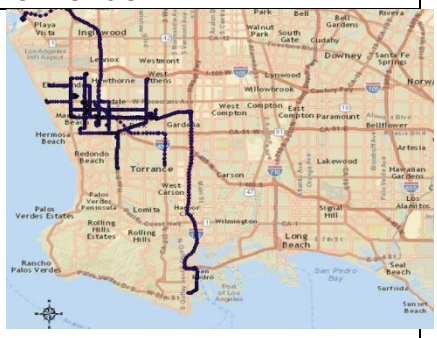
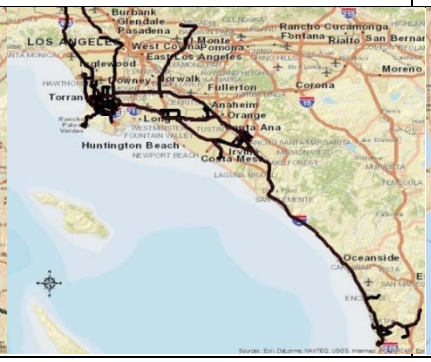
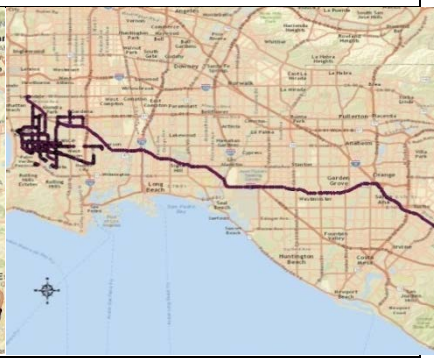
Figure 19: Destination Percentages by Vehicle Type



BEV and ICE Routes

The ROUTE maps show that in general the BEV routes were very similar to the ICE routes. The two types of vehicles were more or less used in the same way. In a few specific cases the BEV was taken in a different direction than the ICEs.

Figure 20: BEV and ICE Routes for 4 Drivers

BEV	ICE Vehicle 1	ICE Vehicle 2
		
BEV	ICE Vehicle 1	ICE Vehicle 2
		
BEV	ICE Vehicle 1	ICE Vehicle 2
		
BEV	ICE Vehicle 1	ICE Vehicle 2
		

Findings

There is substantial variety amongst the households just as there is in the distribution of ICE trips and of BEV trips. The following table highlights three of the seven NEV drivers:

	NEV	ICE	BEV
HH1	High	Average	High
HH3	Low	High	Low
HH7	Low / Ave	Average	Average

HH1 drove the most miles in an NEV, by far. HH3 household was a high volume ICE driver but relatively low in the two EVs. HH7 was pretty average across the board.

None of the NEV households were aggressive BEV drivers, not even HH1. Three were around the BEV average, two slightly below the average, and 2 much below. None were significantly above average.

Driving the NEV did not result in high volumes of BEV use, reflecting the basic fact that most trips are short. This again means that "right-sizing" vehicle choice may be a critical factor towards successful realization of future air quality and sustainability goals.

Speed Analysis

Introduction

Speed of travel is one dimension of the comparative value of a full speed BEV and an NEV. One leading operational characteristic of NEVs is the 25 MPH maximum speed and the restriction of routes to streets with speed limits of 35 MPH and slower. Was the full speed capability of BEVs necessary to overcome the NEV's limited access to all streets? This section shows the average type of road driven in terms of speed for the BEV vehicles.

Methodology

For each vehicle (BEV and ICE), GPS pings with xy coordinates were stored once a minute while the vehicle was being driven. These xy coordinates were saved in spreadsheets to be processed for every household for the two month period of BEV possession. The actual speed travelled has not been determined. The results are based on the posted speed limit of the routes taken.

Analysis

Interesting results arose from the speed analysis. Firstly, it can be noted that over 85% of the streets accessed with a BEV were on 35 mph streets or less. Actually, around 50% were on streets of 25 mph. Only 14% of streets accessed were high speed streets or highways.

In order to understand whether this behavior was specific to BEV driving, the analysis was also conducted on all of the household's ICE vehicles. Not only do the same results appear but a higher percentage of 25 mph streets were accessed with ICE vehicles: 58%.

The implications here are substantial indicating that the sheer bulk of travel occurs on streets adequate for NEVs. The bulk of travel occurs on 25 mph streets which are slow speed.

Table 8: Percent of Roads Driven by Posted Street Speed

	Percent Driven					
	% of 10	**% of 25**	**% of 30**	**% of 35**	**% of 50**	**% of 60**
BEV Average	0.3%	49.9%	2.3%	33.5%	8.9%	5.1%
ICE Average	0.0%	58.4%	6.3%	22.3%	6.4%	6.6%
BEV Range Min	0.0%	21.9%	0.0%	8.7%	0.4%	0.0%
BEV Range Max	2.4%	88.0%	9.9%	63.7%	40.3%	28.4%

Some households displayed slightly different behaviors than the average as indicated in the BEV Maximum range above. Some households had higher percentages of travel on high speed streets than the average BEV driver in the study. This is further explored in the table below.

Table 9: Percent of Roads Driven by Posted Speed for Outlying Households

	Percent Driven					
	% of 10	**% of 25**	**% of 30**	**% of 35**	**% of 50**	**% of 60**
HH 1	0.2%	26.7%	0.1%	32.7%	40.3%	0.0%
HH 2	0.1%	32.6%	2.8%	27.2%	34.6%	2.7%
HH 3	0.7%	30.8%	0.1%	37.4%	30.9%	0.2%
HH 4	0.0%	47.3%	0.2%	32.0%	20.1%	0.4%
HH 5	0.0%	49.4%	1.3%	28.3%	17.3%	3.7%
HH 6	0.2%	37.5%	9.9%	21.7%	2.2%	28.4%
HH 7	0.0%	39.9%	4.5%	25.8%	9.3%	20.5%
HH 8	0.0%	40.6%	5.3%	35.5%	1.4%	17.1%

The above table represents the outlying household in terms of streets accessed. These drivers accessed 50 mph and 60 mph streets more, on average, than the rest of the BEV households. Their patterns can be explained in various ways. Households 1, 2, 3, 7 and 8 while living in the South Bay commuted to worksites within Los Angeles City. These commutes required a combination of both 50 mph streets and highways. Households 4 and 5 made trips to LA and Norwalk which elevated their high speed street percentages. Lastly, household 6 lived near a highway and used it frequently for trips.

Findings

The street speed analysis suggests that in a high percentage of cases, an NEV could have been substituted for the BEV on the routes taken and thus the perceived route limitation for the NEVs is not a reality in terms of posted speed limits. Actual traffic and speeds of other vehicles may still pose problems for many streets upon which NEVs can circulate. The time to reach the destination at a slower speed was not an issue, probably because distances were so short.

The prominence of slow speed streets suggests the possibility of carving out a “slow speed network” by designation of certain routes on 25 MPH streets thereby minimizing the necessity of taking right of way for creating special lanes.

5. Charging

Introduction

One of the key issues in deployment of BEVs is the charging infrastructure needed to make the battery electric vehicle a viable mobility option. The prevalent belief going into this project was that 220V charging would be necessary across the board; that is, 220 charging would be necessary at home, at work locations, in commercial centers and other public parking lots because, it was thought, consumers would want faster charge times to either extend their BEV's range so that they could travel to destinations that were much further away than a single battery charge would allow (before returning to their point of origin) or, to provide a little extra range so that participants would be able to take extra trips that they might not otherwise have been able to taken during the course of the day In other words, 220 charging would allow participants to "top-up" as a way to extend their BEV's range. The results showed that 110 charging was, indeed, suitable for most households. The following analysis explores this issue.

Charging Behavior (Analysis and Data Collection)

All electric cars in the BEV study – Honda Fit EV, BMW Active E and Nissan Leaf - allowed for Level 1 (110) and Level 2 (220) charging. However, only the Nissan Leafs were outfitted with a L3 (440) adaptor for use at a DC 3 Fast Charging Station. As a result, only 23 households in the study had the opportunity to use all three (L1, L2 and L3) charging options.

Only the Nissan Leafs were equipped with sufficient software to account for charge type, number of charges, charge duration, charge type and amount of energy used. Thus, unless otherwise indicated, most tables, charts and graphs in the analysis below refer only to participants who drove the Nissan Leaf. Other anecdotal observations and experiences refer to all drivers using the study's fleet of BEVs and their self-reported experiences of charging.

Charging Quantity and Type

The following table summarizes the charging by type and time over the course of the BEV study. Level 1 (L1) charging represented the bulk of the charges at around 86% of the total. This was followed by Level 2 (L2) charging at around 11% and DC 3 Fast Charges at 3%. Level 1 charging is the most common because it only requires a standard 110 volt outlet which is available to most households at their homes or places of work. With the exception of one household all participants re-charged their vehicles overnight at their homes or at the homes of friends and families.

Level 1 charging time was around 7 hours, producing an average charge of 6kWh. This results in .86 kW per hour of charge. For a 24 kWh battery pack, it would take, on average, 28 hours to fully charge the battery from "empty" or zero charge to one hundred percent or fully charged.

Table 10: Charging by Charge Type and Time

Charge Type	# of Charges	Average Charge Duration	Average Charge (kWh)
Level 1	1,066	5.91	6.79
Level 2	132	2.09	6.50
Quick Charge	41	0.51	10.61

The average Level 2 charging station produced the same average charge as the Level 1 charging station but in less than half the time. Level 2 chargers produce about 10 miles of driving per hour of charge. Generally speaking, these chargers are available at public and municipal parking structures, entertainment centers and some places of work and can be installed in home residences. Installation was estimated that the cost to upgrade to a Level 2 charging station would be between $750 to $1,500; requiring an up-to-date infrastructure rewiring of the household as well as the cost for the L2 charing equipment.

Participants primarily used L2 charging outside the home however two households choose to "upgrade" to home-based L2 charging. the cost for the rewiring was between around $25 and $250, respectively, far less than what was expected. The savings were a result of not having to significantly rewire as well as discounted labor to install the units. Generally speaking, the range of cost for wiring a Level 2 charger depends on proximity to electric panels and availability of slots on the panel. Additionally,the two households that upgraded to L2 borrowed the L2 charging equipment and, as such, did not have to incur the cost of the equipment that might otherwise have had.

DC 3 Fast Charge (L3) charges the fastest and is the most efficient type of charge. This technology provides 440 volts to charge the battery and can "top off" a BEV battery to 80 percent of a full charge in approximately 30 minutes. These types of charges were infrequent among participants. On average they produce close to an 11 kWh charge in a half an hour from the data above. Quick charges require the vehicle be equiped with the proper electrical connections and the station itself requires a high-voltage electrical circuit. The stations cost in the range of $15,000 to $25,000. During the course of this study these types of stations were only found at auto dealerships.

Mechanics of Charging

Household Instructions

Prior to their participation in the study all households were asked about the availability of a "working" 110 outlet that they would use for home-based 110 charging. All selected participants responded that they had identified the necessary and required outlet for charging their respective electric cars using the BEV's portable charging cable. In most cases the outlet worked as expected however in several instances household outlets were discovered to be in disrepair and unusable because the outlet was "old" and not grounded or that it was located in a place that did not allow for ready access to "plug in." In these instances, except for one household, the outlet was either made operational or relocated so

that it could be used for charging purposes. The one household that choose not to fix their 110 outlet had, by necessity, to use workplace or L2 charging outside their home to recharge their BEV.

All participants were given the instruction that they were to "test 110 (L1) home-based charging for the first two weeks" of driving their respective electric cars; they were encouraged to "plug in at night so that the car would be fully charged in the morning." Additionally, the participants could, if so desired, opportunity charge during the day outside the home at any time using charging of their choice. This meant that all households in the BEV study could charge using either L1 or L2 however, because only the Nissan Leafs were outfitted with a L3 (44) adaptor (for use at a DC 3 Fast Charging station), there were only 23 households that had the opportunity to use all three (L1, L2 and L3) charging options.

After two weeks, all participants were given the option to "upgrade" their home-based L1 charging using a loaned L2 (220) charging unit. Participants that chose to borrow the equipment were responsible to ready their electrical wiring at their own expense. Of the 49 households that participated in the study only two choose to upgrade to home-based L2 charging.

In terms of opportunity charging outside the home, participants were briefed about the availability and resources as part of their orientation and training (at the time that they picked up their electric car). On-line resources like plugshare.com; SCAQMD's EV charging Station App; and, each EV's respective on-board GPS functions to find "the nearest charging stations" were reviewed. Additionally, all participants were encouraged (though not required) to "look into" or "sign-up" for either the ChargePoint or Blink Electric Vehicle Charging Station (EVCS) Network Service. All costs associated with participating in these EVCS networks were at the expense of the participants.

Where to Plug In?

Forty-eight out of forty-nine participating Households used L1 home-based charging. In almost all instances this meant using an available standard 110 outlet that was located in or around the participant's garage or area where the EV was to be parked. Often this was not an issue however, there were several instances where the question of 'where to plug in' was not always so straight-forward or obvious. Two primary reasons for discovering the "surprise" of not finding a place to plug in were either that the 110 outlet was not properly grounded (a function of older homes or homes that were wired based on outdated building codes); or, secondarily, some participants learned that in order to readily "plug in" they had to "make room" or "clear space to reach the plug." In several cases, adding a car to a family's fleet of vehicles required more than "simply parking it in the driveway or street" and was something that necessitated some consideration. On the surface, participants' ready answer was "yes, I can plug in" however, the actual logistics of where and how this would happen was not always so obvious.

Single Family Homes

Typically, for the 28 households who lived in single-family homes, they would use an available interior garage wall outlet or an exterior outlet that was located near the area where the EV was parked. For two of these households they needed to call an electrician so that their expected 110 outlet could be grounded (i.e. made functional) or moved to an exterior location for easy charging access. In one

instance a participant choose not to incur any additional costs to fix their intended 110 outlet. As a result were unable to charge at home and relied on L2 opportunity charging at their workplace and at nearby (to their home) locations.

All individuals who reported their household electric costs described an increase in their electric bills that ranged from $15 to $40 per month. Only one participant choose to "sign-up" for Southern California Edison's "EV charging Plan" – a billing plan that allows for discounted electricity rates for charging "off peak hours" (between 11 PM and 7 AM); they too saw an increase in their electric bill following their participation in the BEV study of approximately $30 per month

Multi-Unit Dwellings (MUDs)

There were 20 Households who lived in Multi-Unit Dwellings (MUDs) – defined as apartments or condominiums with shared walls. Of these Households, 11 had similar charging set-ups to single-family homes where the participant would park in their dedicated parking garage/space to plug in; these were condominiums with an attached garage. The available L1 outlet was part of their household wiring and, as a result, they were billed directly for the use of electricity to charge their BEV.

Nine participants lived in Multi-Unit Dwellings that could be described as typical apartments or townhomes where there was either a large common parking garage with assigned parking spaces, separate carports or detached garages. For these participants, the parking and charging scenarios were unlike single family homes or MUD condominiums that were owned by the participants. The difference in these instances were that the available 110 outlet was a "house" or "common plug" and was not wired to the individual participant's electric meter but rather to the apartment complex meter that was billed to the property owner's account. Additionally, the location of an available 110 outlet varied by building and type of parking arrangements available to the participants. For some participants they discovered that there were available 110 outlets however their locations were not where their assigned parking was located. In these situations, participants would ask or negotiate the use of a neighbor's parking space so as to use the outlet.

Entering into the study the BEV participants that lived in these types of apartments did not expect to pay for electricity during their participation. Of these nine participants seven did not pay for the additional electricity necessary to charge their BEV's; they choose not to inform their landlord or property manager – essentially "going under the radar" or observing that their landlord "did not care" or "did not notice" that they were charging their BEV overnight. However, for two participating households, they were directed to pay to charge their electric vehicles. In the first case, a $20 per month fee was assessed by the Owner for "tenants who own electric cars and wish to plug in" using the apartment complex's sole 110 outlet (which was located against a wall in the subterranean garage). The participant thought this cost to be nominal ("not too much given the cost of gasoline for their regular car"). The challenge, however, in this case, was that, in this apartment complex, there were multiple BEVs and plug-in hybrid cars that also used the sole designated 110 outlet. Essentially, there was more demand than available plugs and, as such, there were times when neighbors became agitated or annoyed with one another when they could not plug in at all or when their charge time was shortened due to the lack of an available outlet.

In the other case, the participant was denied use of a common outlet in his apartment's garage. In order to charge his electric vehicle he was told that he had to get permission from the building's Home Owners' Association (HOA) as well as having to pay for wiring; he was told that any and all electrical charges would have to be on his household meter. The participant thought that the approval process was onerous in terms of his time and the costs that would result from this formal process. He choose, instead, to improvise with an alternative charging strategy; he ran an industrial extension cord from his second floor living room to his electric car thereby incurring all additional costs for home-based L1 charging without having to go through the formal approval process with the HOA.

L1 Charging Experience as a Function of Mobility

For the first 2 weeks of their experience as BEV drivers all participants were encouraged to use L1 charging as their primary charging strategy. A routine of charging the BEV at night was suggested so that participants would have a (relatively) full battery and maximum range each morning. Aside from the Household with no place to plug in (at home), all participants utilized this strategy. Over the course of the study forty-three percent (21 households) of all participants choose only to use L1 home-based charging as a means to refuel their electric vehicles. Of those, 89 percent (17 households) stated that home-based L1 charging was sufficient or met their needs for EV use. Beyond that, fifty-nine percent of all households (including those that choose to opportunity charged outside the home) reported that home-based L1 charging was sufficient to meet their BEV travel requirements. That is, participants indicated that "with a full charge they could travel to wherever they needed to" during the course of a typical day. For many participants this was akin to the idea of knowing that their travel was well within the maximum range for their respective BEV (as indicated by the electric car's on-board computer estimate after the BEV is recharged). Often this was described by participants as being able to use the electric car within their (participant's) "bubble" or for "very local" trips.

Home-based (220) Charging Strategy

Only two households choose to "upgrade" their home L1 charging and install an L2 home-based charging unit. The decision to do so was made because it was relatively easy and affordable to do so. In one instance, the participant was a trained electrician whose garage also functioned as a workshop and was already wired for 220. For this individual the cost to install the proper outlet was estimated at $25 in parts and no cost for labor. In the second instance, the participant's reflected that their "electrician friend" could do the rewiring and move the outlet to the garage for about $250 – a price that was affordable to them and something that they were going to do, in any event. Neither household choose to enroll or use the electric company's special Electric Vehicle Charging Program – rather they continued to charge their BEV's late at night; one participant even going so far as to "set the BEV's automatic charging timer" so that he would be certain to pay the lowest rates (between 11 PM and 7 AM).

Both households saw the opportunity to use home-based L2 charging as a "way to test" what it would be like if "they actually were to purchase a BEV." Their assumption was that, "should they purchase or lease a BEV," they would install L2 charging as a matter of convenience. Both households noted that the relative time to charge their BEV was "about ½ the time" that it would otherwise have taken to charge using their homes' common 110 outlet; this was seen as positive. In both instances, there was some initial expectation that they would be able to take extra trips as a result of being able to "top off" or opportunity charge during the course of the day or at the end of the day. For one household the L2 charging station was perceived as an important tool that would enable him to use the BEV for

"emergency calls in the middle of the night" back to his work place in Palos Verdes. However, after experiencing the "actual" charging time for L2 – and the range limitations of driving an electric car - he lacked the confidence of being able to go to multiple emergency calls. As a result, the extra trips he expected from having a home L2 charging station never happened.

For the other household, they discovered that their trips were, primarily, very local. As a result, the idea of using the home-based L2 charging system for extra trips did not materialize. On the other hand, the relative fast charge of the L2 system was a positive experience and each participant affirmed that they would, indeed, install this type of charging system if they were to purchase or lease a new electric car.

Opportunity Charging Outside the Home

Of the total 49 households that participated in the study, twenty-five households (51%) took advantage of using some type (L1, L2, DC 3) of opportunity charging outside their home. Vehicle model apparently was not a factor as 50% of all Honda Fit EV drivers used opportunity charging outside their home while 43% of Leaf drivers and 45% of BMW Active E drivers choose to test opportunity charging outside the home as well.

In terms of L2 charging, 43% of all drivers used 220 opportunity charging outside the home at least once. For Nissan Leaf drivers, 2/3's of those that used DC 3 fast charging also used L2 opportunity charging.

Thirteen participants (26%) reported that they used their BEV's portable L1 charging unit to plug into an available 110 outlet outside of their home.

The location and types of EVCS (electric vehicle charging stations) for charging outside the home varied. All DC 3 fast charging stations were located at Nissan Dealerships and were available only to those participants that drove a Nissan Leaf. All participants, however, found and used L2 charging stations located throughout the Great Los Angeles area – from Costa Mesa and Anaheim to Thousand Oaks to Pasadena to Downtown Los Angeles and across the South Bay area. The types of locations varied from workplace parking lots to government offices, to retail establishments like fast food restaurants to shopping mall parking structures to automobile dealerships. When L2 charging was unavailable, out of necessity participants would seek out and use available 110 outlets to charge. Creatively participants discovered that common 110 outlets could be found against a light pole in a church parking lot; against a garage wall at Disneyland; near an elevator in an office building's garage area or even a relative or friend's carport.

In all cases, participants shared several characteristics in terms of opportunity charging. Essentially, those that choose to plug in outside their home were thoughtful and creative in terms of planning their trips, destinations and the amount of "extra time" that they would have to allocate to see any appreciable range added back into the battery from stopping to charge rather than charging overnight at home. Participants almost always spent time in advance of their travels to identify where they might expect to find an available charging station while traveling. Almost all participants, however, reported that, even though L2 charging is "about twice as fast as L1 charging", the downside to L2 charging was the "time it takes" to charge. When traveling outside the home, participants often lamented the fact

that “even an hour of L2 charging doesn’t really get you that much extra range” or that “there are very few places where you stop for more than a couple of hours.” Level 2 charging (outside of the workplace) was seen as simply a way to “top off” though not a significant way to extend the range of the EV.

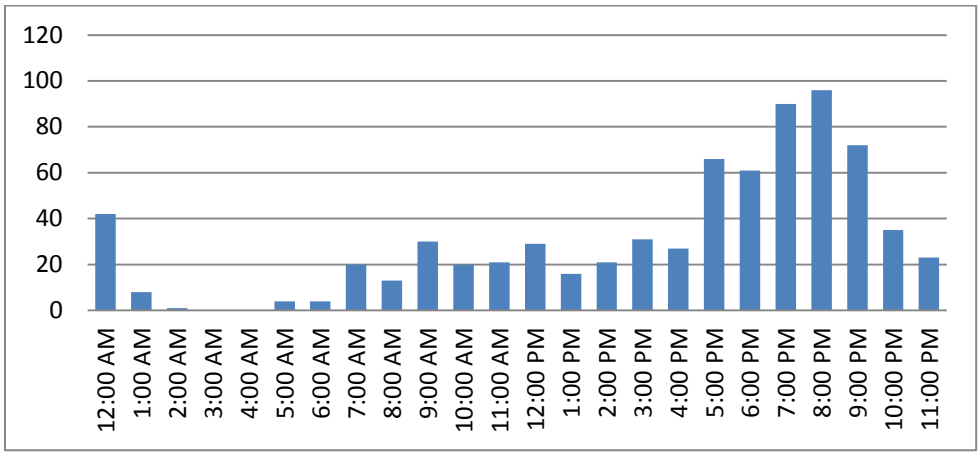
Using smartphone apps like “plugshare.com” or logging on to an EVCS network app like “chargepoint.com” allowed the participants to plan their trips with (relative) confidence that they would be able to find a place to charge.

In terms of paying for charging, participants had a “rule of thumb” that they would “look for free charging first” – essentially, they did not like to pay for opportunity charging. However, if necessary, they would pay if their only charging choice were charging networks like Chargepoint or Blink.

Charging - Time of Day

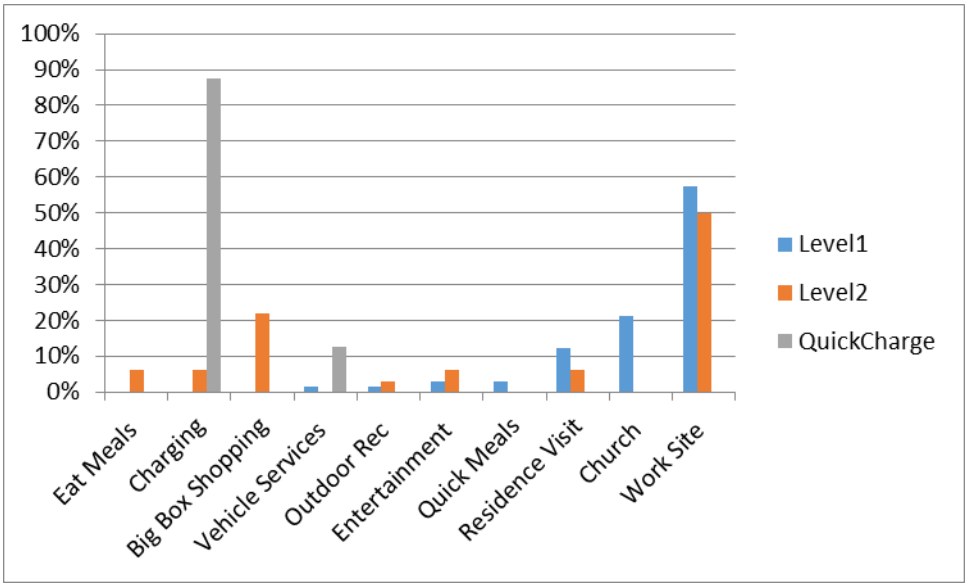
When batteries are charged is important information for understanding demands on the electrical grid. As reported from participants’ logs and surveys the following figure shows that most charging started from 5PM to 9PM when drivers returned to the home. Thus the demand for charging is most heavy in the evening. Around several hundred charges occurred in the afternoon but were proportionally lower than evening charges.

Figure 21: Count of Charges by Start Time of Day



Charging by Destination

Figure 22: Percent of Total Charges by Destination (Other than Home-Based Charging)



Using data supplied by the Nissan Leaf system, the figure above shows that the sheer bulk of charging occurred at home, 90% of Level 1 charging and 40% of Level 2 charging. No quick charging occurred at home.

For charging that did not occur at home (see above figure) the most common Level 1 and Level 2 charging was done at work: over 50% of Level 1 charging and around 50% of Level 2 charging. Level 1 charging was also seen at church and other residences with a few at entertainment and shopping centers. 20% Level 2 charges were seen at Big Box Shopping centers and the rest were seen at other shopping centers as well as auto shops. All Quick Charges were at Auto Dealerships.

Work Place Charging

Around 61% of the BEV participants used the BEV to commute to work. Half of these charged at work and the rest felt the workplace was sufficiently close to home to not need to charge at work. Of the 15 participants who used workplace charging only 7 described using available, working L2 EVCS at their primary work locations. These locations included 2 Aerospace Companies (El Segundo); 2 commercial office buildings (Century City); 1 Corporate Headquarters (Torrance); and 1 commercial retail facility (Costa Mesa).

Four participants used an available 110 outlet located on the exterior of their building or in a subterranean garage; one individual drove their BEV into their warehouse where they "plugged in" to a 110 outlet located near the loading dock door. In each of these instances there were no costs incurred by the participants for opportunity charging at work.

Lastly, 4 participants indicated that they too charged at work, however, because available charging was not located at their workplace they found creative strategies to charge close to their work site; In one instance, a participant would park at a local City Hall and walk about 1 mile to his retail business; he would return in "about 2-4 hours" to unplug the BEV fully charged for the rest of the day's travels. Still another participant used their hour lunch time break to charge using a nearby (workplace) L2 charging station; this additional time gave them about "25% more charge" for the rest of the day. One other participant, at the end of the day, was able to find a convenient DC 3 Fast Charge and "top off for the commute trip home."

The reasons for charging at work varied. Some noted that that their work commute was longer than the average household; some involved travel that consumed greater battery usage through travel on the highway or trips back to the home that involved an incline. In one case, a participant had a commute that required freeway travel and additional sales trips to make throughout the day. The drive back home also included an uphill route. This driver used a 110 outlet located against one of the workplace building's exterior walls. A few times the driver only had sufficient charge to get back up the hill and therefore could not make additional trips after work. In another case, a participant who charged at work and had a longer than average commute she also had to travel uphill to return home. Necessarily, this participant was able to charge at a 220 outlet at work. While charging at work was imperative for some participants' return trip in other cases it was a strategy to mitigate their perceived range anxiety. In one case, a participant who had a very short drive to her volunteer work place at the Port of Los Angeles felt the need to charge at the free L2 charging station in the parking lot because she "needed it to get back up the hill at the end of the day."

DC 3 Fast Charging

Six Nissan Leaf drivers tested DC 3 Fast Charging. All Fast Charging stations were located at Nissan Dealerships around the Los Angeles Area. DC 3 was seen as "very convenient" and not "wasting a lot of time" in comparison to L2 and L1 charging stations. In "about 30 minutes" participants could "top off" their Leafs to 80% capacity. Some participants used this fast charging technology to extend or plan trips

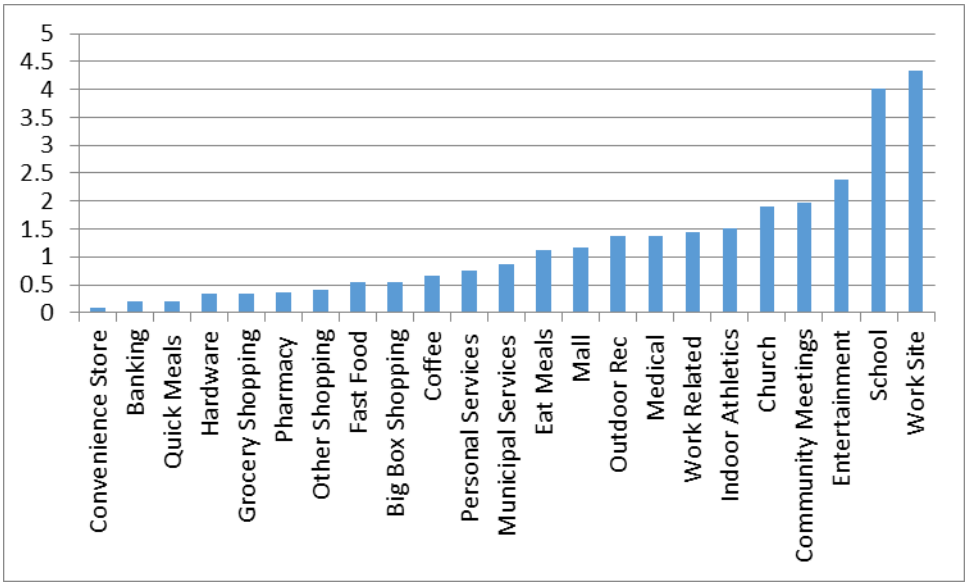
that would otherwise not have been possible given their Leaf's estimated range. In one instance, a participant used the DC 3 Fast Charging Station at a dealership adjacent to the 405 Freeway to "top off" while returning home from visiting his family in Pasadena. In other instances, the convenience of being able to quickly charge was an advantage to filling up outside of the home or while shopping at a big box store like Costco (located across the street from a Nissan dealership).

Charging Station Infrastructure – Type and Placement

The above analysis examined destinations where charging was available for drivers of all BEVs and does not consider the other destinations made. Critical to the success of BEV as an alternative transportation mode is the question of charging infrastructure to support electric vehicles. The key to understanding this are the answers given by the BEV drivers as to where they stopped for charging (destinations) and how long they stopped for charging (duration); the longer the stop the more the battery can be recharged. The following 2 figures chart the average duration of a stop by destination and the frequency of stops at the charging destinations by all participants in the study.

As can be seen from the Stop Duration Chart destinations accessed within a half hour to an hour may be suitable for DC 3 fast charging stations. These include Grocery Stores, Pharmacies, Fast Food Restaurants, Big Box Stores, Coffee Shops and Restaurants. In general though, destinations with short durations such as convenience stores, banks and some fast food establishments would not suitable for charging stations as drivers are stopped here for very brief periods of time. In terms of 110 or 220 charging stations, it can be seen that suitable destinations for charging have higher stop times ranging on average from 2 to 4 hours. Destinations such as schools, work site, places of entertainment, sit down restaurants and churches are all places that may be suitable for planning and placement of L1 or L2 charging stations.

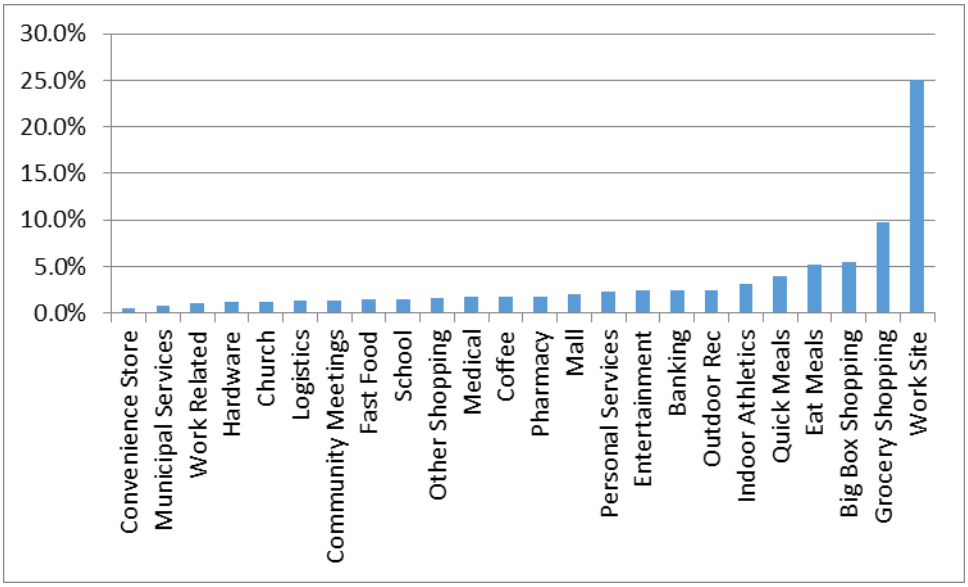
Figure 23: Average Stop Duration for Destinations with Charging



Y axis = Time (hrs)

Planning and build-out of BEV infrastructure should also consider the frequency of destinations to which drivers travel. The figure below describes the frequency of destinations made by all BEV drivers in the study. Heavily travelled places include worksites (the most frequent trip made), grocery stores, Big Box stores, restaurants and gyms all of which, given the duration times, would suggest locations that could support L2 charging stations.

Figure 24: Frequency of BEV Trips (Percent of Total)



Trip Charging Analysis

The table below summarizes the average battery consumed during an average trip as well as various maximum and minimum trip statistics. For the 5,600 trips made by the Leaf vehicles over the course of the program, the average trip distance was 4.37 miles with an average charge consumption of 1.18 kWh. This means that the average Leaf consumed .27 kWh per mile. A full 24 kWh can therefore drive around 89 miles. The reality, however, was that the range varied per household from around 80 miles on a full charge to the low 90s. The variances were due to differences in terrain (uphill driving consumes more battery and downhill less) and routes taken during travel (highway vs. slower speed streets). Highway driving consumes more energy than city driving as breaking regenerates batteries and much of city driving is stop and go. Other variables include seasonal effects such as the use of air conditioning or heat which deplete the battery.

As such, consumption was not always directly related to distance travelled or duration. The maximum energy consumed on a trip was neither the maximum distance travelled on a trip nor was it the maximum duration of a trip. The longest trip made in terms of duration was 90 minutes and the energy consumed was 7.38 kWh, half that of the trip consuming the most energy at 14.88 kWh. The lowest percent of battery charge a driver was willing to start a trip on was 14% of the battery while the lowest battery percentage a driver was willing to experience before charging was 11%. Drivers, evidently, were

not comfortable with driving at a battery below 11%. Interestingly some trips generated energy as can be seen from the minimum energy consumed trip which generated about 1% increase in battery charge.

Table 11: Trip Charging Statistics

	Trip Distance (mi)	Starting SOC (%)	Ending SOC (%)	Electrical Energy Consumed (kWh)	Duration of Trip (Minutes)
Max Distance	41.88	94.00	39.70	12.21	72
Max Energy Consumed	36.31	80.70	18.00	14.88	36
Max Duration	31.43	85.20	47.00	7.38	90
Min Starting SOC	1.23	13.70	12.00	0.32	10
Min Ending SOC	8.56	22.60	11.00	2.05	30
Min Energy Consumed	3.40	50.70	51.80	-0.32	12
Average	**4.37**	**71.53**	**65.74**	**1.18**	**15**

SOC = Start of Charge

Findings

The project was designed, in part, to test the extent to which Level 1 charging (primarily at home) was sufficient to support the driving habits of the participating households. Conventional wisdom was that there would be demand for home-based Level 2 charging and that participants would seek out other available public charging opportunities to either extend their BEV's range. The BEV study discovered that for the majority of participants their charging needs could, indeed, be met by using their household 110 outlet; by simply plugging the BEV in when they returned home they had sufficient range to meet their driving patterns the next day. This finding was true as well for those that lived in apartments, condominiums and townhomes although individuals in these types of living situations often face challenges in terms of infra-structure that required them to be creative in terms of finding a 110 outlet to plug in their BEV. Interestingly, for many participants their patterns for charging began with charging every night and then backed down to a charging pattern of every other night. This suggests that their driving was local and that they had learned and acquired a confidence and understanding of their BEV's range as it related to their driving requirements.

The option of upgrading to home-based L2 charging was not seen as a viable or necessary option as only two participants upgraded to Level 2 charging at home. Moreover, home-based L2 charging did not add any additional value in terms of extra trips that those households might have taken.

In terms of charging outside the home, participants found and used all three types of charging options. Most participants found that their BEV travel was so local that they did not require, nor did they have a need, to opportunity charge outside the home. Others, however, did take advantage of available charging outside the home to extend the range of the BEV thereby allowing participants to commute or travel to areas outside the South Bay. For participants that wished to extend the range of the BEV (for work commutes or trips that were outside the South Bay) L2 and DC 3 Fast Charging were options that proved important.

Certainly, the place, time of day and frequency of charging will have implications for demand management on the electrical grid as well as identifying locations that might support public charging stations. Home charging patterns indicate that participants plugged in to begin charging in the evening, often well before the discounted (off-peak) electrical rates began. Importantly, in terms of range anxiety that might be associated with charging behavior there was great variation as to when participants would decide to charge; some would plug in with 50% capacity while others would be less so. Interestingly, no participant was willing to begin charging at less than 11 percent of battery capacity remaining. Participants' were not willing to run the BEV to empty but rather charged at some point that they felt comfortable.

6. Environmental Benefits of BEVs

The 47 households that participated in Drive the Future drove 39,420 electric miles over the 24 month demonstration period. This amounted to about 40% per household across the board reduction in emissions and air pollutants. Assuming all of them replaced gasoline miles (averaging 20 MPG), 2,181 gallons of gasoline were displaced. At an average cost of $4/gallon, this collectively saved participants $8,724 (minus the cost of the electricity, which is a relatively modest amount). Table 1 shows the reductions achieved by this demonstration.

Table 12: Household BEV Emissions Reduction

Emission Type	Average % of HH Reductions	Total Reductions
Carbon Monoxide	40%	175Kg
Nitrogen Oxide	40%	17.9Kg
Particulate Matter 10	44%	1.8Kg
Particulate Matter 2.5	40%	.9Kg
Sodium Oxide	46%	.2Kg
Carbon Dioxide	40%	18.5 Tons
Total Organic Gases (TOGs)	40%	10Kg
Methane	40%	1.3Kg
GHG (CO_2 equivalent)	40%	18.5 Tons
Gasoline Consumption	38%	2,181 Gallons

Projections

The South Bay could reduce its 2015 transportation-generated GHG inventory by 8% before 2020 if 50,000 households (about 14% of all South Bay households) replaced one ICE vehicle with a BEV.

If we were to project our emissions saving data onto 100,000 households (100,000 HH would own at least 1 BEV) the following savings would be realized:

- 316,090 tons of CO_2 a year. This is equivalent to the carbon sequestered by 259,090 acres of US forest.
- 46,670 gallons of gas per day year or 17 million gallons of gas per year.
- For an entire year, $68 million in savings assuming a $4 cost of gas per gallon.

Regional Sustainability Impacts from BEV Study

The sample of 49 households who participated in the BEV study yielded significant findings to the impact within a household when they are given an opportunity to drive an electric vehicle. These household reductions of GHG and particulate emissions provide critical baseline information for understanding the behaviors and challenges of this alternative transportation strategy towards achieving the target goals set by AB 32 and SB 375. At the household level, there was a savings of 2,181 gallons of gasoline; this

can be thought of (in the language of climate action planning) as having also saved around 19 tons of Carbon Dioxide which is equivalent to the carbon sequestered by 15.9 acres of forest in a year; or, eliminating emissions equivalent to burning 20,826 pounds of coal.

Driving an electric vehicle in Southern California has environmental benefits both at the "tailpipe" and regionally in terms of where electricity is produced. The foremost benefit is that of the reduction in greenhouse gas emissions and criteria air pollutants (particulates) from personal vehicles. Each zero emission vehicle is just that – emitting no GHG or criteria emissions either at the beginning of the trip (through "cold starts") or while in motion. Personal GHG emissions saved from each vehicle is 100 percent, however, this figure must be adjusted to account for where the electricity is produced to fuel (charge) the batteries of the BEV vehicles. In California, electricity is primarily produced at place power plants that, for the most part are regionally located; there is a small sub-set of individuals who (via solar power) are able to generate enough electricity for their personal use (including charging a BEV) though none participated in the BEV study. Given that production of electricity at a regional power plant produces emissions at the point of production, the emissions are still substantially smaller than gas-powered vehicles for an equivalent amount of energy consumed.

In the Southern California, SCE (South California Edison) produces most of the electricity that powers the grid and, ultimately, refuels or charges electric cars; the 15 South Bay Cities that participated in the BEV study are all served by Southern California Edison. In this market, driving an electric vehicle reduces the per mile Carbon Dioxide emissions by 88%, NO_x by 99.9% and other criteria pollutants by nearly 100%. In contrast, these numbers are higher than when using electricity generated by the Los Angeles Department of Water and Power (LADWP) because the LADWP imports a larger portion of their energy from out-of-state coal-fired power plants. However, even when coal is the dominant source of energy generation, per mile CO_2 reductions from electric vehicles can reach 50%.

7. Recommendations for Meeting the Challenge

The Challenge

The recommendations offered in this section will be seen as more or less urgent depending on the perceived seriousness of the challenge. As described in the Introduction, the federal and state governments have established targets for air quality and greenhouse gas emissions. These targets protect public health and strategic concerns around oil dependency that include economic instability; national security threats, and climate change involving, for Southern California, the prospect of extreme heat, droughts, brush fires and rising sea levels.

In order to meet the adopted targets the private vehicle fleet will need to become almost entirely zero emission by 2025 and completely emissions free by 2040. As a modest interim goal, California Governor Brown has called for 1.5 million ZEVs state-wide by 2025. In order to maintain the current South Bay's portion of the statewide vehicles (approximately 4.7% of all vehicles in the state are registered in the South Bay), about 70,000 ZEVs will be required by 2025. In order to stay on track for complete conversion by 2040, about 200,000 ICE vehicles will need to be replaced or eliminated within 10 years.

How difficult will it be to meet this challenge? Extremely – extraordinary measures may need to be considered in order to avoid the worst of the consequences from dependence on gasoline-fueled auto-mobility.

As part of its PEV Readiness Plan for the SCAG region, UCLA's Luskin Center for Innovation provided a market forecast for each sub-region (based on a growth curve derived from original Prius hybrid vehicle sales in North America beginning with the Prius' introduction in 1997). The forecast was expressed in terms of low, moderate (low plus 5%) and high (low plus 10%) estimates.

Table 13: Luskin Center Forecast for South Bay PEV Sales

	Low Est.	Moderate Est.	High Est.	PHEV Registered	BEV Registered	Total PEV Registered
2012	1,020	1,020	1,020			
2013	2,040	2,040	2,040			
2014	3,940	4,042	4,080	1,949	1,101	3,050
2015*	6,270	6,634	6,901			
2020	64,466	79,719	96,451			

*Large annual increases are expected to begin in 2016

If growth follows the forecast, the South Bay will meet the political goal of 70,000 ZEV by 2025 but not the environmental target of 200,000. However, PEV registrations have not been following the forecast. In May, 2014 total of 3,050 PEVs were registered in the South Bay (1,949 PHEV and 1101 BEV). This is almost 25% below the low estimate for 2014 (the SBCCOG is in the process of acquiring the 2015 data). And the South Bay is one of the better markets for PEVs in the SCAG region

The time period for complete fleet turnover is another factor to consider. According to one source (www.calculatedrisk.com) vehicle fleets turn over in 15 to 25 years depending on the economy and the occasional program that encourages scrappage such as "cash for clunkers". A good economy increases the rate of turnover, recession extends it.

Applying this to the South Bay suggests that all 615,000 vehicles currently registered will be replaced by 2040 at the latest. In order to complete the conversion to zero emission by 2040, all vehicles being purchased today would need to be zero emission. We lack even a rough approximation of the current PEV portion of the new auto market but surely it's low.

In order to demonstrate carbon and pollutant reductions, regional transportation planning agencies throughout the state (including SCAG) currently focus on government investments in public transit infrastructure and services plus special lanes for bicycles. While those investments are certainly significant, it is becoming clear that sustainability depends more on private sector innovation and investments.

The bottom line is that the future of sustainable transportation depends on the choices of private households for vehicle and service options provided by the private sector, and supplemented by public transit which has historically played a small role, especially in the South Bay.

The following recommendations based on analysis and insights from the BEV and NEV demonstrations address the challenge of dramatically accelerating the conversion from ICE to zero emission mobility, especially through the market for BEVs.

Recommendations

Given the opportunity to use an electric vehicle as they wished at no expense (except for electricity costs) for a two month period, only a couple of the 47 participants seemed convinced by their BEV experience. Several expressed an interest in plug-in hybrids, a couple were looking at an ICE vehicle as their next purchase, and the rest expressed reservations about the product as it is in 2015, range being the primary concern. It should cause original equipment manufacturers (OEMs) to be alarmed when a group of potential customers actually tries their product for an extended period and isn't impressed. It also does not bode well for the future of sustainable mobility.

The following ten recommendations address the challenge.

1. Develop a decision tool to help households choose among mobility options.
2. Improve the actual value proposition of BEVs
3. Improve the perceived value proposition of BEVs
4. Increase the BEV options
5. Expand the market for BEVs
6. Develop the support infrastructures
7. Credit BEVs and destination compaction as a legitimate strategy for complying with SB 375

8. Develop large scale, high profile demonstration projects
9. Equip every sub-region and county to monitor its own electric vehicle marketplace.
10. Approach the challenge comprehensively and experimentally

1. Develop a decision tool to help households choose among mobility options

The irony of a lukewarm reaction to BEVs tied to range limits is that the participants, based on analysis of GPS data, very successfully met their mobility needs while also substituting electric for gasoline miles.

The underlying problem is that most drivers in the NEV and BEV demonstrations were unaware of their own transportation patterns and consistently over-assessed their needs for mobility. Consumers generally tend is to purchase and accumulate more mobility than they need.

One of the benefits of ride sharing programs such as Uber and Lyft is that trips are sold a la carte unbundling them from the trip-making capacity found in the cars parked in the garage. Once a vehicle has been purchased or leased, there is an economic incentive to drive it since the marginal cost of each additional trip is low. In the car/ride sharing world, the cost per tip is a disincentive to additional travel.

Currently information on BEVs is available in terms of a specific vehicle product, like the Nissan Leaf, or as a class of vehicles like BEVs or PHEVs (see online information at *www.pluginamerica.org*). Our demonstrations have shown that NEVs and BEVs will be more attractive to households as vehicles specialized for certain trips as part of a fleet, at least for now.

The point is to move away from product information toward life style options; and away from information toward a decision tool. The tool will help households assess their actual mobility needs, guide them through a set of scenarios by which those needs could be met, and connect them with vendors who can deliver the vehicles and services identified in the chosen scenario.

For example, the process would begin with participants visiting an online portal in order to respond to questions about their household travel patterns. The portal would calculate the origin-destination distance relationship and provide the participants with a mobility needs assessment. It would then develop a set of scenarios that describe different ways of satisfying those needs – from zero private vehicles to one for every driver in the household – and the costs of each scenario. Chosen scenarios would link to vendors.

This description is for an online portal, but a similar process could be tried face to face in various neighborhoods. It's the kind of process that could be funding by the Caltrans Community Planning Grant Program. Actual effectiveness could be tested through one or more pilot projects in order to evaluate marketing, design, cost-effectiveness, and scalability.

The recommended "decision tool" is essentially a "work-around" of the core problem, the value proposition (discussed next). The "decision tool" would change the focus from the value of the BEV compared to other vehicles to a focus on the value of the BEV for satisfying household mobility needs.

2. Improve the actual "value proposition" of BEVs

There is a reality to concern for the price-performance ratio of BEVs. The following table provides key information on most BEVs currently available on the market. This includes for each model the electric drive range between battery charges, the MSRP, the state cash subsidy (before SB 1275-related changes), and the price to the consumer net of the state subsidy (but not including the federal tax rebate whose value varies by income category).

Seven Honda Civic models have an MSRP of less than $20,000 with gas mileage around 28 MPG. It is difficult for many families to justify spending $25,000 to $35,000 for a vehicle that requires new practices and has limited utility because of limited range.

There are essentially two ways to improve the actual value proposition.

OEMs Improve the Product or Price

OEMs need to improve the product and/or lower the price. Better battery technology which will extend the range to 150-200 miles on a single charge is apparently due in 2016 or 2017 (the Tesla S currently has that range but that is a luxury car out of the price range of most families). Price may suffer but performance will improve. When participants claim they would be interested in BEVs with a 150-200 mile range, they don't say what they would be willing to pay to get it.

OEMs are working hard to overcome the limited range of BEVs between charges. While that is a valid strategy, Drive the Future demonstrated that the actual "need" for longer range is limited to a fraction of the households. This suggests that lower pricing could be more effective than longer range.

Some relatively small changes to the vehicle could help. An inaccurate "fuel gauge" that displays remaining electric charge was a nearly universal complaint regardless of the model being driven. Slightly more cabin space and/or cargo space would help. More efficient air conditioning to reduce battery drain would have a significant impact. Accurate information about the battery drain for the various equipment pieces would mitigate the need for more efficiency. Many people sweltered in heat rather than chance using the air conditioning because they could not anticipate the consequences.

Government Increases Subsidies or Changes the Allocation Schedule

The California Air Resources Board (CARB) currently subsidizes electric vehicles by providing cash rebates through the Clean Vehicle Rebate Project (CVRP) of its Air Quality Improvement Program (AQIP). CARB is in the process of redesigning the rebate schedule in compliance with SB 1275. One significant change will be to add an income component to eligibility criteria in an effort to expand electric vehicle access to middle and lower income households.

Rebate phase-out schedules are tied to penetration levels, but it may be that the later adopters need the subsidy more than early adopters. Drive the Future participants were not early adopters but more of a cross section of the market that must be penetrated in order to accelerate sales of BEVs. Most of that group will not become more willing to purchase electric because the early adopters have, although expansion of the charging infrastructure over time should make a difference.

Moving away from favoring large battery size in the CVRP would radically change the BEV/NEV markets. As the table below shows, big battery BEVs are eligible for $2,500 cash rebate while PHEVs with smaller batteries are eligible for $1,500. NEVs are eligible for about $1,000 rebate.

Table 14: Current Market for BEV and PEV Vehicles

	Electric Miles	Price	Federal Tax Credit	CA Subsidy	Price - CA Subsidy
BEV					
BMW i3	81	$ 41,350	$ 7,500	$ 2,500	$ 38,850
BYD e6	127	$ 35,000	$ 7,500	$ 2,500	$ 32,500
Fiat 500e	87	$ 31,800	$ 7,500	$ 2,500	$ 29,300
Ford Focus	76	$ 29,170	$ 7,500	$ 2,500	$ 26,670
Chevrolet Spark	82	$ 25,170	$ 7,500	$ 2,500	$ 22,670
Mitsubishi I-MiEV	62	$ 22,995	$ 7,500	$ 2,500	$ 20,495
Nissan Leaf	84	$ 29,010	$ 7,500	$ 2,500	$ 26,510
VW e-Golf	83	$ 36,300	$ 7,500	$ 2,500	$ 33,800
Tesla Model S	265	$69,900-$106,200	$ 7,500	$ 2,500	$67,400-$103,700
Kia Soul EV	93	$ 34,500	$ 7,500	$ 2,500	$ 32,000
Plug-in Hybrid					
BMW i3 REX	81	$ 41,350	$ 7,500.00	$ 1,500	$ 39,850
Ford C-Max Energi	20	$ 32,600	$ 4,007.00	$ 1,500	$ 31,100
Ford Fushion Energi	20	$ 34,800	$ 4,007.00	$ 1,500	$ 33,300
Cadillac ELR	37	$ 76,000	$ 7,500.00	$ 1,500	$ 74,500
Chevrolet Volt	38	$ 34,345	$ 7,500.00	$ 1,500	$ 32,845
Honda Accord	13	$ 40,700	$ 3,626.00	$ 1,500	$ 39,200
Porsche Panamera S E-Hybrid	22	$ 99,000	$ 4,752.00	$ 1,500	$ 97,500
Porsche 918 Spyder	18	$845,000	$ 3,667.00	$ 1,500	########
Toyota Prius Plug-in	11	$ 29,990	$ 2,500.00	$ 1,500	$ 28,490

That rebate schedule makes sense on the surface. Batteries capable of longer range will produce more VMT per trip; small battery short range vehicles will generate many fewer miles per trip.

The problem is that in built-out suburbs like the South Bay, the destinations on average are very close to home – 60% are less than two miles from home, 90% less than 8 miles, and 99% closer than 20 miles. The largest amount of VMT is generated on short trips because of their extremely high volume. Eliminating the cold starts associated with the many short trips would more effectively improve air quality than will VMT reduction.

Offering the largest rebates for the smallest battery pack would drive the NEV market and encourage OEMs to market a BEV with less range. A small battery strategy would also encourage cities to retrofit the built environment in order to reduce VMT, especially ICE miles, consistent with SB 375. It would lower the threshold price of driving electric. It would help consumers purchase what they need, which in some situations is less battery rather than more.

Fuel cell electric vehicles (FCEV) under the proposed subsidy schedule could be eligible for a $5,000 rebate. FCEVs are now and in the future will likely occupy the high end, luxury niche. If a $5,000 rebate was offered on an NEV, the final price to consumers would be between $4,000 and $5,000. At that price NEVs would fly into many garages.

3. Improve the perceived value proposition

Separate from the actual value proposition, there is also the value perception by the drivers.

Few people embrace change. Relying 100% on batteries for driving is in the minds of many a huge change – from the on-the-ground reality of household practices to the high level of metaphor. Being able to go anywhere, door-to-door, anytime is embedded in the American sense of freedom. BEVs appear to challenge that freedom.

This is where the personality characteristics of individual drivers come into play. People have very different levels of tolerance for change of any kind, inconvenience, risk, and anxiety. This transcends the rational benefits of the technology.

One measure of the perception problem can be approximated by comparing the price per electric mile of range. BEVs cost around $350 per electric mile (plus or minus about 10%) and PHEVs cost about $1,600 per electric mile (excluding the luxury models -- the Chevrolet Volt is an especially good PHEV option at $860 per electric mile).

That additional $1,250 per vehicle is what consumers pay in order to drive mostly electric with no range anxiety or burdensome route planning sessions. It approximates the monetary value of anxiety. This logic is reflected in the marketplace where PHEVs make up about 2/3 of PEV sales/leases. This despite higher operating costs because gasoline is necessary.

There are limited strategies for improving the perception of the value proposition.

One is the advertising messages used by the industry. The vehicle could be characterized as an extended range local car rather than a limited range regional car. The burden of home fueling could be turned into a significant convenience and a benefit by reducing dependence on gasoline and its price instability.

Another barrier is the expectations of consumers. BEVs look like a gasoline fueled vehicle so they are expected to perform the same. Performance in this case refers to fueling (electric drive is more efficient than internal combustion so BEV acceleration is actually much faster) where 5 minute refueling stops

are the norm with gasoline. Something could be done through an attractive design to brand limited-range vehicles as futuristic.

All levels of government could help improve the image of BEVs through aggressive information and education initiatives. The decision tool previously recommended would also help address the perceived value issue.

4. Increase the BEV options

When considering improving the product, OEMs and CARB should ask whether the existing BEV models are the right product. It appears to be too limited to be a regional car and too much car to be just a local vehicle.

There have been various efforts over the last few years to bring a medium speed electric vehicle (MSEV) to market. The original idea was to enhance the slow speed electric vehicle (NEV) limited to 25 MPH and 25 mile range to run at 35 MPH and 25 mile range. This vehicle option was mentioned by many of the drivers participating in the NEV demonstration. (BEV drivers want more range, NEV drivers want more speed and they both want a lower price.)

This would constitute a new vehicle class and NHTSA would require crash testing and onboard air bags. Those requirements would explode the economic viability of growing an MSEV out of an NEV.

The existing BEVs have all been crash tested and carry air bags and so would not face the same barriers. An MSEV could be created by reducing the battery pack so that BEV performance would be reduced to something like 45 MPH and 45 mile range. Although there has been no engineering input on this proposal, if it's technically feasible we estimate that the price could be dropped to between $4,000 and $6,000 a vehicle.

This could expand the sales of the basic BEV platform by fitting it into two markets with the third coming with batteries that offer longer range. This proposal suggests a general idea of restructuring market supply around four combinations of price-range-maximum speed (see table below).

Table 15: Proposed BEV Market by Speed, Range and Price

BEV Type	Speed (MPH)	Range (Miles)	Target Price ($)
NEV	25	25 Miles	6,000
MSEV	35-40	35-40	12,000 to 15,000
BEV	Full Speed	80-100	20,000 to 25,000
BEV +	Full Speed	150-200	30,000 to 40,000
Luxury	Full Speed	250	85,000 +

The target prices are estimates of what would provide a good value proposition and lead to the levels of PEV sales that would meet the targets needed for the transportation system to become sustainable. The market can be accelerated by providing consumers with as many different speed and range characteristics that can be produced.

5. Expand the Markets for BEVs

Two segments of the population are currently not engaged in the BEV marketplace – used car buyers and lower income consumers.

Some families – we had one in Drive the Future – simply never purchase a new vehicle. Depreciation is typically so high that the value-proposition is difficult to identify. As the original 3 year leases of 2012 and 2013 expire, thousands of used BEVs will become available. Perhaps CARB's AQIP program is developing some sort of moderate subsidy program for used car buyers. But if not, it should consider doing so.

Middle and lower income families are good targets to receive subsidies for purchasing a new BEV. Those groups are not in the market for new cars because they lack the resources (as opposed to disliking the value proposition). Savings from passing the gas station will be most important to a lower income market segment, and not nearly as much to the early adopters.

SB 1275 has directed CARB to address this problem. People with less income should be eligible for a larger rebate. Various approaches to income verification and enforcement are under consideration. Not mentioned so far is simply using CALEPA's existing "disadvantaged community" designation. Market acceleration and low/middle income households will be best served by low administrative costs.

OEMs and CARB should look beyond individual households as the target consumers as another approach for bringing ZEV access to disadvantaged communities. Since BEVs are specialized vehicles, any situation where the vehicles can be shared should be considered. This would include large apartment complexes, condos, blocks, neighborhoods, and so forth. Special rebates could be offered to such potential "group" consumers. The Access Hub in each neighborhood center envisioned in the South Bay Sustainable Strategy could be responsible for acquiring or organizing access to a modest fleet of BEVs that could be shared.

Community-based non-profits are a special case of where BEVs could be shared. Those serving disadvantaged communities could share vehicles but also make them available for local residents to drive as a ride sharing service. This would improve mobility for the transit dependent, create a few jobs, and improve the environment. To do so the CVRP would need to dramatically reduce the vehicle costs, provide financing assistance, and ensure liability coverage.

CARB recently initiated a program that will develop ZEV car sharing programs in disadvantaged communities. The solicitation specifically excluded NEVs and all other slow speed ZEVs from consideration in any car share or ride share application. Assuming many residents of disadvantaged

communities have local travel needs at least some of the time, and since slow speed vehicles cost much less than freeway speed vehicles and would therefore be affordable after the demonstration, we recommend that CARB consider slow speed vehicles eligible in the second round of funding.

6. Develop the support infrastructures

The charging infrastructure is the most obvious component needed. Home charging is the foundation for the new fueling paradigm. Because there was some debate about the level of service needed at home (Nissan among others at one time believed that Level 2 at home was essential; Plug-In America believed Level 1 would be sufficient) Drive the Future was designed to evaluate the need for Level 2.

The result is that for most cases Level 1 is sufficient. The long dwell time overnight makes it possible for drivers to start every day with a relatively complete charge. Access to lower rates off-peak hours will reinforce this practice once the scale of PEV deployment increases.

Residential Level 2 would help drivers who fail to plug-in on a regular schedule and take many daytime trips becoming good candidates to return home for a quick mid-day charge. Even for this group, a better public infrastructure would fill the gap.

Four location-types for Level 2 charging outside the home are needed:

- Employment centers – Only a handful of Drive the Future participants were able to charge at their work site. Comprehensive employment charging should be developed.
- Commercial centers with long dwell times. Work sites, other work related sites, schools and restaurants registered the longest dwell times in the project. Certain entertainment venues such as movie theaters and malls are also good candidates.
- Hot spots if none of the above: Where BEV drivers from different households visited.
- Neighborhood centers enhanced by Access Hubs once they are developed: These centers would by definition be within walking distance of every residence and could offer overnight charging for those who don't have it at home.

In addition, virtually every parking lot should provide a small number of Level 1 outlets as a public service so that they are essentially ubiquitous and free. Slow speed vehicles cannot charge on anything but a Level 1 outlet, so comprehensive access should help accelerate the market for them. Even a half hour charge while in the grocery market can provide a 1 to 2 mile boost in range. Hot spots with an hour minimal dwell times would be good places to cluster charging units.

Cities can contribute by deploying charging units in public places while encouraging employers, multi-family building owners and retail center owners to do the same. A number of local government initiatives can help, including online electric permits, fast inspections, municipal ordinances that establish building standards for renovations and so forth.

Complete streets are a second infrastructure component usually overlooked in the program to make cities more PEV friendly. Complete streets that accommodate slow speed vehicles will help stimulate the low end of the PEV market.

Signage to direct drivers to charging facilities and to slow speed lanes should be part of the PEV ecology.

7. Credit BEVs and destination compaction as a legitimate strategy for complying with SB 375

SB 375 requires that the state's metropolitan planning organizations (MPO) include a Sustainable Communities Strategy (SCS) in Regional Transportation Plans (RTP) that will demonstrate the capacity to reduce GHG emissions from vehicle travel that contribute to climate change. The SCS must show how land use patterns are integrated with transportation investments and Regional Housing Needs Allocations in a way that helps reduce GHG emissions from regional travel.

Three of the four strategies in SCAG's SCS include:

• Focusing new growth in existing and emerging population centers and along major transportation corridors;

• Targeting growth around existing and planned transit stations; and,

• Creating significant areas of mixed use development and walkable communities;

The first two rely on a public transit mobility strategy to reduce ICE vehicles generated by increased density. This is a questionable strategy anywhere in Los Angeles County which has a journey-to-work transit mode share of 7.4% (82.9% drive alone or car pool) and especially in the South Bay with a 5.5% transit mode share (86.4% drive alone or car pool). In addition, the journey to work generates only slightly more than 20% of the total trips; transit mode share is much lower for non-work trips because they are typically too long to walk and too short for transit. (LA Metro South Bay Mobility Matrix, Baseline Report, Cambridge Systematics, 2015)

The third strategy, encouraging mixed-use development, has no particular meaning in built out suburban regions like the South Bay since horizontal mixed use communities define the existing development pattern. At a finer grain, the issues include the right mix of destinations that satisfy residents' travel needs, the proximity to the closest mixed use center, and a mobility system that facilitates circulating between the mixed-use centers.

Essentially the density-transit strategy dominates compliance with SB375, yet it is not a good fit in the South Bay, nor for other similar built-out, transit poor suburban regions.

Improving the efficiency of vehicle fuels is not currently considered a legitimate strategy for complying with SB 375. The targets apply to the transportation-land use integration.

However, range limited vehicles like BEVs, MSEVs, NEVs, Segways, electric skate boards, scooters and a host of other existing and emerging slow speed vehicles are as different a mode from ICE vehicles as are bicycles. The reactions of participants in Drive the Future demonstrate that fact.

Range limited vehicles require a suite of land use policies that make a region's destinations more compact (not residentially dense, vertical mixed use, or transit oriented). Range limited vehicles increase in utility as compactness increases. The range of network transportation services such as car and ride sharing are especially effective in compact regions with short average trip distances.

In the compact destinations scenario, the public transportation investments would focus on charging infrastructure and complete streets that would coordinate with the large amount of private capital investment in vehicle manufacture and fleets for delivering mobility services. That will support the hundreds of thousands of individual households purchasing vehicles that function well in a compact environment.

SB 375 credit for this strategy would encourage cities to become more compact through policies that encourage "neighborhood oriented development" and encourage MPOs, such as SCAG, to work with County Transportation Commissions to balance regional system investments with investments in local circulation systems.

8. Develop large scale, high profile demonstration projects

The NEV demonstration deployed a 6 vehicle fleet and Drive the Future used 4 vehicles. The numbers were small in order to closely monitor their use. Small scale projects like this, while producing unique, high quality information, do not attract attention from the press or from decision centers in government. Recommendations typically do not get much traction with the industry, government agencies or consumers.

Large scale demonstrations that involve more participants and achieve a higher profile from the beginning could be one way to accelerate the market for BEVs and slow speed electrics.

The next set of demonstrations should be large scale with emphasis on making the vehicles highly visible on the street and with data collected from driver satisfaction surveys rather than GPS data.

While there are many options for the next round of demonstrations, the SBCCOG has formulated approaches to the following:

- A 1,000 vehicle NEV demonstration could be based on a partnership between a manufacturer providing heavily discounted vehicles, CARB or another state agency offering aggressive subsidies to lower the price to a $5,000 or $6,000 target, local governments developing complete streets with slow speed lanes and consumers willing to purchase the heavily discounted vehicles. A fleet of 1,000 NEVs in the South Bay or other cluster of cities can be expected to draw a great deal of attention to the slow speed option. This could also serve as a pilot project for testing the cost-effectiveness of large subsidies for slow speed vehicles.

- A demonstration that requires the participants to give up one or more ICE vehicles for an extended period of time in exchange for an array of options including BEVs, Segways, NEVs, electric skateboards as well as transit, ridesharing and carsharing is another possibility. This would combine the EV option with the array of mobility services now available.
- MSEVs can be tested by simply speed limiting a fleet of existing BEVs. Since the 35-40 MPH local vehicle range appeared to be at the sweet spot for sub-regional travel, the option should be demonstrated similar to the NEV and BEV projects.
- Various charge station deployment projects should be demonstrated, especially with employers. Joint use parking areas that can service employees during the day and adjacent apartment tenants at night has promise and is untested in practice.
- The Google self-driving car being tested in Northern California is limited to speeds of 25 MPH and is essentially a robot NEV. The SBCCOG has been developing applications for testing the Google car (or anything similar) which should also generate information about the potential for self-driving BEVs, especially the prospect for consumer acceptance.

9. Equip every sub-region and county to monitor its own electric vehicle marketplace

Measuring progress is a fundamental component of establishing goals. Standardized metrics and sources of data are necessary for key policy documents such as the RTP/SCS and the transportation chapter of a Climate Action Plan.

The SBCCOG is about to begin a 2 year trial subscription of vehicle market data that will track the volume of new registrations by vehicle type semi-annually by city. If the data trial successfully provides the feedback about changes in the vehicle mix following rollout of some BEV market acceleration initiative – the decision tool portal for example -- the data should be purchased on behalf of counties and COGs throughout the SCAG region. This is being considered now even before the SBCCOG trial.

As the leases of new BEVs expire in the coming years, a data source should be developed to assess and track the secondary and tertiary sales/leases of BEVs and PHEVs in this nascent used car marketplace.

A source of data for electric miles driven will also be needed. Composition of the vehicle fleet does not measure the ultimate goal, miles driven. The answer is clear once a 100% electric fleet has been achieved but that is many years off.

10. Encourage small scale innovation

The NEV and BEV demonstrations are examples of small scale innovations that produced information to inform policy and practice. CARB's recent "Targeted Car Sharing and Mobility Options in Disadvantaged Communities Pilot Project" is another good example of funding for small scale projects being implemented in various contexts. The Car Sharing Pilot will help learn more about how to accelerate the BEV market place and include more people in the benefits of electric drive technology. Many more similar projects are needed because meeting the challenge will require more innovation as quickly as possible.

Accelerating the market for electric vehicles is as complex and difficult as it is essential. If followed, the recommendations offered here would surely improve the chances of success. The SBCCOG is prepared to work collaboratively with local and state partners on further demonstrations to implement strategies that have the ability to achieve the state's goals.

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Appendix A - Literature Review

"ECOtotality EV Project"

2013

ECOtotality was awarded over $100M for the EV project from the United States Department of Energy in 2009. Over the course of the project through 2013, ECOtotality deployed over 15,000 charging stations in 18 cities located in the states: Oregon, Washington, California, Arizona, Tennessee, Texas and the District of Columbia. Partners included Nissan North America and General Motors/Chevrolet. Existing EV drivers in these cities who qualified to participate were given a residential charger at no cost along with installation services. Idaho National Laboratory was contracted to perform the data analytics.

The goals of the EV project were to 1. Assess vehicle use in different topographic areas and climate conditions, 2.Better understand charging infrastructure, and 3. Undertake revenue trials for commercial and public charging infrastructure.

For the duration of the project, a quarterly report on driving and charging statistics was produced. The last report was dated August 2013.[3] Statistics for the reports were aggregated to protect the privacy of the drivers. The final aggregate statistics reveal that over 2.9 million gallons of gasoline were avoided by the project from around 8,300 drivers, 762 of them in Los Angeles. Other statistics included the number of public level 2 charging, number of quick charges, percentage of home and away-from-home charging, distance driven, number of trips, average trip distance, and average distance between charging events for the entire study area and for the different urban areas. It should be noted that the drivers for the EV project represented a segment of the population that was willing, able and enthusiastic about driving EVs as they had already purchased their vehicles. Therefore, the study only highlights first adopters.

Although the program is no longer deploying charging units, they are still encouraging drivers to sign up for Blink Charging Membership. For more information on this program visit:
http://www.theevproject.com/index.php

"Plug-in electric vehicles. What role for Washington?"

Brookings Institute, February 1, 2009

http://www.brookings.edu/research/books/2009/pluginelectricvehicles

Abstract

Last year, oil provided more than 96 percent of the energy in our cars and trucks. This overwhelming dependence empowers our enemies, imperils the planet, and strains family budgets whenever world oil prices rise. What can be done? The single most important answer may be promoting the widespread use of plug-in electric vehicles. This important book examines the role that the U.S. government can and

[3] http://www.theevproject.com/documents.php

should play in that mission.

Most major automakers have announced plans to market plug-in electric vehicles, which can generally be recharged with a simple extension cord. What is the national interest in putting millions of these cars and trucks on the road soon? What should the federal government do to help make that happen? Can federal tax or procurement policy play a role? Can federal research and development help? At what point would subsidies for plug-in electric vehicles begin to match subsidies for oil? Answers to these questions and more emerge in this timely, innovative, and provocative volume.

The editor of Plug-in Electric Vehicles is David B. Sandalow, an experienced expert in energy policy. His contributors include former government officials (e.g., former CIA Director James Woolsey), respected private sector analysts, NGO activists, and academic experts. Together they explain the current landscape for plug-in electrics and implications for national security, the environment, and the economy. They discuss what can and should be done to advance the role of plug-in electric vehicles.

"Transport Action Plan: Urban Electric Mobility Initiative"

UN Climate Summit, 2014

http://www.un.org/climatechange/summit/wp-content/uploads/sites/2/2014/09/TRANSPORT-Action-Plan-UEMI.pdf

Abstract

Objective

UN-Habitat has developed the Urban Electric Mobility Initiative with the specific objective of achieving the widespread adoption of electric vehicles in cities to reach a target where travel by electric vehicles makes up 30% of total urban travel by 2030.

UEMI will be implemented in the overall context of better urban planning and a balanced Avoid-Shift-Improve scenario, where *accessibility* is at the core of urban mobility and *access* for all to services, amenities and goods is considered as the overall goal of all transportation (UN-Habitat: Global Report on Human Settlements 2013: Planning and Design for Sustainable Urban Mobility).
The initiative will contribute significantly to:

- Reducing emissions from transport and limiting the increase in global mean temperature to two degrees Celsius;
- Reducing local air pollution and improving health;
- Delinking economic growth and prosperity from GHG emissions.

UEMI will have global coverage targeting at-least 100 cities in an incremental manner.

UEMI Actions

The UEMI calls for complementary actions by "supply side" and "demand side" actors. The supply side actors comprise Electric Vehicle, battery and automotive component manufacturers. Energy suppliers and distributors are also important supply side actors since the widespread transition to Electric Mobility should be accompanied also by the transition to cleaner energy sources. "Demand side" actors comprise city and national governments, people and also businesses. Multilateral Financial Institutions such as the World Bank and the Regional Development Banks are also important demand side players due to the potential investments they can make in EV infrastructure.

"Hybrid and Electric Vehicles: The Electric Drive Gains Traction"

International Energy Agency, 2013

http://www.ieahev.org/assets/1/7/IA-HEV_Annual_Report_May_2013_3MB.pdf

Abstract

Report structure

This report consists of four main parts. Part A "About IA-HEV" describes the Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV), its activities, and its plans for the coming years. The Chairperson's message in chapter 1 includes a summary of IA-HEV activities in 2012, as well as the current structure of the IA-HEV today. Chapter 2 explains the relationship between IA-HEV and the International Energy Agency (IEA), as well as describing the IA-HEV history, results, and current working programme.

Part B "IA-HEV Tasks" presents the results of the work that is performed by the task forces, called Tasks, working under this Agreement to conduct research into specific topics of particular relevance to hybrid and electric vehicles.

A general picture of hybrid and electric vehicles (H&EVs) around the globe is painted in part C, "H&EVs worldwide". The first chapter (12) in this section gives the most recently available H&EV statistical information from all 17 member countries. More detailed information on H&EV activities in each IA-HEV member country is presented in chapters 13 through 29.

Finally, Part D gives practical information related to hybrid and electric vehicles and the Agreement, including a list of IA-HEV publications, definitions of vehicle categories, conversion factors for H&EV related units, a glossary of terms, abbreviations, and contact information of the IA-HEV Executive Committee and Task Operating Agents.

"Will Electric Vehicles Transform the US Vehicle Market?"

Harvard Business School Kennedy Center, 2011

http://belfercenter.ksg.harvard.edu/files/Lee%20Lovellette%20Electric%20Vehicles%20DP%202011%20web.pdf

Abstract

EXECUTIVE SUMMARY

For the past forty years, United States Presidents have repeatedly called for a reduction in the country's dependence on fossil fuels in general and foreign oil specifically. Stronger efficiency standards and higher taxes on motor fuels are a step in this direction, but achieving even greater reductions in oil consumption will require changing the way Americans power their transportation system. Some officials advocate the electrification of the passenger vehicle fleet as a path to meeting this goal. The Obama administration has, for example, embraced a goal of having one million electric-powered vehicles on U.S. roads by 2015, while others proposed a medium-term goal where electric vehicles would consist of 20% of the passenger vehicle fleet by 2030—approximately 30 million electric vehicles.

The technology itself is not in question—many of the global automobile companies are planning to sell plug-in hybrid electric vehicles (PHEVs) and/or battery electric vehicles (BEVs) by 2012. The key question is, will Americans buy them?

The answer depends on four additional questions: 1. Is the cost of purchasing and operating an electric vehicle more or less expensive than the cost of a comparable conventional gasoline-powered vehicle? 2. Are the comparative costs likely to change over the next twenty years? 3. Do electric vehicles provide the same attributes as conventional cars, and if not, do the differences matter? 4. Will electric car owners be able to access the electricity needed to power their vehicles?

This paper attempts to answer these four questions.

There are two basic categories of electric vehicles—electric vehicles (BEVs), which run solely on the electric energy stored in the battery, and plug-in hybrid electric vehicles (PHEVs), which operate on both a rechargeable battery and a gasoline-powered engine. With both types of vehicles, the major incremental expense compared to a conventional vehicle is the cost of the battery. While the industry is working hard to reduce these costs, a battery in a BEV with an average range of 60-80 miles costs between $10,000 and $15,000. Hence, this paper compares the net present lifetime cost of electric vehicles with that of conventional cars, both at today's costs and at projected future costs. The paper also runs comparison scenarios with different assumptions about gasoline and electricity costs, battery costs, consumer discount rates, and vehicle efficiency levels.

"Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions"

Egbue, O. and Long, S. (2012)
***Energy Policy* 48. 717-729**

Abstract

Electric Vehicles (EVs) are promoted as a viable near-term vehicle technology to reduce dependence on fossil fuels and resulting greenhouse gas (GHG) emissions associated with conventional vehicles (CVs). In spite of the benefits of EVs, several obstacles need to be overcome before EVs will be widely adopted. A major barrier is that consumers tend to resist new technologies that are considered alien or unproved, thus, policy decisions that consider their critical concerns will have a higher level of success. This

research identifies potential socio-technical barriers to consumer adoption of EVs and determines if sustainability issues influence consumer decision to purchase an EV. This study provides valuable insights into preferences and perceptions of technology enthusiasts; individuals highly connected to technology development and better equipped to sort out the many differences between EVs and CVs. This group of individuals will likely be early adopters of EVs only if they perceive them to be superior in performance compared to CVs. These results can guide policymakers in crafting energy and transportation policy. It can also provide guidance to EV engineers' decision in incorporating consumer preference into EV engineering design.

Highlights

► We sampled technology enthusiasts to determine attitudes toward electric vehicles.

► Knowledge and perceptions differ across gender, age, and education groups.

► High degree of uncertainty is associated with electric vehicles.

► Battery range is the biggest concern followed by cost.

► Sustainability has less weight compared to electric vehicle cost and performance.

"The Electrification of the Automobile: From Conventional Hybrid, to Plug-in Hybrids, to Extended-Range Electric Vehicles"

Tate, E., Harpster, M., and Savagian, P. (2009).
***SAE Int. J. Passeng. Cars - Electron. Electr. Syst.* 1(1):156-166.**

Abstract

A key element of General Motors' Advanced Propulsion Technology Strategy is the electrification of the automobile. The objectives of this strategy are reduced fuel consumption, reduced emissions and increased energy security/diversification. The introduction of hybrid vehicles was one of the first steps as a result of this strategy. To determine future opportunities and direction, an extensive study was completed to better understand the ability of Plug-in Hybrid Electric Vehicles (PHEV) and Extended-Range Electric Vehicles (E-REV) to address societal challenges. The study evaluated real world representative driving datasets to understand actual vehicle usage. Vehicle simulations were conducted to evaluate the merits of PHEV and E-REV configurations.

As derivatives of conventional full hybrids, PHEVs have the potential to deliver a significant reduction in petroleum usage. However, the fuel consumption benefits are limited by the underlying constraints of the base hybrid systems and vehicles. Even with incremental electric power and speed improvements, the PHEV's lack of full-performance, all-electric capability requires engine operation under everyday speed and/or load conditions, regardless of available battery energy. This creates emissions concerns and can severely limit the actual all-electric driving range in the real world.

The E-REV is principally an Electric Vehicle (EV) with full vehicle performance available as an EV. Significantly, it overcomes the historical EV re-charge time limitations by adding a fuel-powered electric generator to extend driving range. Actual all-electric driving can regularly be experienced throughout the working energy range of the vehicle's battery without fear of being stranded. The E-REV offers the opportunity for petroleum independence, and a dramatic reduction in emissions for many drivers.

An E-REV traction drive and battery system needs to be specifically designed for the task. The systems are significantly more capable and larger than those designed for PHEVs. An E-REV is typically also architected to accommodate packaging of these systems while retaining performance and utility. The compelling benefits of the E-REV drive GM to address these challenges.

The study results indicate that both the PHEVs and the E-REVs can play a role in addressing future needs. The study shows that in the real world the PHEV is quite likely to run with blended operation, but the E-REV is very likely to remain in EV mode for most drivers.

GM is currently developing both PHEV and E-REV vehicles. The Saturn VUE Green Line PHEV is being developed as a derivative of the conventional 2-Mode Hybrid. The Chevrolet Volt E-REV is also under development with full performance, all-electric capability, but without practical range limitations.

"Mainstream consumers driving plug-in battery-electric and plug-in hybrid electric cars: A qualitative analysis of responses and evaluations"

Graham, R., Gardner, B., Abraham, C., Skippon, S. and Dittmar, H. (2012).
***Transportation Research Part A: Policy and Practice* 46. 140-153**

Abstract
Plug-in electric vehicles can potentially emit substantially lower CO_2 emissions than internal combustion engine vehicles, and so have the potential to reduce transport emissions without curtailing personal car use. Assessing the potential uptake of these new categories of vehicles requires an understanding of likely consumer responses. Previous in-depth explorations of appraisals and evaluations of electric vehicles have tended to focus on 'early adopters', who may not represent mainstream consumers. This paper reports a qualitative analysis of responses to electric cars, based on semi-structured interviews conducted with 40 UK non-commercial drivers (20 males, 20 females; age 24–70 years) at the end of a seven-day period of using a battery electric car (20 participants) or a plug-in hybrid car (20 participants). Six core categories of response were identified: (1) cost minimization; (2) vehicle confidence; (3) vehicle adaptation demands; (4) environmental beliefs; (5) impression management; and, underpinning all other categories, (6) the perception of electric cars generally as 'work in progress' products. Results highlight potential barriers to the uptake of current-generation (2010) plug-in electric cars by mainstream consumers. These include the prioritization of personal mobility needs over environmental benefits, concerns over the social desirability of electric vehicle use, and the expectation that rapid

technological and infrastructural developments will make current models obsolete. Implications for the potential uptake of future electric vehicles are discussed.

Highlights

► Qualitative analysis of mainstream drivers' responses to using plug-in electric cars.

► 40 UK drivers interviewed after a seven-day period of use of a plug-in electric car.

► Six thematic categories were identified.

► Current-generation electric cars were seen as 'works in progress.'

► Results highlight potential barriers to purchase and use of electric cars

Appendix B – Methodology

Data: Processing and Procedures

An Explanation of the Trip Metric Calculations

Basic Trip Data

Vehicle metrics were calculated using a customized Excel Spreadsheet. The Procedures and software are on file with the SBCCOG.

Raw data was delineated by date and time by specific GPS Coordinates so that basic trip information per stop and start times could be analyzed by type of BEV. GPS data points were collected every minute that the vehicle was running.

The data was formatted so that it could be used to analyze vehicle destination; vehicle emissions; vehicle parking; BEV charging; and, speed of vehicle in relation to posted street speed. Using Mapping software like Google Earth and Mapquest, destinations were coded using the following Destination Category Table:

Table 16: Destination Categories

Trip Purpose Code	Definition (examples)
Entertainment	Hollywood Bowl, Disneyland, Bowling Alleys, Movie Theater
Fast Food	traditional fast food, usually with drive-thru
Fueling	
Grocery Shopping	Ralph's, Von's, Whole Foods, Sprouts, etc., 99 c only store
Hardware	Home Depot, Lowes, Lumber Yards, OSH
Indoor Athletics	LA Fitness, Equinox, YMCA, 24 Hr etc.
Logistics	Post Office, UPS store, FedEx
Mall	Regional Malls like Del Amo, SB Galleria
Medical	Medical Offices, Dentist Offices
Municipal Services	City Hall, Library
Other	catch-all for destinations that are hard to decipher
Other Shopping	Riviera village, DT long beach, old downtown cores

Outdoor Rec	Parks, Hiking, Beach, sports fields
Personal Services	Salons, Dry Cleaners, Nails, Veterinarians
Pharmacy	CVS, Rite Aid
Quick Meals	Fast Casual type place - dwell time normally 15-40 minutes
Residence Visit	
Return Home	
School	Attend School
Specialty Grocery Shopping	Butcher, Fishmonger, small ethnic grocer
Vehicle Services	Car Wash, Car Repair, Car Dealers
Work Related	Errands done that are for work. Ex - RE agent showing homes
Work Site	

Additionally, property lot type, type of building parking and type of street was coded for each trip leg.

Hot Spot Analysis

Once the three areas were separated, an ArcGIS Optimized Hot Spot Analysis was performed on each of the areas. The process places a polygon over an area of interest and then determines spatial clustering giving each polygon a confidence interval of clustering. From here, polygons with a GiBin greater than or equal to 3, representing 99% confidence that clustering occurs within the polygon, were selected for each area. Stops within the cells were counted and the selected polygons were sorted by the top 10 polygons in terms of stops. A visual scan was performed for the top ranking clusters. It was evident that high-ranking polygons were similar for Beach, Inland and Peninsula stops and so all three were considered together and well as separately. Pings were dropped into the densest clusters and ½ mile radii were drawn around each cluster center.

Appendix C - Operational Manual for Battery Electric Vehicle Demonstration

BEV Program Overview:

Funding for the Battery Electric Vehicle (BEVs) demonstration program was provided by the AQMD. The contract with AQMD had a not to exceed cost of $320,000 was billed on a fixed fee task completion basis. Invoices to the AQMD accompanied the completion of each task which included an Interim Report, a Draft Final Report, a Final Report, and Quarterly Reports. The interim report was due in April 2014, the Draft Final was due May 2015, and the Final Report was due in June 2015. These funds were intended to provide BEVs to 48 households over the course of the 2013-2014 calendar years for two months at a time. 3 BEVs were leased for this purpose and a 4th BEV was used on loan from the SCAQMD.

Vehicles included:

- Two Nissan Leafs
- One BMW Active-E*
- One Honda Fit EV

* The BMW Active-E was on loan from the SCAQMD for the first year and subsequently replaced with a second Honda Fit EV for the balance of the project.

BEV Technology - Definition

Battery Electric Vehicles are powered by storage batteries that must be plugged-in to some sort of electrical outlet – level 1(110v), level 2 (220/240v) or level 3 (DC fast charging). Other types of PEVs include plug-in hybrids (PHEV) that have some form of onboard gasoline-fueled motor that extends the range that can be driven by batteries alone; and, Neighborhood Electric Vehicles (NEV) that are a special sub-class of BEV that operate no faster than 25MPH and over very limited range, usually 20 to 25 miles. NEVs were tested in a previous study but other zero-emission vehicles such as PHEVs were not tested in this study nor were Fuel Cell Vehicles.

Battery electric vehicles (BEV) are full-sized, freeway speed, zero emission automobiles with a range limited by the size of the battery pack. Typically, the average maximum range for the BEVs tested in the study was approximately 80 miles. This is in contrast to Vehicles powered by internal combustion engines (ICE) that can “gas-up” in a manner of minutes at fueling stations - found ubiquitously around the region. This gives ICE vehicles (as well as PHEVs), an unlimited range in practice.

In contrast, all electric drive vehicles require a relatively lengthy period of time to “re-fuel” and, as a consequence, tend to be limited to the driving range allowed by a single full battery charge. An individual’s home tends to be the most likely place to charge the batteries, especially overnight when vehicles tend to be idle anyway. Because these are the early days of electric drive vehicles, a robust, supportive infrastructure for battery charging has not yet been developed. At some future time, assuming the PEV market continues to grow as predicted, the battery charging infrastructure will be

developed around work sites, commercial destinations (such as retail malls) and in public parking areas (such as in municipal parking lots or at on-street parking spaces).

Design

For the purposes of marketing, each vehicle was wrapped with LUV the South Bay - Drive the Future logos and GPS tracking equipment. This equipment was also used to collect information about electrical consumption and charging patterns from the two Nissan Leafs.

This program studied vehicle use patterns of each BEV in comparison with the existing household vehicles. The same GPS tracking technology was installed in each of the household's existing vehicles to establish a baseline for household travel demand. In addition to GPS data, drivers were asked to keep trip logs, complete a pre and post survey, and participate in a focus group.

Vehicles were provided at no charge to participants. Each participant signed a Vehicle License Agreement (VLA) before receiving a vehicle. Insurance was provided for these vehicles by the SBCCOG through a fleet policy with a $1000 deductible (per incident). Only individuals who had been submitted and approved by the insurance company were authorized to drive the vehicles.

Participants tested level one charging for two weeks before an offer to loan level two charge equipment was extended. The level two charging unit was loaned at no cost, but households that choose to borrow the equipment were responsible to ready their electrical wiring at their own expense.

Program Roles:

The BEV Program was staffed by the South Bay Cities Council of Governments' to fulfill the following program rolls:

Database design

GPS device installation

GPS and log data processing

GPS data analysis

Participant & Vehicle Management

- Recruitment
- Orientation/Training
- Site Visits
- Log collection
- Driver Profiles
- Focus Groups
- Rotation vehicle charging
- Vehicle service scheduled maintenance
- Insurance claim management

Invoicing and Reporting

BEV Time Schedule – from date of contract execution:

Contract Deliverables	Projected Deliverable Date
Acquire Fleet	2 months
Develop Deployment Plan	4 months
Prepare Vehicles and Charging Infrastructure	4 months
Deploy all Vehicles	5 months
Status Report 1	8 months
Status Report 2	12 months
Status Report 3	16 months
Interim Report	18 months
Status Report 4	20 months
Status Report 5	24 months
Draft Final Report	29 months
Submit Final Report and Two-Page Synopsis	30 months

BEV Program Processes:

Participant Selection

Applications and selection:

Applications for the program were submitted on the SBCCOG website (http://www.southbaycities.org/projects/electric-vehicles/drive-future/application). These applications were saved in a Google Doc titled "South Bay Electric Vehicle Demonstration Program Application" Eligible applications were applications from South Bay residents. Due to technical limitations in data collection abilities participants were not selected is they the following household vehicles:

- Older than 1996 (1998 was a safer cut off year due to inaccuracies in participant applications).

- Nor should they have had an Acura MDX (Acura's in general were problematic particularly the MDX).

Drive the future participant selection plan:

Participant selection for the Drive the Future Electric Vehicle Demonstration Program was based on research priorities. Four participating households were selected for each round of participation to drive a demonstration vehicle for up to two months. Given the two year total period of the demonstration a total of approximately 48 participating households were anticipated to be selected.

Research goals/targets include:

1. Representative Geographic Distribution of Participants
    a. Inland Cities 35% to 40%
    b. Beach Cities 20% to 30%
    c. Peninsula Cities 35 to 40%
2. Income Distribution
    a. 5% low income
    b. 60% to 65% middle income
    c. 30% to 35% high income
3. Multiple Family and Single Family Residences 50/50 target balance - 20/80 was likely due to electrical infrastructure limitations with multi-family residences
4. Electric Vehicle Readiness
    a. Access to 110 volt outlets in parking areas (50% target)
    b. Access to 110 and 220 volt outlets in parking areas (50% target)
    c. No access to electrical outlets in home parking areas (non-priority applicants)
5. Up to 6 former Local Use Vehicle demonstration program participants (for comparative data)
6. Buyer Readiness (considering a new car purchase in the next two years)

Participating Selection Goals

1. Representative Geographic Distribution of Participants
    a. 17 Inland
    b. 14 Beach
    c. 17 Peninsula
2. Income Distribution
    a. 2 low income
    b. 30 middle income
    c. 16 high income
3. Multiple Family and Single Family Residences 50/50 target balance
    a. 24 Multi Family Building participants
    b. 24 Single Family Building participants
4. Electric Vehicle Readiness
    a. 24 participants with Access to 110 volt outlets in parking areas
    b. 24 participants with Access to 110 and 220 volt outlets in parking areas
    c. No access to electrical outlets in home parking areas (No goal set)
5. Up to 6 former Local Use Vehicle demonstration program participants (for comparative data)
    a. 3 to 6 participants

Participant Management

Each participating household went through the following process:

a) Welcome Letter
b) Pre-Participation Survey
c) Program Orientation
d) Pre-Participation Household Visit
e) Vehicle Orientation
f) Mid-Study Check-up/Household Interview
g) Post-Participation Survey
h) Focus Group

Upon selection, participants were sent welcome emails that required their response confirming their ability and intent to participate in the program. The letter was linked to the pre-participation survey as well as a copy of the Vehicle License Agreement for the participant to review before his/her orientation.

Program orientation was typically held at the lunch hour on a Friday with a light lunch provided. At the orientation participants were introduced to the SBCCOG along with the structure and research goals of the BEV project. Drivers were walked through the detailed process, timeline, and expectations of the project including trip logs, important dates as well as advanced notice of the final focus group and post-participation survey.

During orientation the Vehicle License Agreements (VLA) were reviewed and signed by the participants. The term and specific vehicle information was added before the participant took possession of the vehicle. The VLA was then signed by the SBCCOG Executive Director, Jacki Bacharach, scanned and archived. The original copy of the VLA was also be kept in the paper file archives.

Directly following the program orientation GPS devices were installed in the available cars from each participant. All cars that were not available at the time of orientation required GPS installation; SBCCOG staff worked with participants to schedule installation at the earliest possible time.

Electric Vehicle orientations were one-on-one and were completed two weeks after the program orientations. This provided time for all household vehicles to have had a GPS installed so that a household travel demand baseline could be determined. In the orientation the participants were given signed copies of the VLA and were given a tour of the cars functions and features.

A 'participant check-up/household visit' was scheduled with each participant at approximately two weeks after the vehicle orientation. The check-up provided an opportunity to collect initial impressions, problem solve, and assess participants need for level two charging. If level two charging was desired AND the participant completed any necessary electrical upgrades then the equipment was loaned to the participant at no cost for the remaining duration of the project. Use of this equipment required the signing of an equipment use agreement. The GPS devices in the household's existing vehicles were removed at or around the time of the check-up.

Participants were sent reminder emails about the focus group and the BEV's return starting two weeks before they were scheduled. Emails to participants also included links and prompts to fill out the Post-participation survey before attending the focus group.

The Focus Group and the return of the vehicle were simultaneous in order to maximize participation in the focus group. The focus group was typically scheduled for a Thursday night from 5:30 to 7PM with a light dinner. Keys and remaining trip logs were collected from participants before they left the focus group. Additionally, participants who had not completed the Post-Participation Survey were given the opportunity to complete the survey at that time.

Vehicle Maintenance/Management

Vehicle Drop-off:

Unless scheduled maintenance was required vehicles were returned when participants arrived for the end of rotation Focus Group. Keys, FOBs and outstanding logs were returned at that time. On occasion, maintenance or servicing was required. In these instances, an early drop-off or pick-up at the household was arranged so that vehicle could be serviced and available as close to the pick-up date for the next round participant. At the time of drop-off vehicles were inspected for any damage that would be beyond normal wear and tear over the course of the rotation; any extraordinary damage was noted, photographed with follow-up if indicated; if necessary, the vehicles were washed and vacuumed on

Friday morning prior to participant training for the following rotation. Participants were encouraged to bring their respective vehicles back with a full charge.

Scheduled Servicing/Maintenance:

All vehicles were under lease agreements and the Program Administrator was notified by the respective dealerships of any routine service requirements and/or updates that might be necessary. SBCCOG staff worked to schedule and coordinate maintenance and servicing to minimize any loss of driving time during the study.

Unexpected Needs:

Participants were briefed at the Orientation and at the time of pick-up and training that any and all issues pertaining to major or significant mechanical problems and/or damage to the vehicle should be promptly reported. SBCCOG staff was the primary contact for these communications. Should servicing or repairs be needed documentation was created and the steps necessary to resolve the issue(s) were taken. These steps included working with participants' insurance companies to resolve and adjust damage claims that occurred during the course of a participant's rotation; third party vendors for repairs; and, for SBCCOG staff to be available to assist with charging issues or questions.

All other issues (i.e. programming the Vehicle's on-board systems, etc.) that did not rise to the level of mechanical or damage to the vehicles were documented in as part of the individual's narrative/story and participants were encouraged to "follow-up on their own…as if it were their new car" to resolve or understand these problems. In most cases these issues involved reading the owner's manual to understand specific operational features for their respective BEV.

Insurance Claims Management

Participants were briefed to inform SBCCOG staff should damage occur to a BEV that they were driving. When such incidents occurred, visual inspection, pictures and written documentation took place. SBCCOG staff worked with participants, insurance companies, third party vendors as well as police agencies to resolve and repair damage in the most cost effective and timely way possible.

Level Two Charger Loaning

At the time of the mid-study "check-in/Household Interview" participants were briefed on the opportunity to upgrade their home charging to a 220 charging unit. If the Participant was willing to test this charging option then a time was scheduled for the delivery of one of the loaner charging units. Upon delivery of the unit the participant signed the loan agreement with the promise that at the end of the rotation, arrangements would be made to return the charging unit. Documentation concerning the associated costs and any issues pertaining to the installation and use of the charging unit was noted in the Participants' individual report.

Equipment Installation & Software Update

The GPS logger equipment, servicing and technical support was provided by FleetCarma.

BEV Vehicles (GPS/Loggers):

All BEV vehicles were operational with no inherent issues concerning the collection and/or transmission of data. New drivers were instructed as to where the GPS equipment was located and how, if necessary, to "Power-Cycle" the equipment – that is, to unplug and re-plug the logger into the car's On-board Diagnostic (OBD) portal.

ICE Vehicles (GPS/Loggers):

As new participants were recruited into the program their ICE vehicles were wired with the FleetCarma GPS and Logger system. The following was used as a guide to the installation:

a) Prior to installation, note that there were no cut or damaged wires and that all connections were in proper order.
b) Note logger number and the Participant's ICE vehicle that will receive the unit.
c) Note the ICE vehicle's make/model; VIN; and License.
d) Starting with the antenna, affix it with Velcro to the top of the driver's left side dash board so that there was a clear view from the outside.
e) With care, pull the door flashing out so that antenna wire can be tucked into the space behind the flashing. Press the flashing back into place when this was done. Where this was not possible it may be necessary to open the side panel of the dash board and run the wire into this area. The goal was to make sure that the wire was as out of the way from possible contact as possible.
f) Working from under the driver's side, connect both the logger and the antenna to the modem.
g) Ensuring that there was sufficient wire available to plug in the logger to the OBD fix the modem in a secure position under the dash board. Tie-downs or Velcro stapes may be necessary; to secure the modem it may be necessary to secure the modem against or on to wire bunches or plastic pieces. The goal was to make sure that unintended contact by the driver will result in dislodging and/or disconnecting the equipment.
h) Plug the logger into the OBD port and note the flashing light pattern.
i) The logger should blink "Green" then stop.

j) The Participant should be briefed as to where the GPS equipment was located and how, if necessary, to "Power-Cycle" the equipment – that is, to unplug and re-plug the logger into the car's OBD portal.
k) A Driver's Log should be given to the Participant so that they can document their trips as a back-up to the GPS unit; they should be encouraged to keep the log in the car.
l) Add Vehicle to the following file after install (include date in the GPS start date column): Vehicle "Workbook Progress Tracking" Located in: Dropbox\Drive The Future Team Folder\Data\Calculated Data\Vehicle Metrix.

Troubleshooting loggers that do not provided data

The following issues were the known causes for missing data. Missing data was identified as vehicles that had not uploaded in two or more weekdays in a row. Problem diagnosis was via visual inspection of the equipment. The following were the procedures to "troubleshoot" logger problems:

- Unplugged Logger – plug it back in
- Ejected card. An ejected card will cause a red flashing light (look at the light for at least 15 seconds after plugging the logger in)– a remove and reinsert micro-SD card
- Corrupted card. Corrupted cards will cause a red flashing light (look at the light for at least 15 seconds after plugging the logger in). If corrupt, the card needs to be reformatted. The format for the file system should be FAT with a 32 kb allocation. Once reformatted the configuration files need to be reinstalled. The necessary files include a file with extension .ccl as well as one with .ccf and one with .ccw. These files were periodically updated by the vendor – if you reformat a card, notify the vendor so they can remotely update to the latest version.
- Damaged equipment. The GPS data cable coming from the antenna to the modem was prone to breaking (the break was actually in the receptacle on the modem. If this was the case the modem must be replaced. Cables on to and from the antenna can also be cut if installed improperly – it may be necessary to trace each cable to verify there were no damaged cables (only do this if all other problems had been ruled out. The vendor will split the cost of damaged equipment replacement 50/50 unless the damage was avoidable.

FleetCarma Software Update:

As each new ICE vehicle was installed with a GPS unit and Logger the FleetCarma Software needed to be updated to associate the new vehicle to the corresponding Logger. The following steps were followed:

1. Log on to the FleetCarma Portal.
2. Under the "Vehicle Tab", then click on the "Add New Vehicle" tab.
3. Enter appropriate information regarding the ICE Vehicle – NOTE LOGGER NUMBER – and save.
4. Click on "Admin" tab, then click on "Logger" tab.
5. Using the "Loggers" table find the Logger Name Column (left side) and the Corresponding Logger number for the ICE vehicle that was just saved.
6. Click on the "edit" icon (right side of row).
7. Using the drop-down box find and click on the new ICE vehicle and save.

8. Check status within the next hour and the following day to make sure that there the logger was communicating properly.

Data

GPS Data Collection

GPS Data was collected using the FleetCarma vendor. This data was transferred via the cell network to the FleetCarma database. The database was accessed through a web portal at www.fleetCarma.com. Data was retrieved from the portal for processing (see Data Processing and Procedures)

Divers Log Data Collection

At the time of orientation participants were trained to keep a hard-copy record or "log" of all of their trips taken in both their regular ICE vehicles and BEVs. Logs information included Household Driver's Name; Time & Date of Trip; Trip Purpose (i.e. Grocery Shopping, School, etc.); where they parked; and, EV charging information. Participants were also encouraged to note any other information or feelings that they found pertinent or informative to their driving or charging experience.

Survey Data Collection

Survey data was collected on a Google doc based on surveys taken as a result of participant management activities. The Surveys were downloaded as a spreadsheet and added to the database. Each survey response started with a Household Name that was identical to that used in the vehicle trip reporting metrics. The data was cross analyzed so that it could be coded and compared with the trip metrics or queries from the trip metrics that were grouped by Household Name.

Focus Group Data Collection

Focus Groups were recorded via an audio and video recorder. The recording was played back and responses regarding particular research interest were recorded and categorized in narrative format for each household. These responses were used for the qualitative analysis and to further understand results derived from the quantitative analysis in the database.

Progress Reporting, Invoicing and the Final Report

Progress Reports, invoices and the Final Report were prepared and submitted according to contracted deliverable dates.

Appendix D – Survey Results

BEV Survey on the Importance of Public Charging

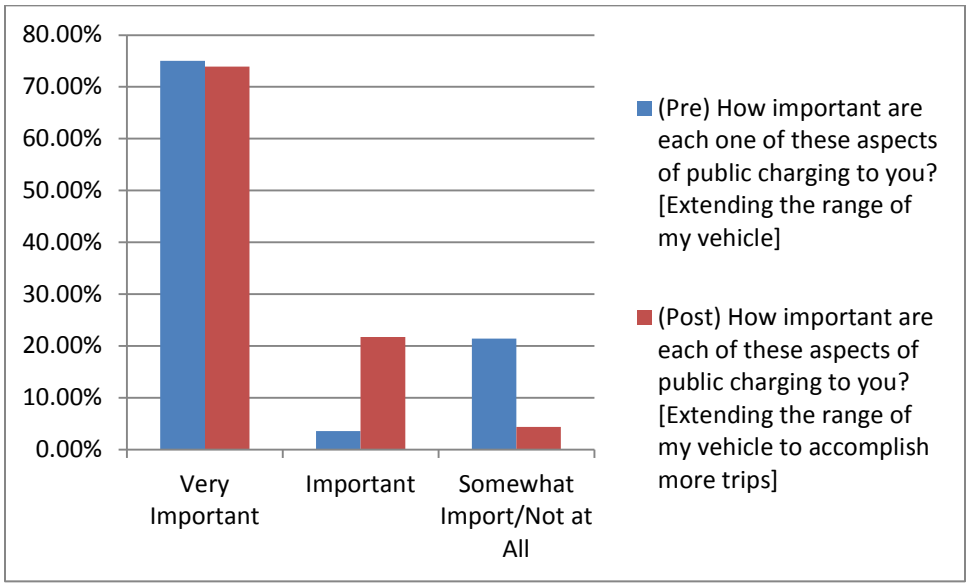
The following three charts describe the participants' perceptions of the value of public charging stations. The survey asked participants prior to and after driving the BEV the importance of public charging to extending the range of the EV; alleviating their fear of running out of power (range anxiety); and, the importance of getting a better parking spot because of the dedicated parking spots for charging.

(Pre Survey n=28; Post Survey n=48)

Public Charging - Importance of Extending the Range of the EV

Prior to their participation, 75% of participants expected that public charging would be important to extending the EV's range. Following their experience as BEV drivers, the relative importance to range extension changed upwards with a combined 95% of participants reporting that public charging stations are either "very important" or "important."

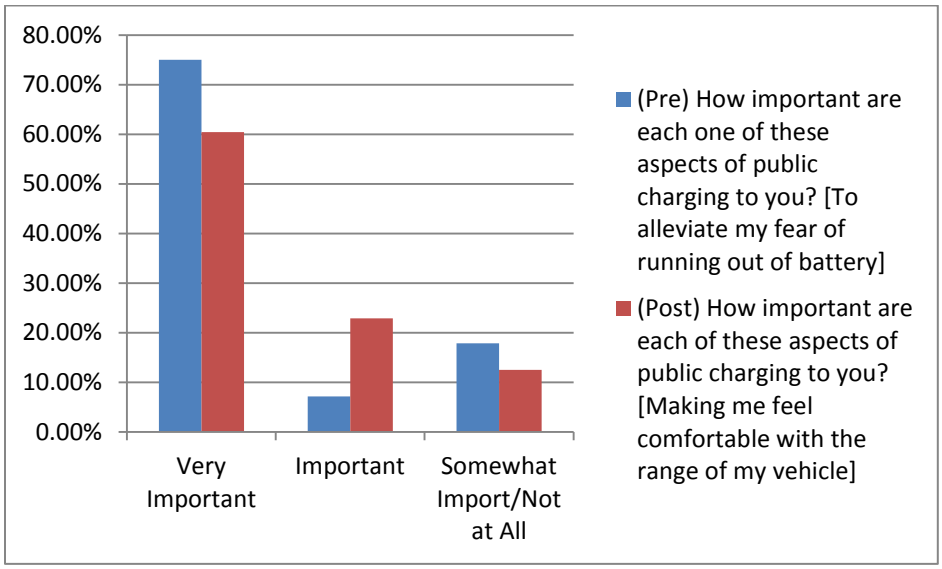
Figure 25: Public Charging and the Importance of Extending the Range of the BEV



Public Charging – Mitigating Range Anxiety

The role of public charging stations to mitigating range anxiety (fear of running out of battery) was seen as either "very important" to "important" by more than 75% of all participants both before they tested the BEV and after driving the EV.

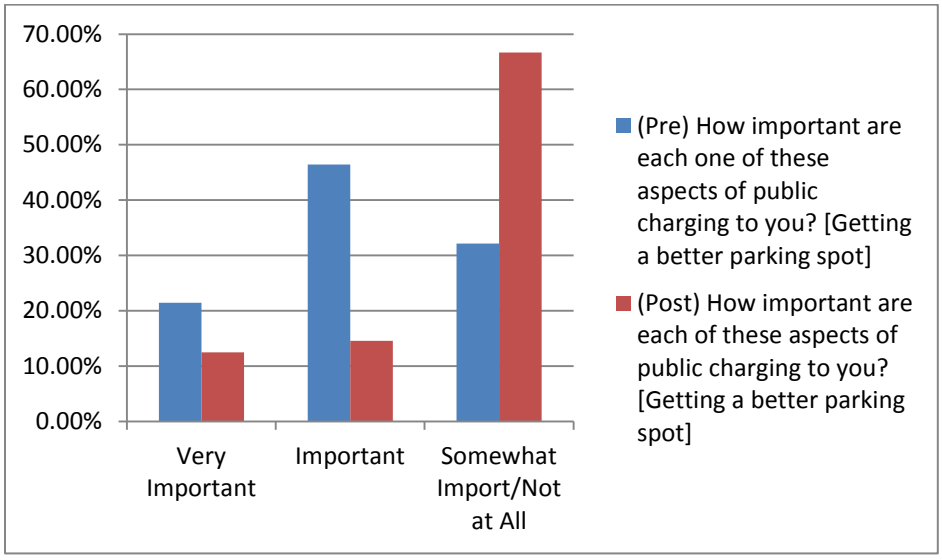
Figure 26: Public Charging and Mitigating Range Anxiety



Public Charging – Getting a Better Parking Spot

Prior to participating almost 70% of the study participants felt that "getting a better parking spot" was either very important or important. After driving their respective BEV's this perception changed as fully 65% of all participants stated that it was only "somewhat" to "not at all important."

Figure 27: Public Charging and Parking



BEV Pre/Post Survey Results

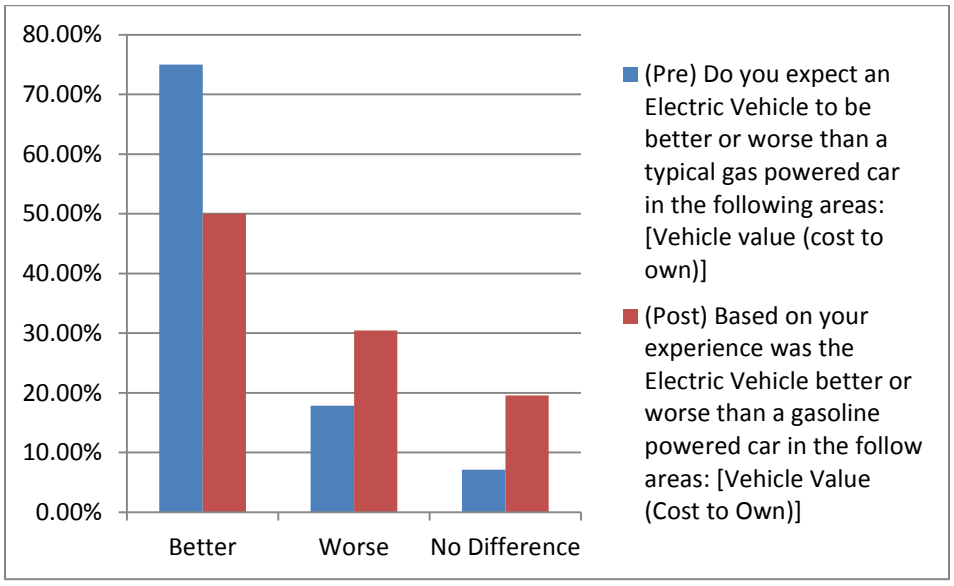
The following three charts describe the participants' comparative expectations between a gas powered vehicle and an electric car. Participants were surveyed prior to and after participating as a BEV driver.

(Pre Survey n=28; Post Survey n=48)

Vehicle Value (Cost to Own)

Before participating in the study 75% of participants' perceived the value of the electric car to be better than that of a typical gas powered car. However, following their test of a BEV and the knowledge they gained through their experience of using it and/or choosing to use their family car their perception changed. Only 50% of the BEV participants thought that an electric car was a better value (cost to own) than a typical gas powered car.

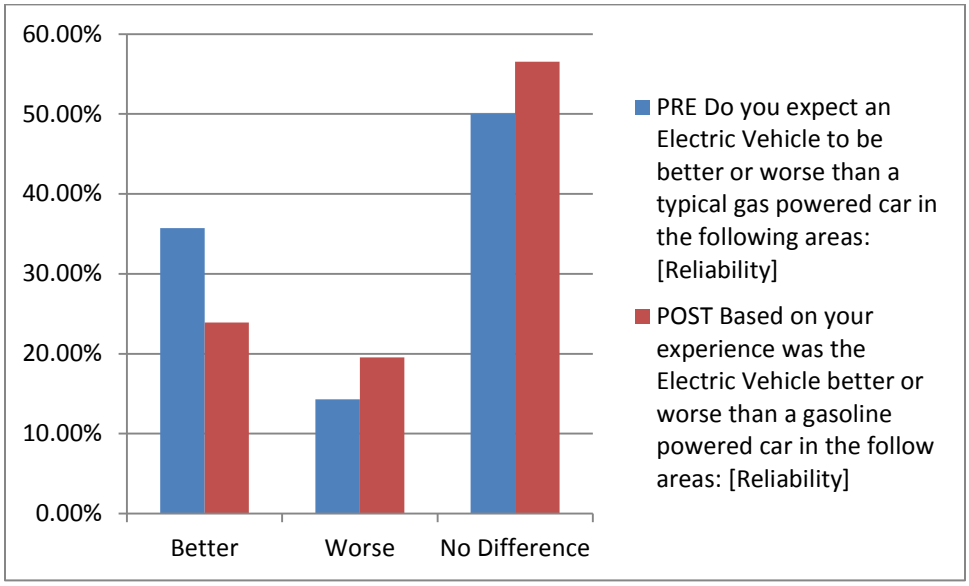
Figure 28: Comparison of Vehicle Cost to Own



Reliability

Generally speaking, participants did not see any difference in the reliability between a gas-powered car and an electric car, either before or after test the BEV. The relative change between those that thought the EV would be "better" to the increase in those that thought it was "worse" might be explained by mechanical challenges or poor experiences while driving the EV.

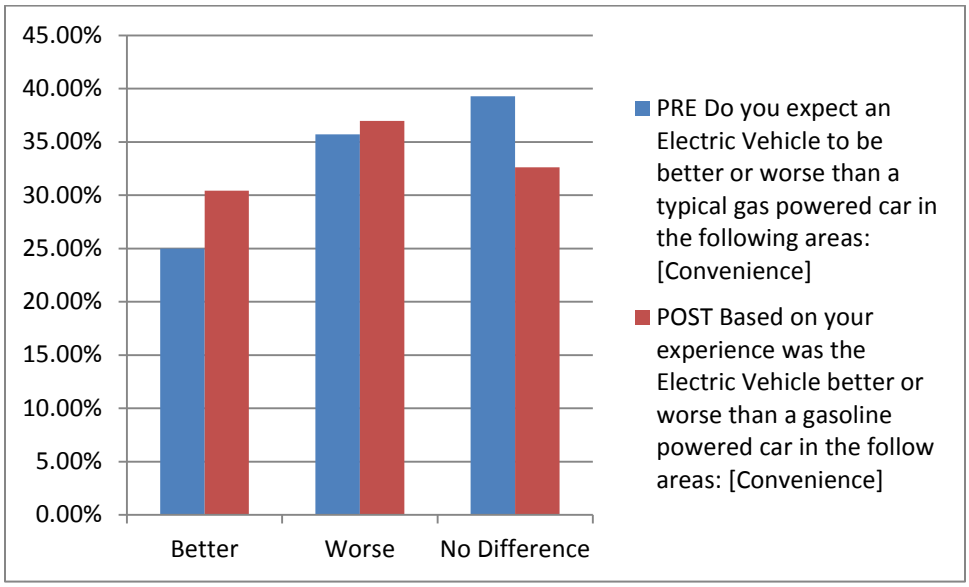
Figure 29: Comparison of Reliability



Convenience

The graph below suggests that there was very little difference between the pre-post survey results regarding "convenience." The participants' expectations for the "convenience" of an EV over a gas-powered car were that there would be no difference or that it would be better with only 36% suggesting that it would be worse. After participating in the study this figure remained (more or less) the same as did their perception that the convenience would be worse.

Figure 30: Comparison of Convenience BEV to ICE



Pre/Post Survey of Barriers to Daily Use

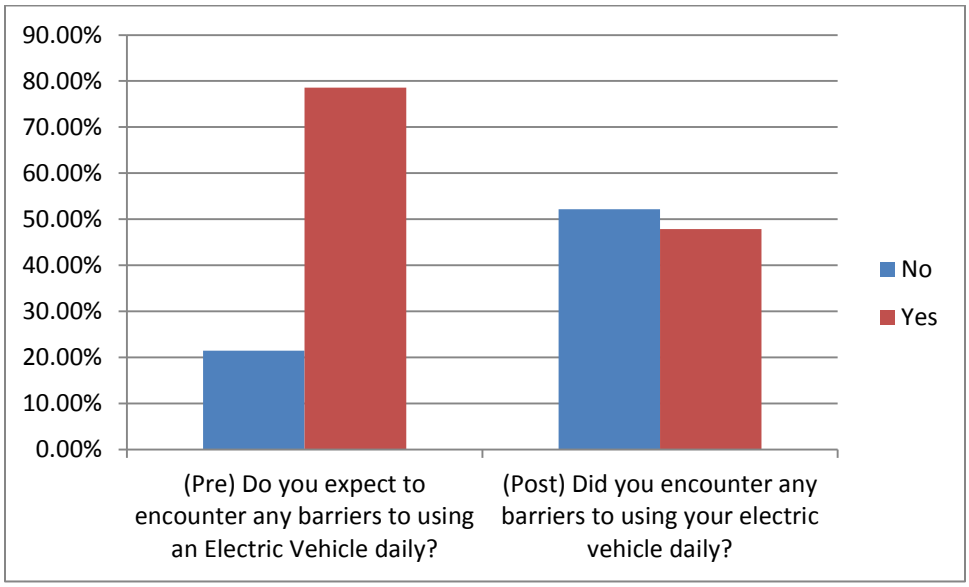
The following graph compares the participants' expectations about encountering barriers to using an electric vehicle prior to driving a BEV and with their experience afterward driving. It suggests that there was both ease of use as well as unexpected challenges to the participants' daily use of their BEV.

Almost 80% of the participants expected barriers to the daily use of an electric vehicle however, after driving the EV those that actually did report barriers, the number dropped to less than 50%.

Looked at from another direction, a little more than 20% of participants did not think that they would encounter challenges to their daily use of an EV however, after driving their electric cars that number rose to slightly more than 50% of the participants in the study.

(Pre Survey n=28; Post Survey n=48)

Figure 31: Comparison of Barriers to Use of BEV



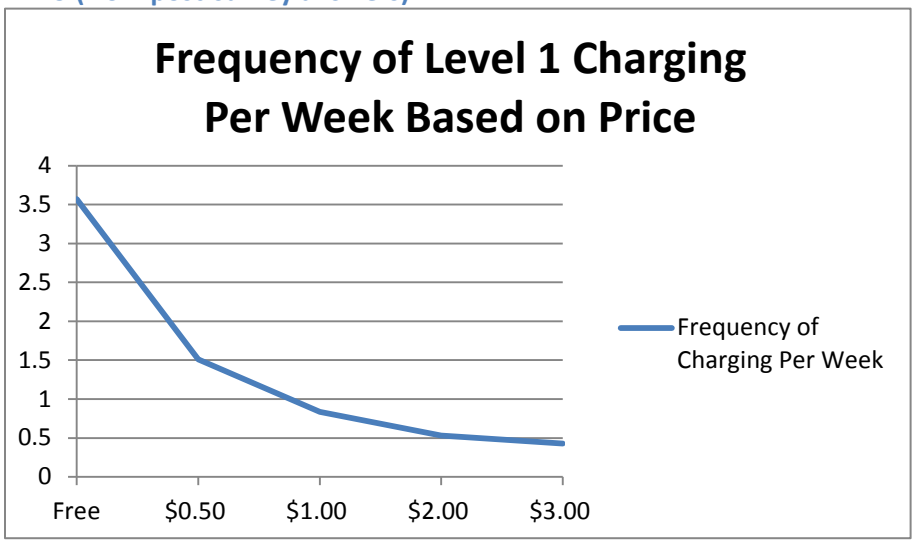
Post Participation Survey Results – Price Sensitivity and Charging

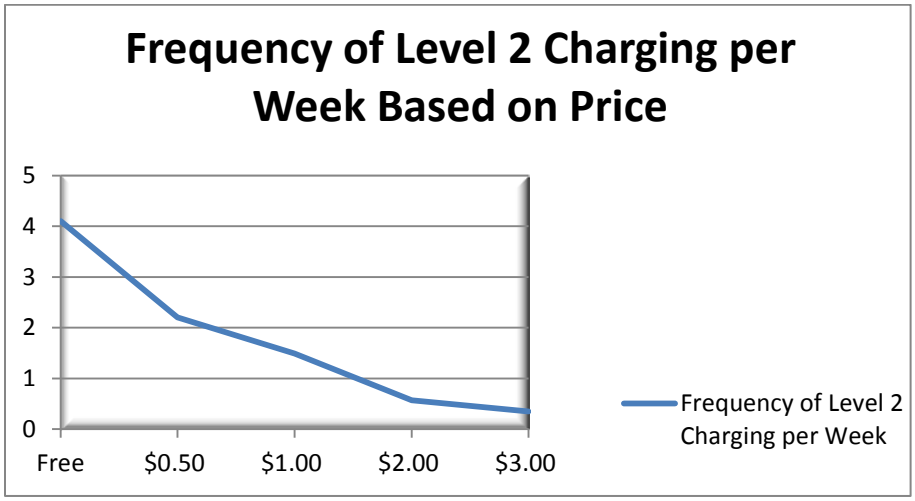
After completing their experience as BEV drivers, participants were asked about opportunity charging outside the home. Participants were asked, by type of charging (Level 1, Level 2, and DC 3 Fast Charge) how often they would charge (per week) and how much they would pay to charge using different types of charging. The following 3 charts describe BEV participants' sensitivity to price for opportunity charging outside the home based on type of charging

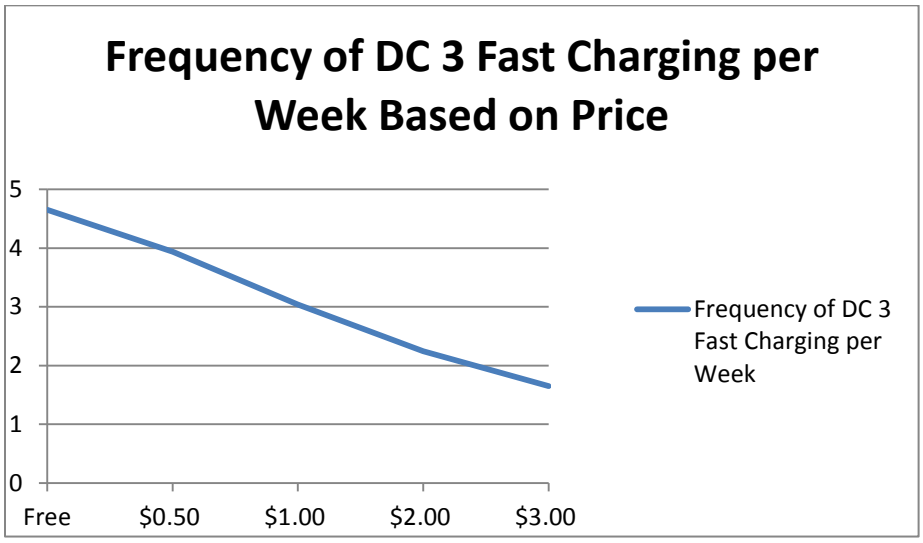
As expected, all participants described that they would charge more frequently no matter and independent of charging type. Price sensitivity is shown in both Level 1 and Level 2 charging as frequency of charging per week drops by half when participants were asked if they would pay fifty cents to charge. Frequency of charging continues to drop, diminishing almost to zero times per week, as price increases upwards towards $3.00.

In terms of DC 3 Fast Charging, there is also a drop off in frequency of charging once price is introduced; however, the decline in use (frequency of charging) is much less dramatic with participants describing that they would charge four times per week with a basic charging cost of 50 cents. Moreover, they would be willing to pay to use DC 3 Fast Charging several times per week even when the price increases towards $3.00.

Figure 32: Frequency of Charging by Type of EVCS (per week) Based on Price N=49 (from post-survey answers)







Appendix E – Household Studies

Table of Contents

Rotation #1

Household 1

Participant: Household 1

City of Residence: Gardena

Date: 12/14/12 – 3/13/13

Age: 37, 34, 13, 11

ICE Vehicles: Mitsubishi Outlander, Ford Expedition

EV: Honda Fit EV

EV Start Date: 1/15/14

EV – TOTAL VMT: 1,211.7 miles

EV Average VMT per Day: 28.85 miles

Overall:

Shantel, her husband Moses and two young sons lived in Gardena in a single family home and were very enthusiastic drivers of the Honda Fit EV. The HOUSEHOLD 1 family "really loved" driving their EV, so much so that it "pretty much" replaced one of the family's large SUV's for all local trips. One might say the Fit EV was a good fit for their family's life style and transportation needs.

During the course of the project the HOUSEHOLD 1 used a two-fold strategy of nightly charging as well as the occasional opportunity charge during the day (typically, during lunch breaks). Generally speaking, the electric vehicle was used as the family's commute vehicle to a common work location for both Moses and Shantel; their children commuted as well, in the sense their parents dropped them off along the way to work and would pick them up at the end of their school day.

Charging Strategy:

Shantel adopted a strategy of primarily charging at home using their 110 outlet that was located in the family washing/drying area; it was convenient to the side door where the Honda Fit would be parked. Typically, the family charged the car each evening ending in the morning before taking their children to school – approximately 10 hours. On most days they would leave the house with approximately 90 to 100 percent charge. However, it should be noted that on one occasion, when the battery was almost

drained entirely (to less than 2 miles of range), it took an extraordinarily long time (15 hours) to "even just charge it back to 50 percent."

On several occasions, Moses would use his lunch time to opportunity charge at the free charging station provided by the City of Lakewood – the choice for using this location was based on the convenience that it was only a few minutes from his work location near the Long Beach Airport as well as the fact that the cost was free. These lunch time "top-ups" last approximately 1 hour and usually add about 10 to 15 miles of range to Honda Fit. As Moses said, "enough charge to add a couple of extra trips" at the end of the day.

Beyond the occasional lunch-time opportunity charging, the HOUSEHOLD 1 family did not really consider using other charging options. Given their daily routine as well as their typical trip destinations (i.e. dropping their children off to school or other activities or going shopping) there was usually "no point" in stopping to charge because they simply didn't have the time to wait or they would not be at the charging location "long enough to make a difference." On the other hand, in the event of an emergency or having the necessity to opportunity charge, Moses was very prepared; he was well versed and familiar with the on-board system for locating charging stations and has also downloaded an APP called: plugshare.com with the idea that there might be, "free charging" opportunities that they could take advantage of, if necessary.

In terms of charging at work, both Moses and Shantel noted that this was not an option. Ironically, they pointed out that the owner of the company where they work drove a Nissan Leaf, yet he was not able to charge at work.

110 to 220 Home Upgrade:

The HOUSEHOLD 1 family could see the value of using a home-based 220 charging station. However, given that their night time 110 charging strategy, along with the occasional lunch time opportunity charge, "worked well" they had no incentive to spend a minimum of "several hundred dollars" for the upgrade.

Household 1 Charging Set-up at Side Door of Home

Travel Patterns and Driving Experience:

Shantel and Moses shared the use of the Honda Fit EV. Shantel drove the EV 40 percent of the time and Moses 60 percent. For the HOUSEHOLD 1 family, the Fit EV became "the family" car replacing, for the most part, the use of their SUV. While using the EV, the family continued their typical driving pattern of car-pooling to the same work location while chaining or stringing additional trips together like dropping off their children

at school and picking them up at the end of the day; the introduction of the EV made relegated the use of one of their SUVs to trips where more cargo space was necessary or as necessary for a longer range. The second SUV, essentially, was not used.

It was clear to the HOUSEHOLD 1 family that driving the Honda Fit EV would accrue significant savings for them. In fact, Moses monitored this aspect of their family finances using the Southern California Edison Smart Connect software. He estimated that it cost "$4.00 per day to charge the car at home"; or about $120 per month. He reflected that this was a "much better" value versus the $400-$500 per month that might be spent on gas at the current rate of $4.00 per gallon. Notwithstanding the savings in gas, the family still (on occasion) used the SUV for running errands that require larger cargo capacity (i.e. shopping) not available in the design of the Fit.

Interestingly, all members of the family noticed the big difference in driving the truck versus the Honda Fit EV. Shantel stated that after driving the Fit every day the "truck seemed like a tank…you could really notice the difference just in pressing the gas pedal." All members of the household have become extraordinarily conscious of the benefits of driving an electric car with the kids noting that it "doesn't pollute as much as their other car."

Both Shantel and Moses primarily drove the Fit in the Eco mode. On occasion they would use the "Sports Mode" which, as their boys said, "is tight!...the car zooms!" albeit at the expense of range. Shantel and Moses noticed a significant drop in the range/charge through the use of the car's heating system; he reported that significant use of the (direct) heater and/or the seat warmers resulted in a diminished range of up to 25 miles. With this fact in mind, there were family "negotiations and discussions" about whether or not to turn on the heat; the family had, at times, chose not to use the heater or only used it for short periods of time to ensure maximum driving range.

In terms of range anxiety, the HOUSEHOLD 1 family had only one enlightening experience in which they "just made it home" with the car warning that there was "less than 2 miles" left of range. On this particular day there were a total of 4 trips taken; 9 total trip legs. The car was not recharged at lunchtime and so, as a result, there was an anxious ride home on the last trip leg (after picking up her boys from afternoon sports practice). While this day resembled typical family driving patterns of chaining trips there was an unexpected trip from work to home and back again which was not accounted for in terms of total range. The lesson that they learned was to be more cognizant of the "unexpected" trips and to adjust their driving and/or top off with an extra hour of mid-day opportunity charging. In other ways, both drivers are also more aware of their driving behavior in terms of using the on-board equipment that might drain power as well as their actual driving habits taking surface streets for regeneration, or driving somewhat slower (on and off the highway) to lengthen the number of possible trips and/or range. The Household1 suggested that potential anxiety would disappear and "bring peace of mind" if the Honda Fit's range were increased to 100 plus miles. Moreover, destinations like downtown Los Angeles would readily be in reach without recharging.

Shantel stated that she would soon be in the market for a new car and, after testing the Honda Fit, she had seen the value of purchasing either a similar EV or a hybrid. Her motivation was fueled by the high price of gas stating, “it isn’t going down any time soon.”

Design/Use:

The HOUSEHOLD 1 family embraced all the on-board features of the Honda Fit. Both the children and Shantel noted that they were lucky to have a “techie” like Moses who had a ready affinity to programing and making the computer, blue-tooth and radio work. On-board features that were regularly enjoyed included: the car’s blue-tooth, voice-recognition system and the GPS features. If there was a downside it was the very fact that the Honda Fit was, essentially, a small compact car and, as such, had a very small cargo capacity. As Shantel stated, when the entire family is driving somewhere; “we really can’t do large shopping runs” with the Fit.

Household 2

Participant: Merin Household 2

City of Residence: Rancho Palos Verdes

Date: 12/14/12 – 3/14/13

Age: 47, 47, 16, 12

ICE Vehicles: Toyota Solaris, Ford Flex

EV: Nissan Leaf

EV Start Date: 1/15/14

EV – TOTAL VMT: 1,705.3 miles

EV Average VMT per Day: 29.4 miles

Overall:

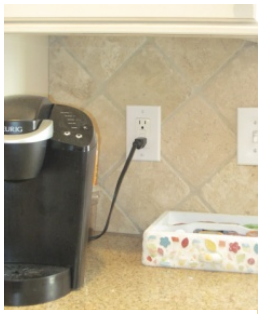
The Household 2 family was unabashedly enthusiastic about their experience driving the Nissan Leaf; Merin stated that she "really loved the car! Their kids love it too, and created a nick name for the EV, participation they used the Leaf as both the family car and her husband Eric's commute vehicle. For Merin, the EV served to replace her Ford Flex and was used as a substitute car for her many daily trips. On occasion, when Merin needed the extra cargo room for errands or dropping her son's (and their friends) to various activities then her husband Eric would use the Leaf as his commute vehicle to his office in Manhattan Beach. For the Household 2 family the Leaf was seen as a "third car" – an environmentally friendly transportation choice for what they saw as local destinations.

While there were no real issues with driving an electric vehicle there was an initial learning curve and understanding of how to drive the Leaf in the hilly community that they lived in.

Charging Strategy:

Merin adopted a charging strategy that was entirely home-based. Merin would charge both at night as well as opportunity charge between trips during the day. The Household 2 used only a 110 outlet that was located in the garage. Initially, this strategy was a challenge because the garage plugs were not grounded – a dated building practice that Merin discovered when the car did not (at first) charge properly. Until an electrician could rewire the garage outlets the family used a convenient kitchen plug. The cost for

Household 2 Home Charging Set-up



Initial Available 110 Outlet for Home-based Charging

grounding the outlets was $90 and the Leaf was, ultimately, charged using an outlet for their hot water heater.

The Household 2 family were "not late-nighters" which meant that the Leaf would be plugged in early in the evening and charge for well over 10 hours each night - from about 8:30 PM to 7 AM. Usually this length of charging did not result in a "full charge" (the computer would read 40 minutes short of a full charge) however, it was enough to comfortably begin the day "driving the kids to school" or enough for Eric to go to work and return home. Typically, when leaving the house in the morning, the computer would read about 70-80 miles as an initial total range.

Outside of "opportunity-charging at home" between various daily trips and errands, Merin (and her husband) did not take advantage or fell the need to use opportunity charging in other locations. Typically, there was not enough time (in Merin's case, when shopping or running errands) to warrant the added challenge of finding and filling up somewhere. In Eric's case, he simply did not find the need to opportunity charge at work as he had enough charge to run short errands and to return home at the end of the day. Thus, he did not inquire about whether or not he could use available outlets for charging at work.

110 to 220 Home Upgrade:

Within their garage, Merin had a convenient washing/dryer hook-up which would have been a suitable location to install a 220 charging station. However, upon further inspection, it turned out that the outlet did not have the correct pin set-up for charging the Leaf. Merin received 2 quotes for upgrading their home from 110 to 220 to accommodate a 220 charging station. The first quote was for $1500. The second quote was for $420. Since their strategy for charging was seen as "working just fine" they saw no point in paying for an upgrade. As Merin stated, charging the way we do it right now "works well with their life-style."

Potential Placement for 220 Outlet for L2 Home Charging

Drive Patterns and Driving Experience

Merin and Eric split the use of the Leaf about 50:50 – their teenage driving aged son was a rare an occasional driver. The types of trips have ranged from Eric commuting to work to Merin's running errands and dropping the kids off for various activities all over town. For the most part the commute trip was a simple journey to Eric's office in Manhattan Beach and home again. On the other hand, Merin generally chained many trips together going back and forth from their home. Each time she would plan and give consideration as to whether or not to use the EV or to take her Ford Flex. Her decisions were

often based around both range (trips that were seen as "too far away") and/or cargo capacity (in terms of hauling goods as well as kids to their local activities). As the family's "third car" Merin had the luxury of choosing the Leaf for trips that were local and made sense for the destinations that she needed to travel to.

The Household 2 family used the EV in the "eco-mode" for all travels as the computer described more range using the car in this fashion; the difference in range (at an early point) was noted as being 86 miles (eco mode) versus 68 miles (driving mode). The challenge, however, was that both Merin and Eric did not feel that the on-board computer gave them an accurate indication of exactly how much range they had. While they would start their driving day with an estimated range of well over 80 miles often it would drop down to 60 miles or less. Merin indicated that this may have been due to the topography of living on Palos Verdes as well as highway driving (or driving fast). This experience informed both Eric and Merin and led them to use the EV mostly for local trips.

Issue of Living in Hilly Community:

Interestingly, for the Household 2 family, was the experience of driving an EV in and around the community of Palos Verdes; their home being high in the hills. Merin quickly noticed the significant battery drain that resulted from driving up to their home and other local destinations around the steep hills of the Peninsula. While Merin never felt "too anxious" she was very cognizant that all trips must be planned using the following heuristic: "whatever the computer says when you start the trip subtract 20-25 miles from the total range" That is, she would expect a significant drain on the battery at the end of each trip and that the last trip "up the hill" will require at least 20 miles of range to make it home. For Merin, this became a key issue for planning and using the EV; especially so, as her trip destinations did not, typically, allow time for opportunity charging – i.e. shopping or running one of her kids up to Santa Monica for an audition.

Merin described the confusing issue regarding the "actual truth" about what the on-board computer described as her trip range. Often her trips began downhill which results in a significant charging of the battery (through regenerative braking) – sometimes, effectively, topping the battery charge from to 100% (approx. 24% increase). However, the reality was that, given the hills, Merin would have to constantly monitor her trips to ensure that there is at least a "total range of more than 25 miles" left before she reached the bottom of Hawthorne Blvd. – enroute to her home. The question for Merin was: "is a mile really a mile" according to the on-board computer.

This experience, of having a (perceived) of a 50 mile range, limited the way the family saw the use of this car. Effectively, it has become like a "third car" for the Household 2. If there is any question or issue about the range or "if they might get stuck" then they take one of their regular cars. Looking forward, Merin suggested that the, "third car" feeling would disappear if the range were "200 miles." However, during the course of the study she didn't "trust the computer."

Design/Use:

The Household 2 overall impression of their electric vehicle was that "the Leaf was great!" Initially, the Household 2 were interested in the Ford EV but after participating in the study have now grown to really like the Leaf. It had ample cargo room and was used for many family outings and errands including hauling the family's empty bottles – 4 large bags to the local recycling center. The Leaf worked well for Merin's car-pool activities and comfortably held four kids. Of the on-board features, there was a debate within the household about using the traditional heating options versus the creative (low-energy) strategy of using the "butt-warmers" on the seats – Merin and the boys liked the later and Eric would rather use the standard heating system even with the loss of range. Given the recent cold weather (during the Household 2 participation) Merin had to use the defroster which worked well and quickly however, she did notice that it drained the battery a little. Additionally, she liked the back-up camera feature. The cloth seats were nice but Merin felts a little uncomfortable that she might damage the interior if, for instance, she allowed the dog to travel with her. The family had "gotten a lot of laughs" from the synthesized on-board computer voice.

House Hold 2 Leaf at Local Recycling Center

Household 3

Participant: Mable Household 3

City of Residence: Carson

Date: 1/14/12 & 3/14/13

Age: 57, 61

ICE Vehicles: El Dorado, Cadillac SRX

EV: BMW Active E

EV Start Date: 1/15/14

EV – TOTAL VMT: 138.6 miles

EV Average VMT per Day: 4.9 miles

Overall:

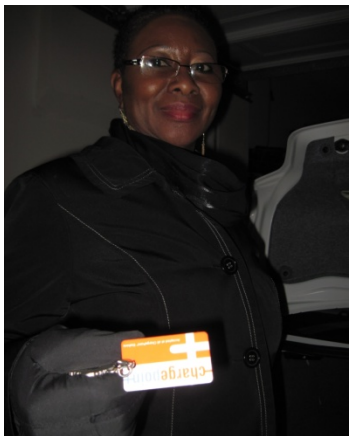
Mable Household 3 really enjoyed her experience driving the BMW Active E. During the course of the study the EV replaced her El Dorado as her primary vehicle for commuting to work and to run local errands; her husband continued to drive his Cadillac SRX. According to the Mable, "Everything was fine…I really enjoyed driving the BMW…We haven't had any problems so far." For Mable the only issue of significance was the range of the BMW. Without a longer range "get out of town" weekend trips could not be taken using the electric vehicle.

Charging Strategy:

Mable has adopted a strategy of using the 220 ChargePoint station that was available at her place of work (Raytheon Campus in El Segundo) to "fill up" her car and then "topping it off" at home using her 110 outlet located in the garage; 110 home-charging was done as needed during the work week but fairly consistently on the weekends. The Household 3 family uses one of two outlets located in their garage. The primary one is located behind their second refrigerator. On occasion they would use the auxiliary plug located above the middle of the garage door opener motor.

Mable applied and received her free ChargePoint card to access the Raytheon Campus charging stations. Presently, this service is free and average "fill-ups" at work are about 4-5

Location for 110 Outlet for Home Charging



Chargepoint Card for Workplace Charging

hours; the typical fill up brings the battery from 50% capacity to 100% and takes about 5 hours of total charging time. The ChargePoint card is set up to let Mable know (by text) that the charging has been completed. When "topped off" at home at 110 for the same amount of charge, it takes well over 10 hours. Mable has not used (nor had to) any other opportunity charging options.

110 to 220 Home Upgrade:

Milton Household 3 met with their electrician and learned that it would cost between $250 and $350 to upgrade and/or move the garage outlet from 110 to 220. The wiring would have to be moved from an exterior wall panel outside the garage to the interior of garage. The cost seemed prohibitive moreover, because strategy of charging at work "is just fine," they see no point in "paying such a high price" – especially since they would not necessarily have a use for the upgraded wiring once the study was completed.

Travel Patterns and Driving Experience:

Mable is the primary driver using the BMW almost 100 percent of the time. She is had a "good time" driving the car and often got "looks" while driving it to work. As Mable says, "it makes her feel like a rock star!" On a rare occasion her husband Milton would drive the BMW Active E. Typically, according to Milton, she would gladly let him drive, but he defers and insists that she take the wheel. The Household 3 family sees the BMW EV as a "nice around town car." The perceived limitation, regarding the car's range, may have confined the Household 3's to using their BMW EV to travel destinations within a 20 mile radius from their home.

To date, Mable's trips have been "pretty much local…to work every day, shopping, and running errands." There was some conversation within the household of taking the BMW to Temecula for a weekend trip the Pechanga Resort/Casino. The challenge, however, became clear when planning the trip because, even though there would be a place to recharge at their destination, the total distance of 84 miles was "right at" (or very close to) the maximum range for the BMW. As Mable described, her husband "doesn't want to have to wait around to charge the car" (if it needs charging while they're away from the house). Similarly, Mable considered a visit to her sister's home in Altadena but had concerns that she would not be able to either get there and/or "fill the car back up" to return home on the same day. Both Mable and Milton commented that a range of 100 (or more) miles would nice and, as such, really increase their options for using the BMW EV.

In terms of anxiety over the range/charge of the EV, Mable has not had any anxious moments or real issues because she is ever vigilant about watching the gauge – "I've never run out of gas (in my real car) and I'm not going to start now!" The only time where she felt some sense of urgency was when the

range dipped to 16 miles and she was notified by the on-board computer. This, however, was mitigated by the fact that she was almost at work and would soon be recharging.

Multi-Modal Commuting

Interestingly, in terms of commuting to work on rainy days, Mable, choses to take the local bus with a connection to the Metro Green line that lets her exit at the Raytheon (El Segundo); Raytheon has a shuttle service to the lobby from the station. The advantage of this, whether it is "her car or the BMW EV" is that she avoids the expected delays and traffic congestion that she would otherwise have while driving to work on inclement days. Moreover, Mable saves money as the transportation fare is provided by Raytheon as part of its commuter services plan.

Design/Use:

While the "BMW is fun to drive" Mable did report that the trunk was "too small" – after shopping she could only put 2-3 bags of groceries in the cargo space. Additionally, she was unable to get the blue tooth to work with her (original) old IPhone was not compatible with the new on-board system. Other amenities like the radio were enjoyable reported to be working well; the GPS system has not, to date, been tried. Given the relatively short trips, Mable did not notice nor has she been aware of any diminished charge or range through the use of the heater or other on-board systems.

BMW Active E Cargo Space

Household 4

Participant: Shawn Household 4

City of Residence: Rancho Palos Verdes

Age: 46, 45, 18, 15

Start Date: 12/14/12 - 3/14/13

ICE Vehicles: Hummer H3; Acura TL; and, Chevrolet Traverse

EV: Nissan Leaf

EV Start Date: 1/15/14

EV – TOTAL VMT: 1,618 miles

EV Average VMT per Day: 47.5 miles

Overall:

Shawn Household 4 states, "it's been a great experience…We really love the car!...it's replaced my Hummer for my daily commute" On weekends, the Leaf has become our primary and (sometimes) singular family vehicle; the kids love it and having experienced and driven the Leaf it has made an immediate impression on the value of driving an electric vehicle. No real issues with the EV however, there is a keen awareness of both the range and the battery charge given the long daily commute and the steep hills that must be climbed on all trips returning home to Palos Verdes.

Horse and Buggy 110 Outlet

Charging Strategy: Shawn has adopted a strategy of consistent opportunity charging to complement the home-based (110) charging the Leaf. In his words, he "charges every time I can." What this means, is that he takes the 110 charge unit with him whenever he drives the Leaf. This strategy is critical for allowing him to commute to his job in the City of Industry and having enough charge to comfortably do sales calls as well as return home. He has noticed, though, that without two charge chords, this practice can be a bit unwieldy and tedious, in terms of having to remember to pack the charger and re-plug it each evening after arriving home.

Charging in the Household 4 home takes place in the garage using a standard 110 outlet – ironically mounted on a "horse and buggy tie down". Shawn anticipates upgrading his charging to 220 by using an old dryer outlet located near his hot water heater. The cost for this upgrade was anticipated to be several hundred dollars.

Shawn has embraced the idea of opportunity charging "wherever and whenever" he parks his car. He has prepared himself for using both 220 charging stations as well as conventional 110 outlets by, respectively, subscribing to both ChargePoint and Blink services, as well as taking the 110 charger unit with him for all trips in the EV.

Household 4 Home-based Charging Set-up

To date, Shawn has only used a 220 service once at a ChargePoint service located at Walgreens (PCH & Crenshaw; located at the bottom of the hill leading towards his home) for a "quick" 1 hour charge. Feeling somewhat concerned that he might not have enough "juice" to get up the hill and home, Shawn pulled in "and shopped for an hour" while the Leaf charged. The result was a "negligible" increase to the range and percentage of power left in the battery. However, it was more than enough to comfortably drive up the hill and home. The Walgreen's price for per KWH was $2.00.

On the other hand, Shawn has been very resourceful and creative in terms of finding and using "other folks" 110 outlets. A good example was his recent family trip to Disneyland. In planning this outing, he calculated that this trip would test the outward limit of the Leaf's range. What he didn't anticipate was that a full car, travelling at a steady highway speed would drain the power at a higher rate. Planning ahead for a "just in case" scenario, Shawn discovered that Disney did not have 110 or 220 outlets within the general admission parking area, however, they did provide this service within the hotel garage where there were outlets designated "only for hotel guests". Upon arrival at Disneyland and needing to charge, he decided to park at the hotel structure, while not allowed to use these designated EV outlets, he did discover that every floor of the garage had multiple 110 outlets on the perimeter walls; he simply found one and plugged in, courtesy of Mickey. Shawn noted that if he was unable to opportunity charge at the park, his fall-back charging scenario would have been to have a long dinner at Carl's Jr. (somewhere on the way home) where 220 charging is now available.

Overnight charging at home with opportunity charging during the day has generally worked well for the Household 4 family. That being said, Shawn is anxious to try charging at 220 to see if it will make a difference towards extending the total daily use (number of trips) of the Leaf. That is, given Shawn's lengthy commute, by the time he returns towards the end of the day the battery is sufficiently drained to a point where there is usually only one or possibly two opportunities (i.e. short trips) left to use the EV before having to plug it in for a lengthy (overnight) recharging. By being able to charge at 220 for "even a couple of hours (plus the regeneration heading downhill from the house)" the family could then use the Leaf for more trips in the evening.

In terms of energy costs for charging the Leaf Shawn is hoping that it will be minimal. He and his family have chosen to be more conscious of using or leaving unattended lights and appliances "on" during the study. His hope is that this strategy will result in "basically" the same electric bill as an average month.

110 to 220 Home Upgrade:

Household 4 Possible 220 Outlet for Home-based L2 Charging

Shawn has a convenient, though capped 220 outlet located in his garage behind a hot water heater. He believes that the outlet is live and that, even if the plug location has to be moved "it shouldn't be a problem" as there are multiple places to locate it in the same general area of the garage. Shawn has indicated that he will upgrade but, to date, has not gotten a quote for the cost to do so.

Travel Patterns & Driving Experience:

Shawn, his wife and daughter split the use of the Leaf (respectively) 90:7:3. The primary trips taken during the week are work related – the longest being Shawn's trip to work at his office in the City of Industry. Tracy, his wife, takes shorter local trips "on the hill" (Palos Verdes) or down to Torrance for domestic errands and/or to "drop off the kids" for various activities. Shawn's daughter has occasionally used the Leaf for trips to and from her part-time work in Redondo Beach. Shawn has tested both the "drive" mode as well as the "Eco" mode for the Leaf. His strategy for battery conservation and extension of range is to use the Eco mode for approximately 80% of his trips. He noticed the "big drop-off" in performance (both pick-up and speed) and, as a result, he changed his driving style to stay "more in the right hand lane…it's safer there given the fact that you just don't have the power to pass easily."

Interestingly, Shawn was appreciative of being able to extend his driving range while in city traffic. That is, with the same amount of battery charge to begin a trip, steady highway driving (at 65 mph) to and from work (without regenerative braking) resulted in about ½ hour less total drive time (i.e. less range) than what he might have doing local sales calls while driving in stop and go city traffic.

Issue of Living in Hilly Community:

As with other participants in the study, the Household 4 family is acutely aware of the significant battery drain from driving up to their home and other local destinations around the steep hills of the Palos Verdes Peninsula. It has taken the better part of 2 weeks for Shawn and his family to now feel comfortable about planning and driving with the intention that there needs to be enough range/battery charge left to "get home". As part of that learning experience, Shawn has, on more than one occasion, pushed the envelope, returning home with less than a 10 mile range; even below the 5 mile range (where he was alerted by the on-board voice warning system of imminent end of power. Shawn's initial anxiety has been quickly mitigated by his actual experience and testing of the Leaf so that he now has a realistic understanding of the how the range diminishes while traveling up the hill towards home. Based on his observations of the on-board computer he estimates that he loses 10-15 miles at the base of the hill to home. If he has that range left he feels confident that "he'll get home…even with the air conditioning on!" On the other hand, Shawn describes his family as "more cautious." Even to the extent of choosing not to drive home with him (in the Leaf when it had about a 15 mile range left) after

a recent family dinner. Instead his wife and kids “jumped into his daughter’s car” (she had met them for dinner) for the ride home, believing that Shawn would get stuck – which he happily disproved, albeit with the warning system notifying him that he was almost out of power.

The positive driving experience of driving the Leaf has proved insightful to his children in terms of their appreciation for the value of the car in the family – both in terms of the environment as well as (Shawn suspects) his daughter’s saving on the cost of gas. Shawn even noticed the difference himself, in that “for the first time (in a long while) he could not remember what the price of gas was!”

Another, perhaps more lasting outcome from his participation is that the positive experience of driving the Leaf (“and not driving the Hummer”) has proved integral and decisive in Shawn’s decision-making process to purchase the Ford Fusion following the completion of the study. Shawn’s rationale for choosing the hybrid Fusion was the extended range that this type of car offered.

Design/Use:

As Shawn happily states, “the Leaf has been great, no complaints.” The Household 4 family got great use of the Leaf. On weekends it has become the family’s primary vehicle. Errands are run by one person, then recharged, followed by subsequent errands and recharging, and so on. There is “plenty of room" for dropping the kids off as well as shopping and running other errands.

In terms of some of the other design features there were a few “that required some getting use.” These included, the gauges and display panels which took about a week, or so, for Shawn to feel comfortable navigating to display the various screens and readouts that he felt were most helpful for interpreting and understanding his driving experience. Additionally, Shawn felt that the location (on the stick shift) of “reverse” and “forward” were counter-intuitive. The air conditioning worked well but was a significant drain on the battery however, the strategy of using the seat heaters worked well to keep warm without diminishing the battery. All the other “bells and whistles” like the radio, blue tooth, etc. worked fine.

Rotation #2

Household 5

Participant: Lori and Rosalee Household 5

City of Residence: Torrance

Age: 39, 36

Date: 3/1/13 – 5/16/13

ICE Vehicles: PT Cruiser, Buick LeSabre

EV: Nissan Leaf

EV Start Date: 3/15/13

EV – TOTAL VMT: 1,620 miles

EV Average VMT per Day: 26.5 miles

Overall:

Lori Household 5 was an enthusiastic driver of the Nissan Leaf. For the most part she was the primary driver of the Nissan Leaf using it almost 100 percent of the time. Lori's driving pattern with the Leaf was to use it primarily as her commute vehicle. The Leaf replaced trips that Lori would otherwise have taken in her PT Cruiser. Since Lori did not have chance to opportunity charge at work, post-work trips became limited by the reduced charge and depleted range; the lessened range resulted from her commute route to and from work by travelling on the freeway (against traffic) on open roads. As Lori said, "the reality is that most of my driving is on the freeway." Lori quickly recognized that her total range was less than what she had anticipated when she began the study. Aside from receiving the initial training to use the Leaf and, subsequently, driving it home Rosalee did not drive the Leaf but, from time to time, was a passenger. While she never experimented with driving the vehicle, it was Rosalee's assumption that should she would have minimal use the Leaf because – by default – "she would use the air conditioning" limiting her range and, moreover, she "would be uncomfortable" driving a car with bucket seats.

110 Home-based Charging

Charging Strategy:

Lori's charging strategy was to solely charge at home. Lori did not have an outdoor 110 outlet to charge the Leaf. In order to charge the car, Lori had to run the charging cord through a high window on the side of the house to reach a 110 outlet located

in the kitchen. Each evening, between 4:30 and 5:30 PM the Leaf was plugged in to be charged overnight. By 6:00 AM the car was fully charged. Over the course of the study Lori came to realize that she could avoid more expensive electrical rates by charging later in the evening as a result she came to charge the car only after 5:30 PM.

In terms of opportunity charging, while either at work or outside of the home, Lori and Rosalee related that they did not spend much time exploring or looking into these options. Lori related that before participating in the project she had anticipated that there might be an opportunity to charge during the day at work – in an outdoor area of her facility that was used for parking and charging electric utility vehicles. However, once the project began, she realized that the company had moved the charging stations for their electric forklifts and other utility equipment to an indoor area that was inaccessible for Lori to park and to charge her Nissan Leaf.

In terms of finding Level 2 charging options in their community they had briefly looked into the charging station that was available at Torrance City Hall. Lori reported that, they "gave up on using it since there were only 2 spots and they were constantly filled." Lori did not investigate other options and did not acquire a Chargepoint or Blink card nor did she download any mobile applications for finding Level 2 charging stations.

110 to 220 Home Upgrade:

Lori and Rosalee decided not to upgrade their home charging to 220. For them the cost was prohibitive; the estimate was between $300 and $400. They observed that their current charging strategy of using their existing 110 outlet was "just fine."

Travel Patterns and Driving Experience:

Aside from Rosalee's initial drive home, Lori had been the exclusive driver of the Nissan Leaf. Though Rosalee had been a passenger many times she chose not to drive the car. Rather, Lori used the car as a replacement for her PT Cruiser. Her daily commute trips involved (mostly) freeway driving without traffic. As such, Lori quickly discovered the relationship of highway speed travel to how quickly the battery drains, thus reducing the total range of the vehicle. As Lori said, when driving on "the freeway you just watch the dial go down." She noticed that it (the battery) didn't "go down that fast" when driving in traffic. For her, "hitting a little traffic would probably (have been) ok." Lori observed that the experience of driving to work on the freeway would drain the battery (and estimated range) by 25 percent. Lori speculated that there was a "science to driving (the Leaf) to keep it in the sweet spot" so that you maximized the range even though she was driving on the freeway – as of the second week of the study she had not figured it.

The return trip from work had a similar result in terms of using more charge than was expected. After each work day the result was that, upon returning home, Lori felt that there were "not too many extra trips" that she could make without feeling anxious about having enough charge to either get to where she needed to go and then return home again.

For the most part, Lori avoided anxious moments by choosing not to drive the Leaf if she felt that there might be any possibility of running low on charge. In one instance, she had forgot to charge the car one evening. In the morning she thought she had enough charge to make it to work and back however, after thinking about the situation, she decided to drive her PT Cruiser instead of taking a chance with the Leaf. Another anxious moment came when Lori ran extra errands after work. After returning home from work she left the house with 35 miles of range remaining; Lori made several stops however, once the range reached 15 miles she became anxious (even with only a few short trips remaining) - "just to be safe," she curtailed her errands and returned home. At that point she switched cars to one of the family cars to complete her shopping. For Lori, in terms of range anxiety, whenever the gauge approached 20 miles of range remaining she felt anxious. Her anxiety level would rise if this were to occur at night or when there might be a need to use the car's lights or other amenities like heat or air-conditioning.

Lori was not really interested in experimenting with different driving styles or drive-modes to economize the battery and maximize her driving range. In terms of driving style, Lori primarily used the "Drive-mode of the Leaf. Lori reported that she tried the Eco-mode however, it reminded her of her experience as a participant in the Neighborhood Electric Vehicle (NEV) study where the cars would be sluggish and have no power – especially when the battery was near the end of its charge. Lori further noted that the difference, as registered by the on-board computer, in range between the Eco-mode and Drive-Mode was just 2 miles of extra range. For Lori, it was "just not worth the effort" to use the Eco-mode to gain a few more miles of range.

Rosalee observed that, the "reality is that most of our driving is freeway…it's (the lack of range) a barrier to purchasing" a car like the Leaf. On the other hand, the Household 5 s noted that they were saving $50 per week on gas that they would have had to spend to fill up the PT Cruiser.

Design/Use:

Both Lori and Rosalee had specific issues with many of the design features in the Nissan Leaf. In Rosalee's case the amounted to her not feeling comfortable enough to drive the car. Among her many complaints and challenges was the "bucket seat" design which she did not like – preferring a bench seat in the car she would drive; additionally, the seat belt was uncomfortable, especially for "a larger" person like her. Beyond the ergonomics of the seating, Rosalee observed that the tint on the window would not be enough to protect her fair skin from trips during the day – night trips being unlikely because of the anxiety that using the headlights would bring in terms of draining the battery during the lengthy commutes to Long Beach for night school. Similarly, Rosalee was afraid that using the air-conditioning (something "she does all the time") would have the same deleterious effect on range during the day.

For Lori there were similar issues concerning the ergonomic design of the seats for "a larger woman" but in the end she was able to adjust both the seat and seat belts to drive "comfortably enough." Lori enjoyed the plug USB port so that she could play her ITunes music and liked the ease of using the Blue Tooth system for her cell phone. In terms of other on-board amenities she liked the heater when she used it however, she was anxious that by using it she would drain the battery more than expected; her strategy would be to use it for the period of time before reaching the freeway then turn it off. Lori was

also pleased with the cargo room – it compared very favorably to her PT Cruiser which didn't have any trunk space.

Household 6

Participant: Rick and Debbie Household 6

City of Residence: Torrance

Age: 56, 57, 21

Date: 3/1/13 – 5/16/13

ICE Vehicles: Toyota Tacoma, Honda CRV

EV: Nissan Leaf

EV Start Date: 3/15/13

EV – TOTAL VMT: 1,641 miles

EV Average VMT per Day: 32.1 miles

Overall:

Rick and Debbie Household 6 were very enthusiastic participants and "enjoyed" driving the Nissan Leaf. The electric vehicle became the family's third vehicle allowing, for the study period, their son the opportunity to drive one of the family's other cars. During the first few weeks of their participation Rick used the Leaf as his primary commute vehicle to his work place in Century City. The Nissan Leaf replaced about 3-4 car-pool trips per week that would have otherwise been made driving his Tacoma Truck. Debbie's trips were not so far afield but rather local trips – mostly to and from her local church where she did volunteer work. Both Debbie and Rick reported no real issues with the Leaf and happily embraced the addition of the Battery Electric Vehicle (BEV) into their family's driving experience.

Charging Strategy:

During their time in the study the Household 6 family employed two types of charging strategies. Routinely, the family would charge the Leaf each night using the 110 outlet that was located on the exterior of the garage. Typically, Rick or Debbie would "plug in" the Leaf in the evening often "checking to see how many (charging) lights have lit up in the window" before going to bed. Generally speaking, this was a sufficient charging strategy which resulted

Parking and Charging Set-up for Household 6

in a “full” battery for the next day’s travels.

In addition to the home-based overnight charging both Rick and Debbie became comfortable with opportunity charging – both at work as well as at other locations outside the home. After “scouting around at work” Rick was able to locate two different 110 outlets within the two parking structures that he typically used to park his vehicle during the work day. While Rick had not received permission from the building authorities to use these outlets he did so anyway noting that “both outlets are out of the way and the way the car was parked no one can really see that I’m charging.” Debbie, as well, employed opportunity charging during her daily trips. Often, while working at their local church she would use a convenient 110 outlet located at the base of the light standards in the church parking lot or, upon returning home from local errands she would simply plug in again. For Debbie, “it just makes sense to re-plug” the car until her next trip; as she described, she “feels better” knowing that, even though it might not amount to a significant increase, that the car has more charge than it would otherwise. Neither Rick nor Debbie used a 220 charging station while participating in the study however both noted that there seemed to be “free charging stations” at the Lomita bus terminus (east of the hospital).

Surreptitious 110 Workplace

110 to 220 Home Upgrade:

Rick and Debbie decided not to upgrade their home charging. Prior to beginning the study the Household 6 family had to hire an electrician to install a working 110 outlet on the outside of their garage. The cost for installing the outlet was approximately $90. At that time, they received a quote of $400 to upgrade and install a 220 outlet that would be convenient for charging the electric car. Both Rick and Debbie reported that the “110 is working out”. Given their charging habits (overnight as well as opportunity charging at work as well as between local household trips, the Household 6 family saw “no real need” to upgrade to 220.

Travel Patterns and Driving Experience:

Rick was the primary driver of the Leaf using it several times per week to commute to his work as an accountant in Century City. Rick’s commute trips in the Leaf replaced car-pool trips that would otherwise have been taken in his Tacoma. His route to and from work included both surface roads and travel on the highway. Debbie used the Leaf when Rick did not drive the Leaf to work. Her trips were very local and included volunteer work at her neighborhood church, shopping and running other

errands. Since the Leaf was seen as a "third car" in the household their son would then be able to use one of their regular family cars for driving to and from work or visiting his friends. Both Rick and Debbie were conscious of driving the Leaf in the Eco-mode so that they would get the maximum driving range. When asked about how they understood the car's range Rick answered that he did not use the car's computer reading of "mileage left" but rather understood how much power remained from the "bars" on the dash-board indicator. That is, when the Leaf is fully charged there were 12 bars – which represent a total of 24 KWH. Rick calibrates his range by understanding (in a general sense) how much power it took to get from one place to another. For instance, it took "3 bars to get from home to work in the morning" whether he traveled via surface streets or on the highway (usually in heavy traffic). Similarly, "it takes 1 bar to travel up the steep incline of Crest Ridge Ave. on the last mile home; thus, he would have to be aware that he needed at least that many bars to easily make it home. Debbie too learned about calibrating her trips using the power bars however she was more inclined to understand her range using the car's on-board mileage readout.

On a weekend trip to Lakewood Debbie and Rick shared the experience of how quickly the battery drained when travelling on a "wide open road." This particular trip briefly caused a little bit of range anxiety regarding how much charge was left for their return trip home. Within a two weeks of driving and testing the Leaf Debbie and Rick had developed their own respective sense of the car's driving range. Rick was far more comfortable driving the Leaf to the point of almost having no charge left (i.e. 1 bar remaining) while Debbie, on the other hand, was far more conservative in her driving behavior and did not feel comfortable nor did she take any chances of running out of power.

Design/Use:

Debbie and Rick were very conscious about the drain of power (and resulting loss of range) when using the climate controls of heating and air-conditioning. Typically, they did not use these features even though, for Debbie, they were features she would have used "all the time" in her family car. The rationale was different for each person. Not using the climate features, readily fit into Rick's sense of "frugality" – he was keen on maximizing his range by "just rolling down the windows." Debbie, on the other hand, "felt like she shouldn't" (turn on) the air conditioning or heating because it would result in making her feel anxious about how much power she might be using – and, as such, taking away from the range for her trip. For Debbie, this wasn't a good solution – however it was one that she typically compromised on so that she would feel less anxious.

The Household 6's found that the Leaf was very functional. Debbie discovered that the cargo space was "surprisingly large" when a fellow friend from church and herself picked up breakfast supplies for 350 people- she "wasn't sure it would fit" but with the hatchback down it did. The ergonomics were such that Rick – a tall person felt he had enough head room as well. Debbie felt the car looked "cute" while Rick and her son didn't particularly like the car's look.

Household 7

Participant: Ruben & Silvia Household 7

City of Residence: Lawndale

Age: 66, 60, 26

Date: 3/1/13 to 4/19/13

ICE Vehicles: Dodge Caravan, Mercedes E350, Toyota Rav 4

EV: BMW Active E

EV Start Date: 3/15/13

EV – TOTAL VMT: 176 miles

EV Average VMT per Day: 14.6 miles

Overall:

Ruben Household 7 and his wife Silvia (and their family) "enjoyed the car" and their experience of participating in the study. The first month of their participation was particularly "busy" in terms of work which meant that Ruben had little time to drive the BMW Active E. In Ruben's absence, Sahill (his employee), drove the vehicle while Ruben was out of town. During the course of the study, Garrett's son (due to travelling and insurance approval) drove the car once for a "test drive" as did Silvia, Ruben's wife.

The types of trips taken using the Active E have varied depending on the driver. Ruben's trips followed his daily work commute to and from his Gardena warehouse where he recycles used office equipment (i.e. Xerox copying machines) for export to foreign countries; local patterns of travel in and around the South bay to run errands and/or check in on his rental properties. Sahill used the Active E to travel further afield commuting to UCLA for classes and, in one instance to Buena Park in Orange County. Initially it was thought that Silvia would use the Active E for her work as a real estate agent (substituting the EV for her Mercedes Benz E350) however both Ruben and Silvia noted that "there was not enough room" in the Active E's trunk to transport the signs and materials necessary for Silvia's work of showing homes. That being said, Silvia did test drive the car and enjoyed her experience; she could see herself using the EV for taking care of errands or other local trips outside of work. Ruben's primary observation of his experience is that the "BMW does not get the range" he expected.

Charging Strategy:

During their participation in the study, the Household 7 household employed three different charging strategies. For the first few weeks Ruben adopted a strategy of only charging at home using the 110 outlet that is located with the electrical box that hangs on external wall of their home – adjacent to the driveway. Ruben's charging strategy *did not* involve a routine of nightly charging but rather charging the Active E only when it was needed – about every third day. For Ruben, this meant that when he noticed that the on-board computer for the BMW had reached 20-25 miles of range (Ruben's "comfort level" before needing a charge) he would plug in the car to be charged overnight. After a night's charging Ruben reported that in the morning the car would indicate that it was fully charged, albeit, with an estimated range of 68 miles. Ruben did not need or nor had any desire to find and use other charging opportunities outside the home.

Household 7 110 Parking and Charging Set-up

Sahill, on the other hand, used a strategy of opportunity charging both at work and outside his home. Since a 110 outlet was not available to use at his apartment building Sahill would pull into an area of the Gardena warehouse where a convenient 110 outlet was available. By opportunity charging during the day he would be able to use the Active E to commute home and/or other destinations at the end of the day. On occasion Sahill would travel to UCLA for classes. During one such trip he took advantage of an open 220 charging station located in one of the UCLA parking structures to "top-up" while attending a class. He reported that the cost to charge was $2.00 per hour; he spent $5.00 for 2 ½ hours of charging.

110 to 220 Home Upgrade:

Ruben had available 220 in his home. It was installed many years ago to run power tools as part of a home-based business. There were two outlets that could have been used to install the 220 charging unit however both would require paid electrical work to do so. The first option would have been to use the available 220 outlet located within the external electrical box (that was used for charging the BMW at 110). In this scenario electrical work would have had to be done to modify the breakers to safely facilitate the use of the charger; because of the external location there would also have been the challenge of mounting and orienting the charging unit so that it could readily plug into the electrical outlet.

The second option would have been to use a dedicated 220 outlet located within the garage. The challenge in this case would have been the orientation of the outlet which would have required paid

electrical work to relocate. Given the short-term for using the 220 charging station and the lack of needing an outlet in the future, the estimated cost of $125-$155 was deemed prohibitive. Moreover, Ruben and Silvia were very clear that their current charging strategy using available 110 was "working fine" and no upgrade was needed – "it wouldn't really make a difference."

Travel Patterns and Driving Experience:

Ruben was the primary driver of the BMW Active E. Ruben noted that he had taken care to use it for his "typical daily trips." That is, to not change his driving behavior simply because "it's a novelty." Typical trips for him were his daily commute to and from his office recycling business located just off the 405 freeway in Gardena. Significantly, Ruben thought that most of his other trips were also well within a radius of 10 miles from his house. Examples he noted were weekly trips to his bank in Manhattan Beach Village, the Lawndale Community Center and visits to his rental properties in the South Bay area.

Sahill, on the other hand, used the Active E for trips to destinations that were further afield. His trips included those to the UCLA campus for classes and into Orange County one evening. Garrett (Ruben's son) and his Wife, Silvia drove the EV only once for a test drive.

Ruben did not experience any range anxiety due to the fact that his trips were highly local. He noted that this may have been different had he had a need to use the car for longer trips however his perceived need or desire for traveling further afield was mitigated by his "disappointment" in the fact that the BMW Active E's range was "significantly less" than what he was expecting and what the factory specs described. After charging to 100% the on-board computer described the maximum range as only 68 miles which was "far less" than his understanding of what the BMW's range would be - i.e. closer to 100 miles. That being said, for Ruben, the total range was more than adequate to facilitate his normal "driving patterns" and it was unclear (at best) if he would have driven outside of the South Bay.

Sahill, experienced one anxious moment when he realized that two additional trips followed by his travelling to his evening destination at UCLA would result in his not having enough charge left to return home. At that point, he found a place on campus to opportunity charge for 2 ½ hours thereby ensuring enough charge to return home and then to work the following day.

In terms of the driving experience Ruben had several observations about driving characteristics of the BMW Active E. First, he noted that there was a period of adjustment to get the "feel" of the car and how it handled. Ruben remarked that "initially, it felt heavy" but that he soon (within a few days) "adapted" to it. Silvia noted that the heavy quality of the BMW EV was very much like "driving a tractor on the farm." Certainly, in terms of acceleration, all of the drivers noted positively that the "car had zip." Lastly, Ruben was surprised, in a positive way, that contrary to his expectations, he did not have "any stress" or anxiety about driving an electric car. He suggested that future training individuals might be "presented in a less apprehensive way."

In terms of driving style, Ruben chose to drive solely in the higher performance "drive" mode. Typically, he did not run the heater or air conditioning. On one occasion, however, he did use the air conditioning: On a hot day, returning home from Manhattan Beach, Ruben noted that the use of the BMW's air conditioning "significantly drained the battery" estimating that he lost 50% more miles of range than he would have without using the air conditioning for the same period of time. Upon noticing his diminished range he promptly turned it off.

Design/Use:

The Household 7 family did not really embrace and use the on-board features of the BMW Active E. Amenities like the blue tooth were not used. In terms of design/build comments, Silvia was disappointed that the trunk of the Active E was not big enough to put her real estate signs and materials in. Because of this she was not able to use the car for work – "it would have been nice since it's a conversation starter and something that perspective buyers can appreciate." On the whole, Ruben and his family liked driving the car.

Household 8

Participant: Kevin Household 8

City of Residence: Carson

Age: 24, 57, 54, 21

Date: 3/1/13 -5/16/13

ICE Vehicles: Acura TSX, Mitsubishi Galant, Mercedes Benz MI320

EV: Nissan Leaf

EV Start Date: 3/19/14

EV – TOTAL VMT: 1,217.2 miles

EV Average VMT per Day: 32.9 miles

Overall:

Kevin Household 8 was an extraordinarily enthusiastic driver of the Honda Fit EV; additionally, at the end of this test period he also drove the BMW Active E. During the study Kevin was the sole driver of the electric vehicles. For the most part, the Honda Fit EV and the BMW Active E replaced commute and personal trips that he might otherwise have taken Acura TSX. Kevin's travel patterns took place within the South Bay but have also taken him far afield – from Los Angeles' skid row to Costa Mesa and Anaheim. From the onset of his participation, Kevin pushed the envelope in terms of discovering the range limitations and driving features of the Honda Fit EV and the BMW Active E. For example, Kevin's first trip was from North West Manhattan Beach to Orange County where he picked up his girlfriend, drove to dinner, then to Disneyland. At this point, well into the evening and needing to charge, he found himself "looking for a free charging station in the middle of the night" - Kevin was able to successfully charge for free and return home to Carson later that night. Very quickly Kevin developed a basic strategy of planning his daily routes as well as "planning trips to go where I can get a charge." What this meant for Kevin was that he would plan his daily trips to both maximize the total trip destinations he could take while all the time keeping in mind the places where he might (if necessary) opportunity charge along the way. Kevin's attitude was one of "going with the flow."

Charging Strategy:

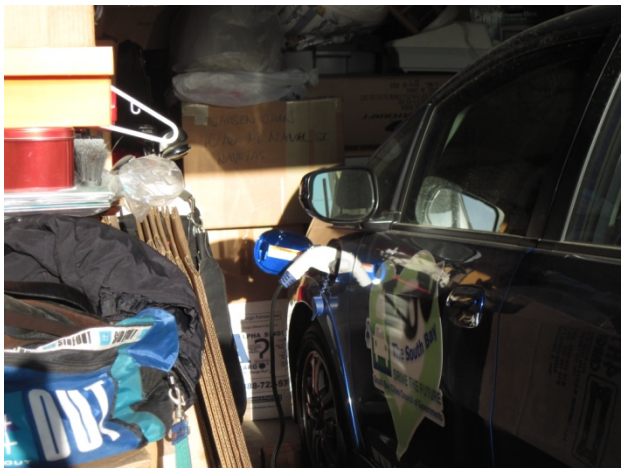
During the first few weeks of the study the Kevin Household 8 tried to charge "whenever possible" using a free Level 2 charging station; he estimated that he did this about 70% of the time and used 110 charging (at home) about 30% of the time; Kevin considered home-based 110 charging as "supplemental" and would do so only when he stay the night at his family's home. Typically though, his charging pattern was such that he would use a free Level 2 charging station located near his girlfriend's home in Orange County. Arriving in the evening after work, he would find a free charging outlet at the South Coast Plaza Mall and plug in. At that point he would be met by his girlfriend (in her car) and return later to a fully charged EV. Kevin's primary strategy for charging was to find free Level 2 charging because it was "cheap and fast." However, when Kevin did return home for the evening he made sure to charge using the 110 outlet located in the family garage.

Household 8 Home Charging Set-up

Kevin noted that the increase in the electric bill from "plugging in the car at home" was approximately $20 higher than he might have otherwise expected – attributing the increase to the amount of power used for charging the Honda Fit EV.

According to Kevin, his charging events usually resulted in a "full" battery for the next set of trips however, there were instances of fast (1 hour, or so) Level 2 opportunity charging to get "enough" charge to make it back to the office or to his next stop.

As a matter of course, Kevin investigated Level 2 charging stations in and around his daily commute and travel patterns. As noted, his primary goal was to charge (for free) at a Level 2 charging station; it was his experience, however, that there were not "many" around here (in the South Bay). "Just to be safe" though he joined the ChargePoint service and, as such, had a tap card should he need to pay for charging. Kevin explored and discovered charging stations that were for pay at such commercial locations as Carl's Jr., Walgreen's, Ikea and Costco. During the course of the study he became familiar with these locations however, he continued to seek out and use only free charging stations. In terms of free charging, Kevin discovered and took advantage of being able to charge (for free) at a local car dealership at the 405 and Rosecrans – a convenient



Household 8 Charging

opportunity charge to "get enough" charge to make it back to work when unanticipated work trip(s) to El Segundo may have deplete his expected range for the day.

110 to 220 Home Upgrade:

Kevin decided not to upgrade his home charging. The estimated cost/quote for an upgrade was determined. Even without a quote Kevin's rationale for not upgrading was two-fold. First, he suggested that the cost would be prohibitive given the time period for participating in the project. Secondarily, he felt that the charging strategy that he had developed – i.e. finding free Level 2 charging stations "was working out for his charging needs."

Travel Patterns and Driving Experience:

Kevin was the exclusive driver of the Honda Fit EV and BMW Active E within his household. Kevin decided not to share the driving experience with his family though he did take them and his friends for rides in the EV cars. Generally speaking Kevin's travel patterns consisted of commute trips to his local office followed by field visits to clients in and around the Greater Los Angeles Area. Often, additional trips at the end of the day were to visit his girlfriend who lived in Orange County. On weekends, Kevin would volunteer for his church and often travelled to downtown Los Angeles.

Kevin noted that his style and "driving behavior had changed" as a result of learning how to drive the Honda Fit. His focus had shifted from not having to concerning himself with how fast he drove or how much gas he had in the car to one of driving in ways that would economize the drain of the battery to extend his range. A good example of this change in driving behavior occurred on Kevin's many freeway trips to Orange County. He's noticed that "I'm driving in the slow lane" – something that he typically wouldn't have done when driving his Acura. Kevin learned to monitor his speed and range by paying attention to the car's gauges – and, in particular, the battery level. He maximized the range by choosing to use the car's Eco-mode "about 95% of the time." However, on occasion, he would opt to shift into drive or sport mode to give the car extra power on the freeway (especially when passing or merging into traffic).

Kevin noticed a distinct difference between driving the Honda Fit and his Acura in that the "handling of the old car felt differently." For Kevin, the Acura felt heavier after driving the Honda Fit EV. Moreover, the performance was different has he noted the fast acceleration of the Fit EV and how smoothly the car glides. Additionally, Kevin learned to manipulate the brakes to add power back into the EV through the regenerative braking system – a behavior that he must remind himself not to do when driving cars that are not electric.

It took Kevin "about 2 days to feel comfortable" with driving the Honda Fit. By this he meant both learning how the car operated as well as its range. In terms of range anxiety, there was a little bit to begin with however once he understood the car well enough (as well as the charging options that were

available) it was not an issue. Rather, he was fully confident that he could find and/or plan his trips to make sure that he had enough charge or could opportunity charge as necessary.

Design/Use:

Many of the Honda Fit's design features worked well for Kevin while others did not. He noticed that the cargo space was surprisingly larger than expected and, as such, he was able to load and deliver the charitable goods and materials (for his Sunday church mission in Los Angeles' skid row) that would otherwise have had to be delivered in the family's larger car.

The on-board navigation system was "ok…and a bit slower than expected" - Kevin noted that his 2006 Acura "had a better interface" than the newer Honda Fit EV. Additionally, there was a problem with the Bluetooth system that did not pair with his phone.

In terms of the climate controls, Kevin mostly chose not to use them. His rationale for using these features was predicated on two conditions. The first being that there was truly a need to use them (i.e. simply rolling down the window wouldn't solve the problem) and the condition that he would soon be "stopping anyway" to charge the car. If both conditions were not met he would sacrifice using the climate features for the extra range that would result.

Kevin reported that has subscribed and embraced the use of Honda Fit's on-line mobile application which supports and assists drivers with monitoring their EV's charging status, range and finding available Level 2 charging stations. Kevin found the app "very useful" though, ironically, he noted that his constant vigilance for monitoring and keeping up with the EV's charging status had affirmed his girlfriend's observation (after he after downloaded the app on to his girlfriend's smartphone) that he was "tethered to charging his multiple electronic devices" – including the car.

Rotation #3

Household 9

Participant: (Mike) Household 9

City of Residence: Torrance

Age: 68

Date: 5/2/13 – 6/6/13

ICE Vehicles: Toyota Highlander Hybrid

EV: Honda Fit EV

EV Start Date: 5/17/13

EV – TOTAL VMT: 439 miles

EV Average VMT per Day: 27.4 miles

Overall:

Mike Household 9 is a semi-retired engineer and property developer who lived in Torrance at the base of the Palos Verdes Peninsula. His home was listed as a free-standing duplex (i.e. two houses on the same property). As an engineer who was working on his own custom fuel cell engine, Mike was very much aware of the benefits of alternative non emission engines and was enthusiastic to be a participant in the Battery Electric Vehicle Study. Honda Fit EV replaced his Toyota Highlander Hybrid vehicle for all trips that were "not long range" and he choose to strictly use nighttime home-based 110 charging.

Household 9 Charging

Typically, Mike would run errands like shopping or to help out his children by picking up and dropping off his granddaughter at her school or at various local activities. Mike's work trips were infrequent however he did test the limits and capabilities by driving the Honda Fit EV to Huntington Beach as well as into Beverly Hills. Mike Mike's tenure in the program was cut short by his feeling that his "non-routine"

life style was not a good test of using the EV. That being said, His feelings about participating in the Study were positive.

Charging Strategy:

Mike Household 9 employed a regular home-based charging strategy. His typical charging pattern was to plug into one of many 110 outlets located within his garage; there were many outlets because his garage also served as his workspace and home shop for his engineering projects and experiments. Mike charged solely at night.

Mike did not participate in any opportunity charging either at home (between trips) and while traveling in the EV. Mike's rationale for not charging outside of his nighttime ritual was twofold. First, Mike's travel patterns were mostly local and did not necessitate the need to "top up." Additionally, Mike felt that he would not have time "to wait" at a local 220 charging station – "it would simply take too long."

110 to 220 Home Upgrade:

Mike decided not to upgrade his garage to accommodate 220 charging station. While he had 220 in the garage and the cost was nominal (approximately $150) it would simply not be worth it. His reasoning was two-fold in that his time in the study wouldn't warrant the expense and his strategy of using 110 charging at night was "convenient" and worked well given his driving patterns.

Travel Patterns and Driving Experience:

Mike described his travel patterns as "not routine." That is, as a semi-retired engineer and property developer who worked at home he had only minimal use for the BEV. His destinations included pick-ups and drop-offs of his granddaughter to her school which was located in Palos Verdes; he did this twice a week. Additionally, there would be the infrequent business meetings which caused Mike to journey further afield. Such destinations included Huntington Beach as well as Beverly Hills. Other trips included running local errands or shopping. Having an EV did not result in any changes in Mike's typical travel patterns. It would be fair to say that Mike was not conscious of chaining or combining trips in any unique way to maximize his range or his gas mileage in his Hybrid SUV.

For Mike, he saw the value of driving the Honda Fit EV for local trips. Other trips which would require a longer range he would simply take his hybrid SUV. While Mike did not experience any range anxiety he was "very aware" and "monitored" the charge and range of the EV. Interestingly for Mike, was the fact that traveling up the hill to drop off his granddaughter resulted in his range going from full (80 miles) to 53 miles at her school. Using regenerative braking on his way downhill was advantageous due to the regenerative braking as he noted his range would return to 93% (65 miles) upon his return home. This, for Mike, was a good lesson and informed his understanding about what trips were possible (or not) for him.

Generally speaking, Mike saw that driving the Honda Fit EV was like driving “a normal car” and he did not note any changes in his driving behavior or in his perceptions about driving. Mike recognized that his best use of the EV was for City driving on surface streets where he could maximize his range. He enjoyed his driving experience and rather thought of it as an experiment to test the viability of having an EV instead of his Hybrid SUV. His conclusion was that “he learned a lot.” On one level he could see EV’s as “being a good car to have in Southern California” with the idea that if and when he needed a larger vehicle.

Design/Use:

The Design/Use of the Honda Fit EV was seen as positive by Mike. He liked the fact that the car was quiet except for the apparent “jet engine” sound of the engine as it engaged (a sound that was enjoyable to him). In terms of cargo space, the Fit seemed to work for him; even though it was “a small car” it still had room to comfortably seat 4-5 people or with the seats down to carry groceries or other items. Mike thought that the pick-up was good and that there was “no shortage of power.” In terms of performance he noted that seemed “very stiff” and that it drove like a truck; it was not “smooth” which was something that he expecting in comparison to his Highlander (which he considered to have a smooth ride). Even though the GPS system did not work as expected, Mike was, on the whole, positive about his observations of the design and use of the Fit EV.

Household 10

Participant: Scott & Shirley Household 10

City of Residence: Gardena

Age: 46. 43, 19, 16, 11, 10

Date: 5/2/13 – 7/18/13

ICE Vehicles: Yukon Denali, Cadillac Escalade, Chevrolet HHR, Winnebago

EV: BMW Active E

EV Start Date: 5/17/13

EV – TOTAL VMT: 986 miles

EV Average VMT per Day: 20.5 miles

Overall:

Scott and Shirley Household 10 enjoyed driving the BMW Active E. The family included their two driving age sons; The family cars included 3 large SUV's and a Winnebago Recreational Vehicle that they used for weekend and holiday vacations. During the course of the study the EV became a substitute for one of the Household 10 family's large SUV's. Typically, Scott used the Active E the most – driving it approximately 75 percent of the time with the balance of the remaining time split between Shirley and their oldest son. Generally speaking, the Active E was used for local commuting to their restaurant as well as running errands. On occasion, the Household 10's treated the BMW as their family car and would drive it further afield to activities around Los Angeles, traveling to the Staples Center one evening and to a family function in Glendale on another occasion.

Household 10 Charging Set-up in Driveway

The Household 10 Family's experience was a very positive one in which they enthusiastically embraced both regular home-based charging as well as near daily opportunity charging; Scott developed a commute ritual of charging for free at Hermosa Beach City Hall. Typical travel patterns involved both commute trips to and from their family restaurant as well as chaining or stringing trips for "lots of local" errands that might

involve work destinations or personal trips for shopping; often Shirley would use the Active E for local errands at the end of her work day.

Charging Strategy:

Household 10 Electrical Panels for Charging

The Household 10 family employed both a regular ritual of home-based charging as well as opportunity charging on most commute days or when they would travel further afield. In terms of home-based charging, Scott would plug in at night to an outlet conveniently located behind his driveway gate. Because there was no room behind the gate to park the Active E (as the family Winnebago took up that space) Scott devised a novel plan to ensure that the car could be charged without the possibility of having the charging cord stolen. To do this he simply wrapped the cord around the gate anchor so that if the cord with dislodged it could not be readily taken (there were no incidents of attempted theft or disturbances during their time in the study).

With regards to opportunity charging, Scott noted that sometimes he would not have a full charge to start his day. He quickly developed a strategy to "top off" nearly every day on his way to work. The ritual he developed was that he would stop at the Hermosa City Hall charging station to plug into their 220 outlet; Scott used his Chargepoint card to access this service. As the EV was charging he would then walk the rest of the way to work, getting "a little exercise by walking up the hill." After 2 hours he would return to pick up the Active E with a "full tank." Scott relished the idea of incorporating "free" charging with exercise. Using his mobile apps Scott would, if necessary, pay for opportunity charging. An example of this was a

Household 10 Securing Portable Charging Cord

trip to the Staples Center to see a music show. Though he could not get tickets at the door he was able to find and use a charging station while he and his wife enjoyed an evening in downtown Los Angeles. Opportunity charging became almost a sport (especially free charging opportunities). As Shirley said, He's always looking for plugs."

110 to 220 Home Upgrade:

Logistically, the Household 10 Family had the capacity for setting up a 220 charging station. The electrical panels were readily accessible at the back of their driveway on an exterior wall. However, there were two reasons why upgrading did not make sense for the Household 10 s. First, in order to access the panel (for the most cost effective placement of a 220 charging station) they would have had to move and park their RV on the street. This was something that Scott was not going to do. Second, Scott did not see any advantage to upgrading their home charging from 110 to 220 as pointed out the Family strategy of 110 charging at night followed by "free" 220 charging station at Hermosa Beach City Hall was working just fine and really didn't cost them anything.

Travel Patterns and Driving Experience:

The BMW Active E became Scott and Shirley's family car. When they choose to drive the EV it replaced the respective SUV that they would otherwise have driven. Typically, the Active E became Scott's car of choice to commute to and from work. He would only use his truck when he needed to carry or haul materials for the cleaning and maintenance of their restaurant. Besides commuting the Scott and his wife would chain local trips during the weekday to run both business and personal errands like going shopping or to the bank. On occasion their son would use the car to drive to work or to school. As the family car the Active E was used by Scott and Shirley to travel for pleasure to downtown Los Angeles as well as further points like Glendale. Range anxiety was never really a problem however their first trip to Glendale gave them a feeling that this was their range limit. Understanding the EV's range led them to analyze their trips for what they would consider local versus trips that might be too far away (which would require the use of one of their family's larger vehicles). Trips to Mission Viejo or to Lake Havesu were two examples where the Active E was not deemed the car that would readily get them to and from those destinations. Both Scott and Shirley were careful to monitor the range differences when driving on surface streets versus highway driving. On longer trips they would be sure to use the car's eco-mode to maximize their range.

One of key experiences that the Household 10's felt was that by driving an electric vehicle they were able to decrease the amount they spent on gas each week. A quick analysis of their fuel costs by Scott showed him that they were spending in excess of $200 per week for both his and Shirley's SUVs. The savings incurred by not having to spend this much were noticed and appreciated.

In terms of how the car performed, it had “fun pick-up” and, on the whole they enjoyed testing it. However, as they look out into their changes in the types of vehicles they might purchase to replace one or both of their large cars they would consider a hybrid EV like a Volt as opposed to a BEV in so far as they would be able to extend their range. As to which vehicle they might replace the Household 10 ’s were not clear if they would, indeed, replace one of their family cars or simply add a fuel efficient vehicle to their mix of family cars.

Design/Use:

The Household 10’s were quick to point out that the BMW Active E was, as expected, a sports coupe. The low seating was not uncomfortable however, for larger people it might have been a problem. Moreover, the lack of cargo space, while understandable, was problematic in that they could not use it for longer trips since it could not accommodate their luggage. In terms of the “bells and whistles” both Scott and Shirley were expecting “more and better” since, “after all it was a BMW.” However, that being said, car drove smoothly and quietly which was a pleasant surprise though some of the features, like the cruise control could have been better placed within the car. On the whole, the Household 10’s thought that driving the BMW Active E was a very positive and fun experience, one that will assist them in their choice of a hybrid EV in the future.

Household 11

Participant: Tanja Household 11

City of Residence: Rancho Palos Verdes

Age: 40, 54, 27, 10

Date: 5/2/13 – 7/17/13

ICE Vehicles: Prius, Lexus RX 300, BMW 535 XI

EV: Nissan Leaf

EV Start Date: 5/17/13

EV – TOTAL VMT: 1,395 miles

EV Average VMT per Day: 30.3 miles

Overall:

Tanja Household 11 was, at first, a very enthusiastic participant who "truly wanted to see what driving a zero emission car was about. Over the course of the study her attitude and enthusiasm shifted to a skeptical and somewhat critical view of battery electric cars. The Household 11 family lived at the top of Palos Verdes and her household consisted of her husband, an owner of a used car business in Lawndale, a graduate school age son and two young girls.

As the primary driver of the Nissan Leaf, Tanja was able to replace her Toyota Prius for a variety of trips that constituted her typical day of driving. These trips included night time college courses, work in Orange County as well as taking her daughters to various activities. For Tanja, the Leaf was both a family car and her commute vehicle. In order for Tanja to drive the EV in this fashion she used a home-based charging strategy of plugging into a 110 outlet every night that was complimented by necessary 220 opportunity charging at her work location in Orange County; without opportunity charging at her work location Tanja would have had to use her Prius to commute to work. On occasion, her husband Vito would use the Leaf to take the children to various activities. His usual vehicle of choice to commuting to his Lawndale work location was to drive one of the used cars from the lot.

Over the course of her participation in the study Tanja became less enamored with driving the Leaf as she came to realize that the inherent issues of an electric vehicle's range and necessary time for charging could and did cause real anxiety. This anxiety and concern was manifested through an experience where she received a call that her daughter was ill at school however, because she was at work and needed to finish (opportunity) charging to "even get back to pick up her kid" she was unable to do so; the emergency was mitigated by having another family member pick her up and take her home. This inability to get to where she needed "in an emergency" or to simply "make it home" if

opportunity charging wasn't available was, for a mother of two young girls, not a positive experience and one that left Tanja questioning the practicality and reliability of substituting an EV for a family car.

Household 11 Charging Nissan Leaf Using Outdoor 110 Outlet

Charging Strategy:

The Household 11 family employed both home a regular home charging pattern as well as opportunity charging during the work day. Tanja would park the Nissan Leaf just outside the family's two car garage and charged the car using a convenient outdoor 110 charging outlet. Her home-based charging ritual was to plug in every night after her last trip and leave the car plugged in until morning.

In terms of opportunity, charging Tanja would take advantage of both available 220 charging stations at work as well as use the Leaf's 110 charging cord (which she carried with her at all times) to use where 220 charging was not available. Work-based 220 charging was not provided by her employer but was, instead, a public 220 charging station located in the South Coast Plaza parking structure adjacent to her office and in an area where she would have typically parked Prius. Tanja reported that were a total of 8 charging stations in two different locations. At first there were no issues in terms of accessing the stations, however, Tanja soon came to realize that since the stations were "first come first served" and that "more and more cars" were using them (often plug in hybrids like the Volt). As such, Tanja became sensitive to a "window of time" in which she "had to be there" so that she could begin charging right away. If she was late arriving then there was a chance that she might have to wait for several hours until a charging station became available. When this happened, Tanja would feel anxious and, if it were too late in the day, then the Leaf would not be fully charged and, as a result, the return trip home (especially "up the hill at the end of trip" would be stressful).

Tanja also took advantage of using the Leaf's 110 charging cord to opportunity charge in other locations where 220 charging was not available yet she felt the need to for additional charge. Examples of this included charging in a parking structure in Culver City while attending an evening college class. The necessity of charging using 110 (even for a few hours) was to "have enough juice to get up the hill" and home. Additionally, Tanja had to opportunity charge as an emergency resort when she was not able to charge at work. Thinking that she "might" have enough power to get home Tanja realized that she would not have enough battery to climb the last few miles of Palos Verdes. While enroute Tanja called her sister in Torrance to arrange a place to charge at her home and to coordinate being picked up by her father in her Prius so that she could return home; the Leaf was charged overnight and picked up two

days later. Tanja also opportunity charged while helping out at her husband's business at the used car lot in Lawndale.

110 to 220 Home Upgrade:

Tanja felt that her strategy of home-based 110 charging strategy at night followed by free 220 charging during commute trips was sufficient. Beyond the fact that she felt her charging strategy worked well enough, Tanja also noted that any additional costs would not be worth it because of the relative short length of the study, the cost that would be associated with rewiring to create a 220 outlet as well as having to reorganize the garage (as this would be the closest place to create a 220 outlet).

Travel Patterns and Driving Experience:

Tanja's travel patterns included a regular long commute trip to Costa Mesa for work, driving to night classes in Culver City and lots of "the usual" chaining of multiple drop-offs and pick-ups for her children's activities. Many of these trips for her children's activities required that she travel "down the hill" and would be very conscious of having to have "35 percent charge" (or more) so that she could get back home. Tanja felt that the experience of driving the Nissan Leaf was very much like the experience she had growing up and driving in Europe. For her the car was "smaller" than the North American cars she was used to. Tanja reported that the first week of driving the Leaf was "tense" as she "didn't know what she was getting into." However, after the first week, Tanja had a good understanding of the Leaf's range and she felt as though she had "figured out how to use the EV."

In terms of how the Leaf actually drove, Tanja appreciated that it "rides nice" and she liked the silence and lack of noise from the motor. Both she and her husband noted that they "did save gas" though, how much they actually saved from not purchasing or filling up during the study was not known. Overall though, Tanja described her experience as one of being taken "out of her comfort zone." Her discovery of driving the Leaf was one of "inconvenience." As Tanja noted her family (because of her husband's used car business) had other available cars to drive long distances; with respect to economizing on fuel she used the "Prius for city driving to save fuel."

Issue of Living in Hilly Community:

As with other participants in the study, Tanja was very much aware of the significant battery drain from driving up to their home and other local destinations around the steep hills of the Palos Verdes Peninsula. Tanja's rule of thumb was that she needed to have "35 percent" charge left in order for her to climb (from the base of Palos Verdes) home at the end of any trip. For Tanja, she was "always worried about going up the hill" for the last leg of any trip. On the other hand, Tanja did appreciate that the regenerative breaking system was able to put additional range into the Leaf at the start of the trip.

This became useful as Tanja's commute trips to Orange County consisted of mostly highway driving (which drained the battery faster than traveling on surface streets). Overall though, living on a hill with an electric vehicle proved challenging and, for Tanja, the need to constantly gauge the range was problematic.

Range Anxiety, Charging and Emergency Trips

Tanja experienced range anxiety when she discovered, much to her surprise and distress, that she would not be able to pick up her sick daughter (from school) because the Nissan Leaf was not fully charged; there would not be enough range to pick up her daughter and either get home or take her to a doctor's office. For Tanja, what seemed to be a simple and easy commute using the Leaf became a stressful and anxious moment when she had to find another family member to take care of her daughter. As Tanja said, "it was not a good feeling." The experience made her more aware of the practical range limitations of electric vehicles as well as the fact that both the technology and infra-structure for supporting EV charging is insufficient and problematic.

Tanja noted that, "more and more" there are not enough charging stations for all the EV's that need to use them and even if there were more stations. Commuting and having to arrive "in time" to charge became an anxiety filled trip for Tanja; additionally, the time it took to charge (using a 220 public charging station) was, for Tanja, not fast enough. The combination of lack of infra-structure, limited range for long distance commuting and the over-all time necessary to fully recharge while at work effectively undermined any confidence that Tanja could rely on the Leaf to get her home if there was an emergency.

Design/Use:

In terms of the Design/Use of the Leaf, Tanja had mixed feelings. She was not "hot" about the car's body style going so far as to comment that the Leaf had "no design style." However, she did consider that the car layout on the inside was "ok" in terms of comfort and cargo capacity. Tanja critically noted that the use of the AC and the resulting diminished range was a drawback to her overall appreciation of the EV. Overall, Tanja's positive feelings about the utility, design and ease of use of her Prius far exceeded her feelings towards that of the Leaf.

Household 12

Participant: Chuck and Elizabeth Household 12

City of Residence: San Pedro

Age: 48, 49, 21, 19

Date: 5/6/13 to 7/18/13

ICE Vehicles: Ford Expedition, Chevrolet Cobalt, Saturn Vue

EV: Nissan Leaf

EV Start Date: 5/18/13

EV – TOTAL VMT: 1,330.4 miles

EV Average VMT per Day: 23.3 miles

Overall:

Chuck and Elizabeth were enthusiastic drivers of the Nissan Leaf. Having grown up in families with a strong affinity and culture for cars – both Chuck and Elizabeth were excited to compare the differences between their regular family cars and a battery electric vehicle; participating in the study was seen as an extended test-driving opportunity toward the future possibility of adding an electric vehicle as an additional family car. Their experiences, to date, have been very positive – both in terms of appreciating how the car handles and drives as well as in understanding how an electric vehicle might benefit their family in the future.

During the first 2 weeks of the study Chuck drove the car "most" of the time – approximately 70% while Elizabeth estimated that she drove the Leaf 20% and their son 10% of the time. Chuck's driving pattern was to use the Leaf as a substitute for his SUV. As such, it became the vehicle of choice for commuting to his office at the local shopping center in Rancho Palos Verdes. As a Property Manager for this and other shopping centers, Chuck's job (at times) took him further afield to places like San Diego. For these types of commute trips he chose his SUV. Elizabeth chose to use the Leaf for local trips including shopping, physiotherapy sessions and volunteer work. Their son would use the car, on occasion for trips to Harbor Community College to attend classes or to go shopping in the nearby areas.

Because Chuck's job often required him to be "on-call" to answer emergency property issues after work hours. As such, Chuck was reticent to use the Leaf during these times – functionally, the EV would be charging on the home 110 outlet and, should he need to "dash off" he felt uncomfortable that there would be enough charge to get him to where the needed to go. This issue, was the part of the rationale

for considering and subsequently, upgrading and installing a 220 charging outlet so that he would be able to quickly charge the car and be prepared to use it should he be called to work (locally) after hours.

Household 12 Townhouse Parking for Nissan Leaf

Charging Strategy:

The Household 12 family employed both home a regular home charging pattern as well as opportunity charging during the work day. The garage had multiple available 110 outlets to facilitate charging in either parking orientation. Typically, the Household 12's charged the car at night "when they go to bed." Whether or not the car was fully charged in the morning was a bit problematic and depended upon how depleted the battery was at the time of charging. At times, this was a liability for Chuck as he would leave for work in the morning without a full charge; thus, needing to opportunity charge when he arrived at work. In that regard, Chuck would took advantage of opportunity charging at his work location. While the shopping mall did not (at the time of his participation in the study) have 220 charging stations there were several 110 outlets – located in the parking structure that he was able to use. There are several 110 outlets that could be used however, their location, unless otherwise known would make them very hard, if not impossible to find. As Chuck said, "you have to know where to look (near the elevators)". Since Chuck, as property manager, knew their location – "one of the advantages of my job" – he was able to opportunity charge for periods of 3-4 hours during many work days. Additionally, Chuck discovered, upon dropping off his son at Harbor College, that he could opportunity charge "for free" at the school's 220 charging stations that were located in the parking structure.

Household 12 Available Outlet Near Dryer

In general, both Chuck and Elizabeth felt that 110 home charging was sufficient for their needs however, given where they live (near a hilly community) and their family's driving patterns they were quite excited to try 220 home charging to see if the faster charge time would allow Chuck to use the EV while on-call as well as to extend the total number of trips that the family could take during the course of the day.

110 to 220 Home Upgrade:

Chuck and Elizabeth decided to upgrade their home charging to 220. Chuck was a trained electrician (a skilled learned in the military) and felt that there would be minimal cost – "perhaps $25 dollars" for equipment and materials to rewire the existing 220 outlet that was available and currently being used for the home dryer – located in the garage. Chuck expected to spend "an hour or two" of his time to make these changes and subsequently install the 220 home-based charging unit.

Travel Patterns and Driving Experience:

The Household 12 Family's travel patterns were essentially local. Whenever possible Chuck used the Nissan Leaf as his primary commute vehicle to travel to his office located just "up the hill" in central Palos Verdes; these trips in the Leaf replaced those that he would have made using his Ford Expedition. For Elizabeth her use of the Leaf was for running local errands and to go to doctor's visits. Their son used the EV to travel to and from a local community college.

In terms of their driving experience, Elizabeth described a conversation she had with a "hot grandma with red hair" in the parking lot of a Michael's Art Supply Store. The woman was also a Nissan Leaf owner and her words – which Elizabeth whole-heartedly agreed with – were, "just so you know, it has a devil inside it!" Elizabeth was quite taken by the power and maneuverability of the Leaf, "a pleasant surprise" or as she said, "my goodness, she's a good little girl." Chuck was enthusiastic, though somewhat less expressive, noting that it drove better than he expected and found it easy to "embrace the technology"; he liked the way the car felt when driving.

Both Elizabeth and Chuck noticed that their driving styles changed in relationship to the car and to the Leaf's regenerative breaking abilities. They were "surprised at home much energy could be put back into the car by coasting to stops or travelling downhill. Chuck noted that he was cognizant of "coming in slowly" so that he wouldn't have to stop, thereby adding charge back to the battery and increasing his range. Elizabeth suggested that because of the increased pick-up she was more conscious of the "distance between her and other cars" perhaps, she suggested, making her a better (safer) driver.

For the most part, the Leaf was driven in the Eco-mode. On occasion, however, Chuck and Elizabeth did experiment with driving the car otherwise but, ultimately, felt like the best result – in terms of both range and performance – was the Eco-mode. In terms of feeling comfortable with their driving experience it took Elizabeth one day while Chuck indicated that he felt at ease with driving the Leaf after "two or three days."

Elizabeth had an initial moment of range anxiety when (following training) she drove the Leaf home from north Manhattan Beach. She noted that she "had no real idea" of what to expect in terms of how much battery charge would be left while driving home on the freeway; While watching the range rapidly deplete on the way home she recounted that she was glad that she did not run out of electricity on the first drive. Chuck felt pretty much at ease with the range however, he did have one anxious trip to El Segundo when he left his home with an estimated range of 36 miles. Arriving at his destination (via the highway) he had 22 miles of range left. However, after a couple of brief (yet unexpected) detours or

stops he became anxious. As he put it, “I got sweaty palms” when the range dipped below 25 miles remaining. Chuck realized that travelling the same way home might result in running out of charge and made a decision to take surface streets – a longer trip but one that, ultimately, used the Leaf’s battery regeneration to get him home comfortably with an estimated 30 miles of range.

When asked if using battery draining amenities like the air-conditioning caused any anxiety both Chuck and Elizabeth noted that that was not the case; respectively, Chuck did not use the AC while Elizabeth used it on “warm days.” As a matter of course, both drivers had no hesitation or issues with using any or all of the vehicle amenities even though they did notice a slight decrease in range while using the air-conditioning (approximately 10 miles) – “it’s a car, we might as well use them” was how they put it.

Chuck found the Leaf on-line apps useful and informative even though his driving patterns did not necessitate having to find or use any of the many charging stations available in the Greater Los Angeles Area. Interestingly, while traveling in San Diego Chuck was able to notify his wife and alert her to the fact that, although she had plugged it in and thought it was charging, it was, in fact, not charging as expected; thus, saving Elizabeth from returning to the car in the morning without sufficient charge for her day’s travels.

Chuck and Elizabeth’s experience driving the Leaf suggest to them that an electric vehicle might be sufficient as a second car instead of one of their larger SUV’s. As Chuck said, “they would still keep their Expedition (or similar 4 wheel vehicle) for camping…” but an EV would be useful for “tooling around town.” In terms of price/value the Leaf’s sticker price is too high ($34 K) however something in the range of $10,000 to $20,000 would be a price that they would consider.

Design/Use:

The Design/Use of the Leaf was seen differently by Chuck and Elizabeth. In terms of aesthetic Elizabeth thought that the car was “cute” and loved the extra cargo room – for carrying groceries as well as various added features like the extra cup-holders. Chuck, on the other hand, wasn’t particularly enamored with the look of the car but was surprised with the large cargo capacity. Both Chuck and Elizabeth noted that there were no vents in the back for air-conditioning. Of note as well, Chuck thought that the counter-intuitive position of forward/reverse on the stick shift should be changed while Elizabeth had no issues with it at all. Other features, including on- board computer and navigation monitors were easy to use and seemed to make sense in terms of how they monitored the car’s range.

Rotation #4

Household 13

Participant: Zvia Household 13 and Family

City of Residence: Manhattan Beach

Age: 53, 52, 22

Date: 6/6/13 – 9/19/13

ICE Vehicles: Prius, Acura MDX, Toyota Corolla, Motorcycle

EV: Honda Fit EV

EV Start Date: 6/13/13

EV – TOTAL VMT: 1,575 miles

EV Average VMT per Day: 19.4 miles

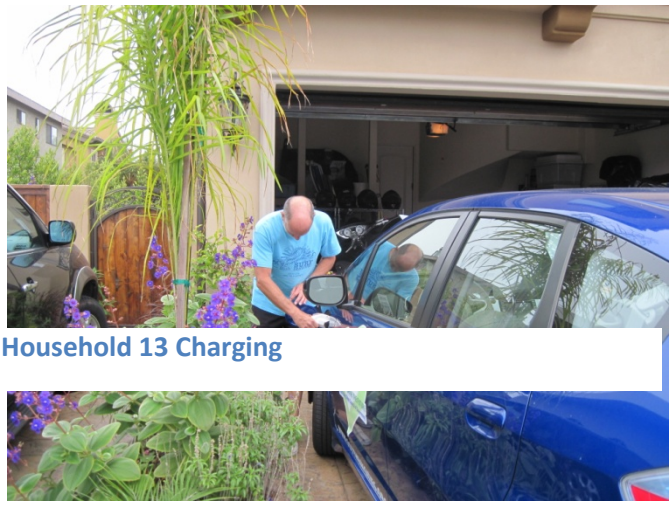
Overall:

Zvia Household 13, her husband Scott and Dina, her driving aged daughter lived in a single family home located on the eastern side Manhattan Beach. The Household 13 Family were very enthusiastic participants; their enthusiasm was based partially on having had a successful and positive experience as participants in the Neighborhood Electric Vehicle Project. During the course of the study Zvia was the primary driver of the Honda Fit EV; Dina drove the EV while Zvia and Her husband were out of town. Respectively, the EV replaced the Prius for Zvia and the Toyota Corolla for Dina.

Zvia's travel patterns were very similar to those that she had while as an NEV participant. Essentially, her trips consisted of a lot of very local, chained trips to work (teaching yoga) errands and other local destinations in and around the South Bay. On occasion she and her husband would venture to destinations like the Music Center in Downtown Los Angeles however they would do a great deal of planning to make sure that they could comfortably return home without charging. While Zvia was out of town Dina used the EV for a few trips that were further afield including a trip to Disneyland and Long Beach. The Household 13 s reported that, in comparison to the NEV that they tested, the Fit EV as a "real car" which gave them additional travel options that they would not have had in an NEV. Overall they enjoyed and valued their experience testing the Honda Fit EV and stated that if the economics were right they could see adding an EV to their family's fleet of cars.

In terms of charging, the Household 13 Family used a strategy of 100% home-based charging. After 2 weeks of 110 charging they opted to spend approximately $250 to upgrade garage outlet so that they

could test the viability of using a home 220 charging station. According to the Family, the test was a very positive experience allowing them to charge the Fit EV in less than ½ the time. It was noted that, they would be "ready" should the family purchase or lease an EV at the end of the study or in the future



Household 13 Charging

Charging Strategy:

The Household 13 Family chose to use a 100% home-based charging strategy. For the first 3 weeks of their participation the family used a 110 outlet located in their two car garage. The family would plug in in the evening (after 9 PM) to take advantage of lower electric rates. In the morning the Honda Fit EV would be fully charged with an indicated range of over 80 miles

Zvia and her husband explored the idea of opportunity by researching where, on their various they might find and use public 220 charging stations. They found that there were numerous places that they could charge however, given their pattern of chained short trips they felt that there "would not be enough time" for this type of charging to make a difference. They related that, "if they worked" or spent more time in the vicinity of a public charging station then they might feel like it would be worth their time. However, given their schedules and their pattern of very local trips it did not make sense to charge outside of their home.

After 3 weeks the Household 13 s decided to upgrade to install a home-based 220 charging station. The family continued to (exclusively) use home-based charging through the remainder of the project.

Household 13 Home-based 220 Charging System

110 to 220 Home Upgrade:

Zvia and Brian decided to upgrade their home charging to 220. Their rational was that "the cost of minimal" and that they wanted to see what the difference was between using the 110 and having 220 available. As Brian said, "it just made sense to do it."

The Household 13 s received a quote of $250 to run conduit a short distance from a nearby electrical panel; additionally, a 220 outlet was

installed. To complete the project the electrician mounted the home-based 220 charging station on the garage wall which afforded the Household 13 s with easy access to charging the Honda Fit EV either in the garage or just outside in the driveway.

The Household 13 s noted that charging the Honda Fit EV was noticeably faster using the 220 charging station. In comparison to simply plugging the EV into 110 outlet they estimated that it took ½ as much time to charge. To take advantage of lower electrical rates the Household 13 s continued to charge in the evening and late at night. Additionally, Brian discovered and learned how to program the EV so that he could plug it in at the end of the day and the EV would begin charging between 10 PM and 5 AM; this was a nice convenience for the family.

Travel Patterns and Driving Experience:

Zvia was the primary driver of the Honda Fit EV. She estimated that she drove the EV about 99 percent of the time. Her travel patterns were, generally, speaking very local and included routine destinations located in Redondo Beach, Manhattan Beach and El Segundo. As a yoga teacher she would commute to different studios in the South Bay to teach or take classes. Additionally, Zvia often chained her trips so that she would run errands to go shopping, the store and doctor's office before heading home. On occasion Zvia and Brian would venture further afield driving into Downtown Los Angeles to attend a show at the Music Center. Dina, Zvia's daughter, drove the EV while she was out of the country. Though she did not drive the EV often she did not have any problems taking longer distances. Brian drove the Fit EV "only a couple of times." His vehicle of choice was his motorcycle which he used for his daily commute.

The Household 13 family's driving experience of driving the Honda Fit EV was one of contrast to their ICE vehicles as well as their experience of testing a Neighborhood Electric Vehicle. Zvia and Brian's first observation was that having a full-sized electric car was "more convenient" than the little golf cart like car that they test drove. That is, they had more range and could drive it on all surface streets and highways, as well. The issue though was that the range of the Fit EV was just not contusive to longer trips to visit family members like Zvia's mother who lived in Arcadia or to go golfing. In those cases taking the Prius or MDX became the preferred travel option.

Neither Zvia nor Brian reported having any range anxiety. Generally speaking, their trips were very local and, as such, they realized that they could easily reach and return from any of their trips. However, as a way to mitigate any possible problems, the Household 13 s would spend time each day planning where and how far their EV travel would take them. They would take into account possible (emergency) opportunity charging locations as well as calculating and/or approximating the miles that they would need for the day's travels; they also became skilled at understanding and accounting for the range variations that occur from steady highway driving versus surface streets and stop and go driving.

Overall the Household 13 s enjoyed their experience, "it was like driving a real car." Moreover, they were pleasantly surprised that they "hadn't had to go get gas" Brian even noted that "Costco (where

they purchase gas) has sent out a search party looking for them…" Both Zvia and Brian suggested that, at some point (perhaps retirement), they might consider a full-sized EV as a cost effective travel option for their local travels however, at this point, the Prius, with its good fuel economy, and Brian's motorcycle would be sufficient for local travels with the MDX SUV reserved for trips that required extra cargo space.

Design/Use:

In terms of the Design/Use of the Honda Fit EV, Zvia noted that it was a "little bit smaller" than her Prius. This did not pose a problem as there was sufficient cargo space for all her yoga equipment and other personal items that she carried in her car; for security purposes she thought that a "cargo cover" for the back area of the car would have been a good feature to have. The other features on the Fit EV were appreciated but not really used. However, the blue-tooth was problematic and required servicing; something that the Household 13 s expected to work without any issues

Household 15

Participant: Steve Household 15

City of Residence: Rancho Palos Verdes

Age: 49, 45, 10, 8

Date: 7/2/13 to 9/15/13

ICE Vehicles: Acura TSX, Acura MDX

EV: Nissan Leaf

EV Start Date: 7/19/13

EV – TOTAL VMT: 978miles

EV Average VMT per Day: 25.74 miles

Overall:

Steve Household 15 was an enthusiastic driver of the Nissan Leaf. Steve, his wife and two elementary school aged children lived in Rancho Palos Verdes. Steve is an engineer and works in the City of Redondo Beach Planning Department. Steve was the primary driver of the Leaf and used it as his commute vehicle during the course of the study. The Leaf essentially replaced commute trips that he would have otherwise have driven in his Acura TSX. Similarly, the Leaf's significant cargo space afforded the Household 15 family the opportunity to replace many of the local trips to "drop off the kids" at their various after school activities. As a practical matter, the Household 15 family felt that Steve should be the primary driver. His wife tested the car however because of her job as a doctor it was felt that she should have the security of continuing to drive her own MDX rather than "worrying" about charging or range issues with the electric car.

Throughout the course of their participation the Household 15 family used, exclusively, a home-based charging strategy. Typically, the Leaf was charged each night and, if the opportunity was available (i.e. Steve would be home for a couple of hours during the middle of the day), then the family would opportunity charge between the many local trips made during the day.

The Household 15 family really enjoyed their experience of driving the Nissan Leaf. However, as Steve stated, he would have liked to the Leaf to have had a longer range so that family visits to Orange County and possible work related travel could be taken using the EV.

Charging Strategy:

Steve Household 15 employed a two-fold home-based charging strategy. Each evening, after the last trip of the day, Steve would plug the Nissan Leaf into a 110 outlet located on the back wall of his garage. Over the course of the project Steve came to embrace home-based opportunity charging. Instances where this would happen often were when Steve would come home for lunch or between dropping off his children for their various after school activities; he would opportunity charge for an "hour or two" to top off the battery to ease his mind about having enough charge for a possible "additional" trip that he might have to make later in the day. This type of home-based opportunity charging was critical since "coming up the hill for the last trip" would significantly drain the battery thereby making multiple future trips (further up) the peninsula problematic; even though downhill trips would yield additional charge because of regeneration Steve felt comfortable and had peace of mind knowing that he had opportunity charged (even if it was for a short time).

Household 15 Creative Mounting of 110 Charger

In terms of charging at work, Steve noted that there was an outlet that "might be available" however he would need "special permission" to use it. For Steve, opportunity charging at work was mostly a moot point. Steve's trip to work was always downhill for the first few miles. Since he left the house each morning with a "full charge" he would actually add more miles (range) by simply using his breaks or coasting to add back energy to the car's battery. Often he would arrive at work with a full battery or more miles/range than when he left his home.

110 to 220 Home Upgrade:

The Household 15 family could see the value of upgrading their wiring to facilitate a 220 charging station. Faster opportunity charging between trips would have been a welcomed result however, they decided not to upgrade for two reasons. First, the existing home-based 110 charging was "working well" and their test of the EV was for a relatively short period. In Steve's mind, there was no reason to change. Second, the Household 15 s were in the process of doing a major remodel of their household. As such, upgrading their garage outlets from 110 to 220 would be a "waste of money" since if they put it in then they would have to redo it again as part of their longer range plans when construction began at some later point.

Travel Patterns and Driving Experience:

Steve described his travel patterns as "very local". Mostly his trips consisted of travelling to work, then home to dropping off kids for various activities (including hockey and soccer). Initially, it took Steve a week to "get comfortable" with the car's range. In particular, he was surprised by how much energy it took the car to travel up the hill to his home. While this did not give him range anxiety, per se, it did make him conscious of the Leaf's range. On one early trip he felt the need to conserve his range by driving slower and turning off the AC so that he could "make it home." Quickly though Steve was able to learn to take advantage of the downhill portion of his trips to add energy back into the battery through the Leaf's regenerative system. Most of Steve's travel was on surface streets which added the total range that he had at any given time.

Steve was very aware of "all the electronics" that made up the car and was somewhat anxious that there were could be "problems" or "issues" with the EV. He was pleasantly surprised that there were no such issues during his participation in the study. In terms of the range of the Leaf, Steve felt that it was sufficient for his needs however he did lament the fact that he couldn't travel further afield. He noted that if it had a little more range than he would have felt more comfortable in taking the car to such places as Irvine. On the whole though, Steve loved the experience of driving the Nissan Leaf "it was perfect" for his local trips. Looking into the future Steve would seriously consider replacing his TSX with a similar BEV or perhaps a hybrid electric vehicle. He noted that he and his wife would still need a larger SUV like the MDX for longer trips as well as instances where they needed more cargo room or needed to carry (more comfortably) additional passengers.

Design/Use:

The Design/Use of the Leaf was seen very positively by Steve. As a tall individual (over 6 feet) he felt very comfortable sitting inside the car. The utility of the car was perfect for "hauling all his kids' sports gear." Steve and his wife both liked the fact that there were no exhaust smells from the Leaf when it was running in their garage. Moreover, they enjoyed the fact that the car was "very quiet." Steve did not use or choose not to use other amenities like the Leaf's blue-tooth system or the GPS. He did not feel the need to download or make use of any of the apps that support the Nissan Leaf or electric vehicle driving.

Household 16

Participant: Household 16 Family

City of Residence: Rancho Palos Verdes

Age: 51, 49, 16, 14

Date: 7/2/13 to 9/12/13

ICE Vehicles: Honda Civic SI, Toyota Sequoia

EV: BMW Active E

EV Start Date: 7/19/13

EV – TOTAL VMT: 1,510.4 miles

EV Average VMT per Day: 31.4 miles

Overall:

Larry and Susan Household 16 lived in Rancho Palos Verdes with their two elementary school children. Both were curious and excited about the opportunity of test driving the BMW Active E. As a family they were interested in seeing what kinds of efficiencies and savings could be had from using an electric vehicle. Respectively, Larry and Susan shared the use of the BMW with Susan using it an estimated 60 percent of the time to Larry's 40 percent. The family negotiated and planned who would ultimately drive the electric car based on where their trips might take them and the potential for multiple trips that might be chained for a more efficient route; additionally, they would factor in which car made more sense in terms of cargo room and range. Susan noted that since "she drove more" mostly because, as a stay at home mother, she had a "routine" that involved local drop-offs, pick-ups and errands. From time to time, Larry used the BMW Active E as a replacement commute vehicle for his Honda Civic. Over the course of their family's participation both Susan and Larry became "more aware" of the repeated nature of their driving patterns and discovered how "combining trips was a good thing" or practice to making their use of the electric vehicle more effective and efficient.

Household 16 Charging Set-up

In terms of charging, the Household 16 Family used a home-based 110 charging that included both overnight and opportunity charging. The standard practice for the family was to plug in the Active E at the end of the day so that it could charge overnight; because of the family's schedule the car would often get 10-12 hours

of charge. Additionally, Susan would opportunity charge during the day between trips however, as she noted, it "wasn't worth the trouble" if she had to turn around and go back out in a short period of time. Her rule of thumb for deciding whether or not to plug in during the day would be if she knew that she would be home for at least one hour.

Opportunity charging outside of the home was explored both in terms of workplace charging at Larry's place of work at Cal. State Dominquez Hills as well as Level 2 public charging stations. While Larry discovered that campus vehicles had access to a campus charging station he did not pursue permission to use it or look to see if there might be other options available to charge; Larry's feeling was that he had sufficient range to easily return home at the end of the day. In terms of public charging both Larry and Susan felt that two issues mitigated their use of this charging option. The first challenge was the limited availability of charging stations. On several occasions the family explored the idea of using public stations only to discover that, for instance, the charging stations at Costco were already being used or that ICE vehicles were parked in marked charging spots thereby making charging impossible. The second challenge was time. As Susan noted, "she was not usually at one place for more than ½ hour." Even using 220 this was seen as not enough time to make a difference to their range.

Charging Strategy:

The Household 16 Family exclusively charged at home using a 110 outlet located inside their garage. The BMW Active E would be parked in the family's driveway and oriented so that the EV's charging cord could be pulled under the closed garage door to be plugged into a wall outlet. The typical scenario for charging the Active E was to plug it in at the end of the day so that it could charge overnight. Often, because of the family's schedule (i.e. they would be home in the early evening because of their children's school schedule and homework) the car would charge for 10 to 12 hours.

While the family did not avail themselves of either workplace or public opportunity charging they did take advantage of home-based opportunity charging between daily trips. This strategy was used mostly by Susan who developed a rule of thumb that she would plug the Active E in if she were home (from one of her trips) for more than 1 hour. Anything less, in terms of time, was seen as not making a difference to her range.

Home-based Wiring Challenges

The Household 16 Family discovered that charging the BMW Active E could be problematic. At issue was the fact that the simply plugging the EV in to charge would often "trip (the outlet's circuit breaker) in one or two seconds" after being plugged into the wall; all of the 4 available plugs within the garage would produce the same experience. As Larry stated, "this became a little annoying" however, with a little ingenuity he was able to "trick it into getting past tripping" by plugging it into the wall in a certain

way; sometimes it would take upwards of 10 minutes to successfully get the Active E to start charging properly. In terms of ease of use, this was not what the Household 16 Family had expected. As Susan stated, our "expectation was that you plug it in and walk away."

110 to 220 Home Upgrade:

Larry and Susan were not interested in upgrading their home charging to 220. While the family noted that 220 charging "might make a difference" and possibly "change their (EV) driving habits" because they would be able to effectively keep the EV (more) fully charged through day time opportunity charging they did not see the value of incurring the cost for doing this for the time remaining in the study. As far as the Household 16 s were concerned nighttime 110 charging along with the occasional home-based opportunity charging was sufficient to meet the family's charging needs.

Travel Patterns and Driving Experience:

Susan and Larry shared the use of the BMW Active E. Respectively their travel patterns can be described as "routine." For Susan her typical trips involved a series of chained local trips to local destinations in and around their Rancho Palos Verdes home. The destinations that she would travel to would consist of dropping off and picking up her children from various school activities, shopping and other running errands. For Larry, his travel patterns during the work week would consist of a 40 mile round trip to Cal State Dominguez Hills. Both Larry and Susan would spend time considering which car would be best fo their respective day's travels and/or a specific trip which might require larger cargo space or a range that the BMW Active E would not be able to provide.

For Susan it took "about 1 week" to learn and feel comfortable driving the BMW. Larry, on the other hand, felt at ease much sooner. For the Household 16 s, the primary feeling of range anxiety had to do with the fact that they lived in Rancho Palos Verdes and, as such, there was the fact that all trips home from the base of the RPV would necessitate going uphill. Understanding the rapid decrease of range (available battery charge) from traveling uphill was an integral step in becoming comfortable with using the electric vehicle. The Household 16 s learned that this last leg of their journey required at least 10 to 20 percent of available charge to make it home. As such, they learned to watch the dashboard indicator so that they could feel less anxious about this part of their trip. This was especially so in light of unplanned or multiple stops before returning home and travelling up the hill as they needed to make sure that there were "10 miles" of range left.

Range anxiety as expressed through longer trips were not really an issue for the family because they spend time to plan their day's travel patterns and to efficiently chain their destinations. The idea of running out of electricity was something on Susan kept in mind both in terms of her planning and her actual travels. She noted that driving an electric car was very different than driving her Toyota Sequoia.

With her car she could “drive anywhere – it was unlimited” because she could stop for gas almost anywhere.

In most instances, Larry and Susan choose to drive the BMW Active E in the standard driving mode rather than in the Eco Mode. Driving the EV in this fashion did not make a significant difference to either the range that they required when choosing to use the car. While not getting the maximum range (based on driving mode) both Larry and Susan discovered that they could maximize their range through regenerative braking; when leaving their home and heading downhill it became a “game” to see how many additional miles they could add to Active E’s stated range.

Design/Use:

Susan and Larry appreciated that the EV was a BMW and had the “same style” as a regular car. In comparison to Larry’s Honda Civic SI he felt that the Active E’s performance and handling was comparable and more than adequate to meet his needs and expectations for how a car should handle. Both Susan and Larry noted that the Active E had “good pick-up.”

In terms of design there were challenges that became apparent due to the fact that the Active E was a sports coup rather than a 4 door hatch-back. The primary issue concerned cargo room and the low design of the car. As Susan noted, the small trunk space limits all the stuff they might want to take for kid’s activities or what they carry when shopping. The low to the ground design of the car required that they drive cautiously so as not to “bottom-out” when driving over speed bumps or entering or exiting their driveway.

Other positive amenities included the GPS and Bluetooth that the Household 16 s used on a daily bases. Unfortunately, for their children, there was only one cup holder which was problematic given that they both wish to use it at the same time.

Rotation #5

Household 17 (Rotation #5 & #6)

Participant: Nancy Household 17

City of Residence: Redondo Beach

Age: 55, 56, 15, 10

Date: 9/6/13 to 11/16/14

ICE Vehicles: BMW 328I, Toyota Highlander

EV: Nissan Leaf

EV Start Date: 9/23/13

EV – TOTAL VMT: 1,909 miles

EV Average VMT per Day: 20.0 miles

Overall:

Nancy Household 17, her husband Michael and two teenage children lived in a single family home located in Redondo Beach. As a former participant in the Neighborhood Electric Car (NEV) study she was very curious and excited to test the differences between a range and speed limited Local Use Vehicle (LUV) versus a full-speed electric car; Nancy fast became a very enthusiastic driver of the Nissan Leaf. Nancy was a stay at home mom with a small internet "reselling" business who's motivation for participating in the BEV study was to learn if a full-size, full-speed electric vehicle could "serve the needs of her family" as a second car.

Nancy's travel patterns were "similar" to those that she discovered when she was a participant in the NEV project. That is, her trips consisted of "very local" destinations that were chained together; her trips were, as Nancy described, "mostly of running errands" for her family and for that of her home-based internet reselling business.

During the course of the study Nancy was the primary driver of the Nissan Leaf; she used the EV extensively within the household approximately 98% of the time. Her husband was offered the opportunity of using the Nissan Leaf for the occasional commute trip to his office in El Segundo at the Raytheon Corporation however he declined. Rather, he briefly tested the EV for a few short trips of running errands to the local hardware store. Nancy, on the other hand, used the Leaf to replace 100% of all the trips she would have otherwise made using her BMW 328I. That is, for the course of her participation, Nancy was able to test the idea of fully replacing her ICE vehicle with that of an electric car.

In terms of charging, the Household 17 Family primarily used a strategy of charging at home late at night using an outdoor 110 outlet located near their home's rear/kitchen door. On occasion, Nancy tested the use of opportunity charging at other locations throughout the South Bay including the DC fast charge at the local Nissan Dealership and free 220 charging stations in the community. Aside from the convenience of "filling up" using DC 3 charging she found that opportunity charging was both problematic in terms of the time it would take to charge and accessing available outlets (i.e. someone would be using the charging station or parked there without charging). Nancy's solution became one of setting up a routine of home-based charging (as necessary) late at night to take advantage of lower utility rates.

Household 17 Charging Nissan Leaf

Charging Strategy:

The Household 17 family's primary strategy for charging their Nissan Leaf was to employ a home-based 110 home-charging strategy. Typically, "at the end of the day", the Leaf would be plugged in to an outdoor outlet that was conveniently located near the rear door of the family's home. Initially, the ritual was to plug in the car every night however the exact time for plugging the car in would vary. Often, if Nancy would arrive home early she would plug in before the "off-peak" hours for billing began (i.e. she would plug in at 6 PM well before off-peak billing began later in the evening).

In terms of opportunity charging Nancy would, initially, plug in the EV at home between daily trips.

Household 17 Charging Set-up on the Back Porch

Outside of the home there were only a few instances where Nancy tested other local opportunity charging. In one instance she used the DC 3 fast-charge located at the local Nissan Dealership for a fast and free charge. Additionally, Nancy attempted to charge on two other occasions however, in both instances, she was unable to charge due to the fact that there were no available stations because cars were either charging or parked without charging (making it impossible to park and charge). When asked about her rationale for choosing or using opportunity outside of her home Nancy was clear that it

had to be “where I can get it fast and free.” Additionally, the challenge of opportunity charging using Level 2 charging stations was problematic for Nancy in the fact that it just took too much time. “Sitting and waiting (hours) for the car to charge” was not an option” for Nancy and her busy schedule. Nancy was quick to point out that “charging needs to fit your lifestyle…fast or overnight.”

The cost of home-based charging became an issue for the Household 17 Family after Nancy inspected the first electric bill that she received following the addition of the Leaf to her household. She became very concerned that the Nissan Leaf was “costing” her more money than expected to charge the vehicle. Nancy based this on the observation that her household bill for electricity had risen to the 4th tier during the time that she started driving (and charging) her car. For Nancy the “shock” of seeing her electricity bill reach levels that she had not seen before was enough for her to question whether or not having an electric car made economic sense for her and her family. As she put it, “if I’m going to go green I want to see the savings.”

Nancy explored this issue by participating in a household electrical audit and consultation by the South Bay Cities Environmental Service Center. She learned that, beyond the addition of the Leaf to the household consumption of electricity there were other appliances that contributed to the excessively large electricity bill. Nancy learned that one way to mitigate this expense was to change her charging patterns as well as her electricity billing plan.

Nancy was able to do both. First she changed her Southern California Edison (SCE) billing plan to the home electric vehicle plan which afforded the Household 17 Family a discounted rate for charging at night between 11 PM and 7 AM. To take advantage of this discount Nancy learned how to program the Leaf so that, once plugged in, it would automatically begin charging within the discounted SCE billing hours.

110 to 220 Home Upgrade:

The Household 17 Family decided not to upgrade their home charging to 220. Given the very local nature of Nancy’s trips and her effective strategy of charging the Leaf at night there was no need to pay for an electrician to upgrade and install a 220 outlet for home charging. As Nancy said, “I don’t really need it as the chances are I won’t get stuck.”

Travel Pattern and Driving Experience:

Nancy’s travel patterns were very local in nature. In general she described “running errands all day” by chaining her trips so that her travel time was more efficient. A typical day’s travel pattern might consist of dropping her kids off to their respective schools followed by shopping at Trader Joe’s, working out at her local gym and business errands for her internet sales business. Very few of her trips (aside for some business pick up and drop-offs) were outside of the South Bay area.

Nancy saw herself as a planner in terms of her daily travel. Her experience as an NEV participant taught her that if she was thoughtful and organized she could maximize the total trips that her range limited electric car could make. Taking that experience forward into the BEV study Nancy was comfortable in chaining her trips together to get the most range out of each daily charge. Only in one instance, a business trip to Beverly Hills followed by another stop in Santa Monica (with both surface streets and highway driving) did Nancy experience range anxiety. In this instance she didn't figure out the mileage to account for an extra stop along the way as well as the significant decrease in range that results from highway driving. Nancy became anxious when she noted that she had a range of 9.5 miles left and her home was 7 miles away. The "car talked to me" warning me that I was running out of range. She made sure to turn all extra amenities off and "didn't gun it" so that she could make it home. In this case however, it wasn't a problem. Nancy did note that it would have been an issue had this been her only car and if additional trips could not take place because the car was charging.

Nancy's driving experience of the Nissan Leaf was informed by comparing it with both her BMW 328I and her experience driving the NEV. According to Nancy the Leaf "drove well" and had good pick up though it was not a "chick car" and had "little pizzazz" like her BMW it was very practical and it was much more like a real car than the range limited NEV that she drove in the earlier study. Certainly, savings in fuel cost were a significant aspect and colored Nancy's driving experience in a positive way. For Nancy, one of the key metrics to the success of the using the Leaf was if she was saving money. She felt good driving the Leaf especially knowing that she could easily quantify (even with the added cost of home-charging) how much she was saving (or not spending) in gas for her BMW. Interestingly though, even though Nancy was knew that she was "saving money" she categorized her driving experience with the Nissan Leaf by making the distinction that she did not have an "energy saving car" but rather an "electric car."

In terms of driving behavior, Nancy did not see any noticeable differences. She still ran multiple errands and her understanding and planning for chaining of trips was something that she carried over from what she had learned testing the NEV. For Nancy, the Nissan Leaf was a very practical car that facilitated her travel patterns of going from "point a, to b, to c, to d…" the bells and whistles were rarely used.

Design/Use:

While Emma (Nancy's daughter) saw the Nissan Leaf as "cute" and liked its design Nancy view of the Leaf was different. She saw the Leaf as being mostly functional rather than aesthetically pleasing; "a middle-class car." The fact that Nancy could comfortably pick up 3 girls and her son from various activities was viewed positively. So too the hatch-back and cargo space was "pretty good" and afforded Nancy the opportunity to haul large objects for her internet re-selling business.

In terms of design and use of the other amenities, Nancy did not use the AC or heater and she was unable to use (or "figure out) the GPS. She did, however, appreciate the rearview camera for backing up as well as the Bluetooth.

Household 18

Participant: Victoria & Greg Household 18

City of Residence: Redondo Beach

Age: 51, 46, 13

Date: 9/6/13 to 11/21/13

ICE Vehicles: Toyota Highlander, Toyota Matrix

EV: BMW Active E

EV Start Date: 9/20/13

EV – TOTAL VMT: 745.0 miles

EV Average VMT per Day: 16.9 miles

Overall:

Victoria and Greg were very enthusiastic drivers of the BMW Active E. The Household 18 and their 2 teenage sons lived in a multi-unit apartment located in Redondo Beach. Greg worked as an independent software and website development consultant commuting daily to El Segundo and into Culver City to work with his clients. Victoria's work day consisted of running the household which included taking care of the daily routine of dropping their sons to school and taking them to their many after school activities. At the beginning of their time participating in the study, the family had two cars, the hybrid Highlander and a Toyota Matrix, driven respectively by Victoria and Greg. The Highlander functioned as the all-purpose vehicle for errands, shopping and dropping of their kids while the Matrix was used exclusively as Greg's work commute vehicle. Of note, however, after receiving the BMW Active E, the Matrix was parked on the street where it suffered major damage after being hit by another car. As a result, the family decided that Greg would use the electric vehicle for his "commute car"; he drove the Active E approximately "99% of the time."

Most of the EV trips were for commuting however, over the course of their participation, Victoria and Greg where excited to learn that for "a family of 4 (the Active E) was perfect" as a second car. They appreciated how the car handled and could see how it could, additionally, could be used for local trips. The disadvantage was primarily the range which typically was 66 miles or less.

Charging Strategy:

Household 18 Designated Apartment 110 Outlet for Charging

The Household 18 family employed a strategy of exclusively charging at home typically after the work day. Of interest was that they lived in a multi-unit building where two other households had plug-in hybrid vehicles. Since the Household 18's were the third family to inquire about charging the landlord had already created a system/policy for tenants to access a 110 outlet to charge their cars. The cost per household per month was $20.00. There were no improvements to the electrical panel or additional outlets which meant that there was 1 outlet with 2 plugs for 3 cars. The Active E needed to be plugged directly into the outlet. Because of the demand and lack of an available outlet there was, from time to time, issues of not being able to plug in to charge their car (an issue, as well, for their neighbors). At the beginning of the project Victoria and Greg had expected to charge every evening however, as a result of their unique charging situation they wound up charging the Active E about twice a week.

Neither Greg nor Victoria attempted or felt it necessary to charge outside of the household.

110 to 220 Home Upgrade:

The opportunity to upgrade to 220 was logistically possible – the designated "house" outlet was located directly beneath the apartment's electrical panel. The landlord, however, was not approached to upgrade his electrical panel to accommodate a 220 charging station. The on-site apartment manager indicated that the landlord did not want to get involved and/or spend additional funds at this time.

Household 18 Designated 110 Outlet Near Electrical Panels

Apartment Charging & Permission:

Since the Household 18 s lived in a multi-unit building they had to get permission to charge from their landlord; a nominal $20.00 monthly fee was added to their rent. For the Household 18 s this seemed like a "fair" price given the fact that they no longer had to purchase gas for Greg's Toyota Matrix. The designated common 110 plug in the parking area of the garage was used not only by the Household 18 Family but also by 2 other households who owned plug-in hybrid cars. Given that both Greg and Victoria expressed their

reticence to charge elsewhere (whether for free or, in particular, if they would have to pay for it) they decided that they could easily "charge enough" at home. This strategy resulted in unexpected and surprising issues concerning the availability of the outlet for charging. For the Household 18 s, having 1 plug with 2 outlets for 3 cars, proved sufficient for their charging needs it did serve notice to them that the etiquette for sharing a charging station was not yet developed and could be problematic. They learned that there were no clear cut ways for people to act courteously about charging. It was "first come first served" as far as using the outlets. Responsibly moving a fully charged EV was not necessarily something that was taken care of by neighbors to accommodate a waiting EV. One neighbor was generous and "moved his car when he was done" the other neighbor was "a vampire." On another note, Victoria discovered the electrical limitations of their charging situation when, in one instance, she plugged into another (non-designated) outlet only to discover that by doing so she had tripped the circuit breaker for the garage resulting in a short-term black out for the area.

Travel Patterns and Driving Experience:

Greg drove the Active E approximately 99% of the time. He noted that it was "a zippy car and that it would be hard to give back!" His typical trip patterns reflected his daily commute to and from the Culver City area. On the occasions where Victoria would drive the EV she would take it to run errands and/or dropping off her sons for activities in the South Bay area.

There was only one experience of range anxiety that occurred for Greg. His experience resulted occurred on a day in which the car had not been charged the previous evening. In the morning Greg commuted to a client's office in the El Segundo area. Following the meeting Greg realized that he would not have enough range to be able to get to an important meeting in Culver City and home again. At this point he called Victoria and arranged for her to swap cars so that he could drive the Highlander to his meeting without fear of running out of charge. The result of this incident led Greg to appreciate his daily travel patterns and to plan more fully (given the fact that he did not charge every night) for days where an extra trip or longer stringing of commute trips would be necessary. For both Victoria and Greg there was a real difference in their thinking in that the idea of running out of power (gas) for their regular cars were not possible while driving the BMW Active E made them consider exactly "how many miles they had left."

As far as their driving experience went, the Household 18 s enjoyed the BMW Active E. It had plenty of pick-up and was a "fun car to drive." Their 11 year old son thought his father looked like a "rock star" while driving the EV. The Active E was a good replacement for Greg's Toyota Matrix saving them at least $40 per week in the cost of gas. On a critical note, however, the range of less than 70 miles was limiting to their idea of how they would have liked to have used the car. While the EV was a great commute vehicle they would have liked to have tried to take it Palm Desert or to other areas outside of the Greater Los Angeles area. As Greg stated, he would have liked the opportunity to have used the DC Fast Charge (L3) charging stations to travel further afield.

Design/Use:

The Household 18 Family enjoyed the fact that their EV was a BMW. The loved the sports coupe design. Though the back seat was (somewhat) uncomfortable for their children it was fine for the family the few times they all drove in it together. Certainly, it was more than adequate as Greg's commute vehicle. The design features like the GPS unit, on-board computer and eco mode were well received and appreciated. On the other hand, aspects like the placement of the (single) cup holder were not so well appreciated as inconvenient.

Household 19

Participant: Daniel Household 19

City of Residence: Redondo Beach

Age: 48, 50, 15, 12

Date: 9/11/13 to 11/21/13

ICE Vehicles: Ford 250 Truck, Jeep Liberty

EV: Nissan Leaf

EV Start Date: 9/20/13

EV – TOTAL VMT: 837.8 miles

EV Average VMT per Day: 13.5 miles

Overall:

Daniel Household 19 was a curious and enthusiastic driver of the Nissan Leaf. Daniel, his wife and two teenage boys live in Redondo Beach; Daniel is a self-employed entrepreneur who works out of his home as well as a small office near the Redondo Beach Pier. Daniel's wife works as an airline attendant and commutes to and from Los Angeles International Airport. The Household 19 family participated in the Neighborhood Electric Vehicle Project (NEV) and tested both the GEM and the Miles. Daniel's experience and appreciation of "local" mobility through his participation in the NEV project was the impetus for participating in the Battery Electric Vehicle (BEV) Study. As Daniel stated, driving the Nissan Leaf was a "very positive experience"; it was a good test to see the difference between a light weight, slow-speed NEV and full-speed electric vehicle. Participating in the study shed additional insight into the Household 19 family's consideration of, at some point, replacing one of his family cars.

Household 19 Garage Cleared to Park Nissan Leaf

Charging Strategy:

The Household 19 family exclusively employed a home-based charging strategy. Space was cleared in the garage so that the Nissan Leaf could be plugged into a 110 outlet. Daniel never really thought to opportunity charge outside of the home because, based on his experience as an

NEV participant, he knew that most of his driving would be local. As such, he could plan his day's driving accordingly so that he could comfortably string trips together and charge at the end of the day or, if necessary, opportunity charge at home in the middle of the day. Of note, was the fact that Daniel observed two issues that validated his strategy of home charging and precluded any possible opportunity charging outside of the home. The first issue was when he tested his mobile apps (Charge-point and Plug-share) to identify 220 charging stations that might be useful for opportunity charging. Unfortunately, he discovered that while the apps were easy to use several of the charging stations that he found and that were identified as "working" or "operational" turned out to be "broken" and/or "not working". As a result Daniel became skeptical that, should he need to charge, he would be unable to trust that he would find a convenient working charging station. Moreover, even if he did find a place to opportunity charge, Daniel felt that he did not have the relative time to wait around to "fill up" let alone "top off". Thus, through daily trip planning, Daniel was able to exclusively home charge using his garage 110 outlet – "there was never a time when I wanted to drive it but couldn't because it needed charging."

110 to 220 Home Upgrade:

Daniel felt that there was no need to upgrade his home 110 to 220 for the purposes of using the home 220 charging station. His primary rationale was two-fold. First, because of his experience as an NEV driver he knew that most of his trips would be local and that a known strategy of stringing these trips together would be easily sufficient for a full day's charge. Second, in a similar sense, because he worked from a local office or at home, he did not have to "commute" (in the traditional sense across town) and would not have to "top off" when he came home so that he could continue to use the Leaf after work; Daniel stated, that if he did use the EV as a "commuter car" then his feelings about upgrading would be different.

Travel Patterns and Driving Experience:

Daniel drove the Nissan Leaf 100 percent of the time. While his wife was, at first, interested in using the car to commute to the Los Angeles International Airport (LAX) she lost any interest in using the EV when she discovered that there was no easily accessible charging stations to use. Moreover, Daniel felt that the family would "save more" if he chose to use the Leaf rather than his truck.

Daniels typical travel pattern consisted of stringing multiple daily trips for work to his office in Redondo Beach and to local meetings and sales calls in the South Bay, Long Beach and Los Angeles. Additionally, Daniel would organize his travel day to include household errands and dropping off his teenage sons for various local activities. From time to time, Daniel would make the choice not to use the Leaf. In these instances his choice not to use the EV was based on either capacity (i.e. he needed the cargo room of the truck) or "not enough range" in that he would not feel comfortable to be able to carry out all his trips and return using the Leaf; depending on the challenge and/or availability he would either use his wife's Jeep or his truck.

In terms of driving experience, Daniel had a very positive experience particularly at the beginning of his participation. As Daniel stated, he was "very gung-ho" however, over the course of his participation he

became less so as the novelty began to diminish and the Leaf was seen (more and more) as a "third car" for the family.

For Daniel, the first 10 days of driving the Leaf was a series of "little experiments" to test the how the car performed and how to drive it effectively. More often than not, Daniel's analysis would be based on comparing his BEV experience with what he had learned about his driving patterns with those that he understood through his having driven an NEV. Based on this understanding Daniel had no range anxiety and could, with a full charge, easily string together many trips during the course of the day, returning home with less than 20 miles of range left (on the Leaf's computer). Through Daniel's "testing" he quickly came to understand that the stated range of the Leaf's on-board computer was "not true" or accurate. This wasn't a problem, however, he began to create his own internal calibration for understanding the "real" range of the EV. To do this Daniel spent time testing and planning where and how he would use the EV. He would take into consideration his destination(s); whether or not his trip(s) would be on highway or surface streets; his need for air conditioning (if he were wearing a business suit); as well as the geography of where he might need to go. Daniel came to understand his travel and destination landscape and developed his own heuristics as to how much charge he might need for any particular set of trips. For example, he would be comfortable with a "full charge" to get to Long Beach (and other trips) while if he did not have a full charge at the beginning of the day (and needed to travel to Long Beach) then he would use one of the Jeep or Truck. AC or not; etc.).

The experience of driving an EV clearly changed Daniel's style of driving. One of Daniel's strategies for maximizing his driving range was what he called "Hyper-miling". That is, using all the Leaf's features to regenerate electricity and drive more efficiently (i.e. "not stepping on the accelerator) thereby getting more range than what the on-board computer would state. Household 19 was very proud that, through this experience, he has now become a "hyper-miler!" – a style that he now carries forward when he drives his ICE vehicles.

Critically, Household 19 felt that the experience would have been enhanced if the range was both true and further. He wanted to know that when the on-board indicator said "98 miles it meant that instead of 70 or 80 miles." For Daniel, it would be optimal if the Leaf had a range of at least 120 miles (that was accurate).

Design/Use:

The Design/Use of the Leaf was seen functional by Household 19. Ergonomically it was "fine" and there was sufficient cargo capacity for shopping, taking his sons to various activities generally errands. Additional features like the GPS system worked as expected. Certainly, in comparison to the NEV Miles Wagon and GEM the Leaf was "leaps and bounds" ahead of those types of EVs in terms of build, performance and overall "feeling of safety" Comparatively, Daniel saw the Leaf for what it was, a "real car." That being said, as far as cars go, Daniel thought that the Leaf was not a particularly good looking design, stating that it was "different" and going so far as to say the Leaf looked "ugly." His boys, on the other hand, loved it and thought it "unique" – particularly how quiet it the Leaf drove.

Household 20

Participant: Brian and Ronda Household 20

City of Residence: Gardena

Age: 30, 35

Date: 9/6/13 to 11/21/13

ICE Vehicles: Toyota Prius C, Toyota Tacoma

EV: Nissan Leaf

EV Start Date: 9/20/13

EV – TOTAL VMT: 1,117.6 miles

EV Average VMT per Day: 18.9 miles

Overall:

Brian and Ronda Household 20 live in Gardena and work in the Aerospace Industry. Being technically and environmentally inclined they were willing and enthusiastic participants in testing the Honda Fit EV. Additionally, as former participants in the Local Use Vehicle (LUV) Program, they were excited about the seeing the difference between the functionality of a full-speed battery electric car versus the speed limited (and route limited) LUV vehicle that they tested.

Both Ronda and Brian described their experience of driving the Honda Fit EV as "cool and awesome." They loved the way the car performed, its ergonomics and the fact that it met their family needs – in terms of local transportation needs; far exceeding the limitations of the Miles Pick-up LUV that they had tested in the earlier study. Brian noted that if the Fit had been available in 2012 they would have likely chosen it as their new car rather than their Toyota Prius.

In terms of driving, Brian was the primary driver using the Fit about 80% of the time while Ronda drove it about 20% of the time. Typically, the Fit was used to replace the family pick-up truck and served as Brian's commute vehicle. The family used the car for running other household errands and, from time to time, Brian would load up his musical equipment for practice sessions in San Pedro. The Household 20 would have liked the car to have had a greater range or for there to have been possible Fast Charging options available so that they could have explored the idea of taking longer road trips with the car. As

Household 20 Charging in Garage

such, they would research their travel plans and make an informed choice as to whether or not they could use the EV to get them to and from destinations further afield. Brian's rule of thumb was that they could not (at this time) take trips "more than 1 hour away" by highway. Though they desired to use the EV for longer trips they often had to choose between their Prius and Truck for these types of journeys.

Charging Strategy:

In terms of charging, the Household 20 charged the Honda Fit EV in their garage which was accessed via an alley behind their home. They charged exclusively at home after 6 PM. Their travel patterns did not necessitate having to opportunity charge. In fact, the local nature of their trips resulted in a charging strategy of "not having to plug in every day." Rather, the Household 20 would plug in about 2-3 times per week typically, when the battery level dropped below 40%, when longer local trips were about to take place (i.e. music practice in San Pedro); or, on Thursday or Sunday evening in advance of the weekend or the coming work week, respectively.

110 to 220 Home Upgrade:

Ronda and Brian did not see the need to upgrade from 110 to 220. The limited number of times per week for recharging suggested that (at this time) they would not need to upgrade from 110 to 220. That being said, they did discuss the fact that if and when they were to start a family they could foresee the need to upgrade. As Ronda said, there would "lots of other errands, kid activities and other stuff" we would use the EV to do. As a result, she could see the need for faster opportunity charging so that she or Brian could add extra trips (if needed) with the electric car.

Driving Patterns and Experience:

The Household 20 used the Honda Fit EV to replace almost 100% of the trips that they would have otherwise taken using their Toyota Tacoma. Categorically, the Household 20 driving patterns were very local; consisting of relatively short daily work commuting and running personal errands during other times.

During the work week Brian would use the Fit EV as his commute vehicle while Ronda would use the family's Honda Prius C for her commute vehicle. A typical daily trip pattern might consist of commuting to the Northrop Aerospace campus in Manhattan Beach, returning home for lunch, returning to work followed by a shopping or a series of errands while returning home afterwards. On the weekends Ronda would run errands using the Fit EV. Additionally, on a regular basis, Brian would travel to San Pedro in the evenings for practice sessions with his band.

Both Brian and Ronda thought that driving the Honda Fit EV was "cool and awesome." They were effusive and loved "the way it drives." In point of comparison, they noted that had the Honda Fit EV

been available when they were shopping for their most recent car (Toyota Prius C) they would have certainly purchased or leased it as their second family vehicle. For local driving they noted that it "fit their lifestyle" and had the same basic configuration as their Prius. The only downside to the Fit EV would be the range in that trips of longer than 1 hour of freeway driving are not readily possible. At this point though, they are happy that they have a car like the Prius that can "drive cross county."

The "peppy" feel of the Fit EV was noticeable in both the Eco and the Sport mode and Brian was surprised when he realized how quickly the Fit EV reached 60 mph while accelerating from a stop light. Generally speaking both Ronda and Brian drove the EV in Eco Mode so as to maximize the range and efficiency of the electric car; Brian reported that his driving behavior changed from driving quickly to "granny style" – a term he used to describe driving more efficiently. For Ronda, she did not notice any real changes in how she might otherwise drive her car versus the electric vehicle. As she noted, "I just drive."

Because most of the family's trips were local they did not experience anything that they would have termed "range anxiety." Rather, as Brian noted, the experience of knowing where you are, what your range is and how far you have go until you need to recharge was one of "range awareness." Using the car's energy consumption indicators, having a learned sense of distance and time necessary to travel from one location to another as well as an engineer's sense of planning made range anxiety a moot point. For Ronda, she was concerned about possibly running out of charge however because her trips were relatively short distances and her general cautious nature to "not get too close to empty" she too never really experienced any anxiety of driving an electric vehicle.

Design/Use:

In terms of the Honda Fit EV's design and the use, the Household 20 were quick to note the comparative differences between Fit EV and both the LUV truck (that they previously test drove) and their current Honda Prius C. Without a doubt the difference between an LUV and a full-speed BEV was noticeable and very much appreciated. The Fit EV was seen as a real car. As Brian noted, it was "night and day" between the two vehicles – like the difference between a "tricycle versus a road bike."

Moreover, the Household 20 pointed out the challenges they experienced when driving an LUV through and around a community that was almost completely surrounded by arterial surface streets posted at 40 mph – a time consuming and sometimes scary experience to navigate were mitigated by having a full size and full speed car; the Fit EV solved the problem of "island" living.

With regards to the amenities the Household 20 compared the Fit EV to that of their Honda Civic C. Generally speaking the Prius C was seen as being "nicer." An example of one such feature missing from the Fit EV was the "keyless" amenity found in the Prius. In terms of utility the Honda Fit EV had comparatively as much or more cargo room than the Prius – a feature that was important for Brian in terms of hauling his band equipment to practice in San Pedro.

Rotation #6

Household 21

Participant: Fred Household 21

City of Residence: Redondo Beach

Age: 61, 58

Date: 11/5/13 to 1/16/14

ICE Vehicles: GMC Sierra 3500, Lexus RX 350

EV: BMW Active E

EV Start Date: 11/22/13

EV – TOTAL VMT: 475 miles

EV Average VMT per Day: 10.8 miles

Overall:

Fred Household 21 and his wife Mary live in Redondo Beach; Fred is a general contractor who owns and operates a company that primarily does business in the South Bay; Mary volunteers at a local school and library. The Household 21 family's interest in the Battery Electric Vehicle (BEV) study was a result of observing their daughter and son in-law's positive experience in both the Local Use Vehicle (LUV) and BEV studies. Fred's observation was that he and his wife's work and life-style would be a "good fit" and an opportunity to test the idea of whether or not their family could practically use an electric vehicle.

Both Fred and Mary worked as a locally. Fred was a contractor who worked out of his home while Mary commuted a short distance to work at a local high school. Prior to driving the BMW Active E, Fred's travel patterns consisted of using his large work truck to go from site or client visits – often, if there were multiple jobs going on, he would chain or string his trips together – going from one job site to the next with occasional stops to pick up materials. Mary, on the other hand commuted to work with her own car to and from work Monday through Friday. Household 21 enjoyed camping and other trips outside the South Bay on weekends and holidays.

Fred was the principal driver of the BEV using it almost 100 percent of the time; Mary tested it for a few short trips but otherwise drove her Lexus RX for any trips that she needed to make. During Fred's time as a BEV driver he would, on occasion have multiple stops in the South Bay and his wife, who was a teacher at a local high school had a relatively short commute trip each day. Fred did a lot of very local traveling to and from job sites. He was excited about the idea that he could use the BMW Active E as a substitute for his big work truck. As he said, the BMW Active E became "my work car" for the time of his

rotation; as necessary, he would lend out his truck to "his crew" for their use as another industrial vehicle, while he used the BEV for his supervisorial and client work.

Fred and Mary enjoyed their experience of driving the BMW Active E with Fred noting that the EV "handles very well." Fred did observe that driving the EV was different experience than just simply driving a regular car. He noted that the BMW Active E's range was not a problem for him as he was able to do everything he expected with the electric car.

Charging Strategy:

In terms of charging, the Fred charged the BMW Active 3 using an available outdoor 110 outlet located adjacent to their garage. Initially, Fred would plug in every night after work; usually he would plug in after 6 PM. After driving the Active E for about a week he realized that he had sufficient range left over from his daily trips so that he did not have to charge every night. Fred soon settled in on a charging pattern of "about 3 times" a week which gave him enough range to meet his local travel needs.

Household 21 Exterior Outlet for 110 Charging

While charging overnight provided ample range Fred observed that 110 charging was "slow." He recognized that opportunity charging using Level 1 – while working at home was not very efficient yielding only a few extra miles. Additionally, he tested 110 opportunity charging by using the Active E's portable charging cord while working (for several hours) at a customer's home; again, experiencing a slow rate of charge. As such, even when he was working at his home office during the day, he did not plug in. In terms of opportunity charging outside the home, Fred felt that there was "not enough time" for him to stop "to make it worthwhile." Even though Level 2 charging was faster he did not have the time to stop. Given that overnight charging was sufficient and Level 2 charging took time out of his day, Fred chose not to opportunity charge during his rotation.

110 to 220 Home Upgrade:

Due to the length of the study and the fact that he was not in the market for a new BEV Fred did not see the need to upgrade from 110 to 220. That being said, Fred did consider that if he were to become a BEV driver he would install 220 because it would be faster than 110; he could easily make the upgrade himself (with minimal costs) which meant that he could "keep the car fully charged" while he worked at home.

Driving Patterns and Experience:

Household 21 used the BMW Active E to replace almost of all of his "local" South Bay trips. However, after first receiving the BEV fast realized that the BEV would not work their longer trips as their first week of participation saw them on a camping trip in which they took their truck to travel outside of the Los Angeles. The Active E's range averaged around 64 miles (less then what Fred had expected) however, this did not preclude him from using the BEV to travel to and from his company's many work sites in the South Bay, run errands and otherwise "enjoy testing the car." Mary, while interested in the technology did not drive the BEV other than to go "around the block." Her feeling was that she was comfortable with her Lexus and would "wait" to drive a BEV until "they work out the bugs."

Since most of Fred's travels were within 10 to 20 miles of his home he did not really experience range anxiety. However, on one brief work visit he felt a little anxious as he noticed that he had used "30 miles of range" to get to his appointment – just less than ½ of the BEV's stated range. His trip home was uneventful though he did "keep an eye on his range." Generally speaking Fred, maximized the BEV's range by "not using the heater or AC" – amenities that did not seem to matter to his experience of driving the Active E. Fred considered that "if he were younger" he would have (liked) to have bought an electric car however in his mind he would want a BEV to have a range of about 200 miles – "a car that would take him to Palm springs."

One of the chief benefits to driving the BEV was the realization that "he didn't have to stop for gas" as often as he would have while driving his truck. Fred estimated that he saved "almost $240" from driving the Active E. He did not have an accurate estimate on what his electricity costs were other than to note that "they didn't seem out of line" since he was already paying at a "tier 3 level" and that he wasn't charging every day.

Design/Use:

In terms of the BMW Active E's design and the use, the Household 21 noted that he "was surprised at how well it performed." The BEV exceeded his expectations in terms of "power, comfort and handling." Fred did note that the "controls were not user friendly" though the Active E's small cargo space "worked just fine" for going shopping and "carrying groceries."

Household 22

Participant: Debbie Household 22

City of Residence: Manhattan Beach

Age: 53, 58, 16, 13

Date: 11/5/13

ICE Vehicles: Dodge Grand Caravan; Lexus RX 350

EV: Honda Fit EV

EV Start Date: 11/22/13

EV – TOTAL VMT: 162 miles

EV Average VMT per Day: 2.95 miles

Overall:

Debbie Household 22, her husband Tony and two daughters live in the eastern side of Manhattan Beach. Overall the Household 22 family "enjoyed their experience" of driving the Honda Fit EV. The electric vehicle did not replace any of the cars within the household but rather "became the starter car" for their oldest daughter Caroline; typically, the car was driven to and from her high school. Additional trips included running local errands with the occasional commute trip to Tony's law offices in Beverly Hills. There were no real issues regarding the performance of the electric car however Debbie felt that longer trips to places like Moreno Valley (to visit family) would not be possible do the limited range precluded them from taking longer trips like those to Moreno Valley to visit to visit family

Household 22 Exterior Outlet for 110 Charging

Charging Strategy:

Tony and Debbie adopted a strategy of charging almost 100 percent at home using a 110 outlet which was conveniently located outside the garage door. The family did not charge every night but would plug it in to "top it off" if the Honda Fit EV battery gauge read "less than 70%." Charging would usually take place in the evening and would be ended before the family turned in for the night. While Tony noted that they

were not getting the best rates by charging during this time they were more concerned that the charge cord could easily be stolen since it was outside – "it was not worth risking having the charger walk away." This charging strategy sometimes resulted in the car not having 100% charge in the morning. There was general consensus that this did not affect or change how or where the car was driven.

Each of the family members considered the idea of opportunity charging but, respectively, it was either unavailable or not convenient. In Tony's case his office did not have a charging station available; finding a local charging station in Beverly Hills, leaving the car to charge and returning (at some point) during the work day was untenable. In Caroline's situation her school had limited student parking far from any place where there might be an outlet; moreover the school did not have any charging stations on campus. Debbie, drove infrequently and, as such, was "perfectly happy" with the home-based 110 charging.

The Household 22 rotation was conducted during the holiday season and, as such, it was unclear because of the holiday lighting what added costs for home-based charging were incurred.

110 to 220 Home Upgrade:

Due to the short duration of the project as well as the fact that the 110 charging system was "working fine" the Household 22 family did not see any advantage to upgrading and installing a 220 charging outlet.

Travel Patterns & Driving Experience:

Debbie, her husband and daughter split the use of the Honda Fit EV (respectively) 20:15:75. The primary trips taken during the week were Caroline's trips to and from school. Additional drop offs and local errands constituted her travel patterns. In terms of Debbie's use of the EV she chose to use it for running local errands but was not able to use it for her work. As a local real estate agent her work required both meeting and/or driving clients to and from local properties. Debbie did not see the Fit EV as being large enough or comfortable for this aspect of her work. Additionally, Debbie needed a larger trunk/cargo space for carrying her real estate signage; something that the Honda Fit was too small to accommodate. Tony, did, on occasion, use the EV to commute to work. This was more of a "test" rather than a full fledge change in the switching from his Lexus to an EV for commuting purposes.

Both Tony and Debbie were keen to point out that participating in the BEV Study provided a "third car" to the family. In fact, the Honda Fit EV was seen as a "starter car" for Caroline and a real life opportunity to see if an electric vehicle would be the type of car that they would purchase for their daughter's first car. Caroline saw it as a "green" choice as thought that it would be great for her however both Debbie and Tony were not sure if the cost versus the range limitations would justify purchasing this type of car instead of a some type of used ICE vehicle for a Caroline's first car; their solution might well be an electric hybrid like the Volt or plug-in Prius.

In terms of understanding how to think about driving the Honda Fit EV and the issue of range anxiety none of the Household 22 's had what they considered a truly anxious moments. They quickly learned to gage their trips (mostly local) and felt at ease driving the car. Only one early trip where Debbie was notified by the on-board computer that there were only 16 miles of range left gave her pause. This was mitigated by the fact that she was about to end her trip at home and would soon be able to recharge. Additionally, they each noted that their trips were sufficiently short and local so as it was unlikely that they would ever have range anxiety.

The Tony was the only one who had a smart phone and though he did download the some applications for use with the EV he did not need to nor did he rely on their use for his trip planning or travelling.

Design/Use:

As the primary driver Caroline liked that the Fit EV was small and easy to drive and park; particularly "since the van is way too big to park." She saw the car as "sporty" and a great vehicle to go to and from school as well as running errands or drop-offs. Debbie liked the car but noted that, in comparison to her Van, there really wasn't a lot of cargo or storage room. When shopping at Costco the EV "would fill up fast." Tony liked the way the car drove however, like Debbie he felt the car was too small for carrying what he and/or typically would in the larger car. In his case he pointed to the fact that he still needed the family van to haul his scuba gear out to Palos Verdes. The family used the GPS system to a limited extent and did not choose to set up and use the car's blue tooth phone feature. All family members did take note that traveling on the highway as well as using the heater or air conditioning diminished the estimated range of the car. As Caroline said (after turning on the heater) "I watched it (battery gauge) go down."

Household 23

Participant: Heidi Household 23 and Ernie Participant 2

City of Residence: Redondo Beach

Age: 53, 52, 19, 16

Date: 11/5/13 to 1/16/14

ICE Vehicles: Toyota Highlander, Honda Civic NGV, Honda Accord

EV: Nissan Leaf

EV Start Date: 11/22/13

EV – TOTAL VMT: 495 miles

EV Average VMT per Day: 9.0 miles

Overall:

Heidi and Ernie live in Redondo Beach with their two teenage sons; one son attended a local community college while the other was in his senior year of high school. Heidi works independently at home on public interest projects that include the recycling of child car seats and her husband is a doctor who works out of one of Los Angeles' regional hospitals. The family has three cars; one, of which, is a Honda Civic Natural Gas Vehicle (NGV). Heidi considered herself and her family to be environmentally conscientious and, during the time that they test drove the Nissan Leaf, they were excited and enthusiastic Study Partners; their interest in participating in the project began when they saw the "love bug" type Electric cars that were used in the (earlier) Local Use Vehicles (LUV) study. As a family they were interested in discovering if a battery electric car could, at some point, substitute for one of their family's current cars as well as comparing it to the performance and utility of their natural gas vehicle.

Over the course of their family's participation the Leaf was driven primarily by Heidi and her youngest son, Liam. Respectively, each thought that they drove the Leaf about 45 percent of the time. The balance of the EV's use was spilt between Ernie and their oldest son – essentially, for only a handful of test driving experiences. To a person, their experiences were "positive" so much so that they had to "fight over who would use the car" on any given day. Generally speaking, the Leaf performed very well and was a suitable vehicle for almost all of the family's activities which ranged from local trips to school, to the occasion of a family trip into Downtown Los Angeles for the Auto Show to running daily errands. On most days the respective family driver of the Leaf would "chain" their trips before bringing the EV home to be recharged for the night. Of note, the placement of the Nissan Leaf into the Household 23 household did not result in the subsequent replacement or non-use of any of the family's regular cars. Rather, at any given time, there was always an extra vehicle available for use within the household. The Leaf was tested once by Ernie as his "commute" vehicle to a regional hospital.

Charging Strategy:

In terms of charging, the Household 23 /Participant 2 family charged the Nissan Leaf in their garage which was accessed via an alley behind their home. During the first week they would "plug in" whenever the EV was at home – both during the day as well as at night. However, shortly thereafter, the family decided to charge only at night so as to "save money" on their electric bill. This meant that the Leaf would only be plugged in after 6 PM. The family discovered that, aside from the rare instances of opportunity charging outside the home, they had more than enough range to accomplish their local trips (i.e. to school or running errands, etc.) by simply using 110 charging overnight.

On occasion there were instances of 220 opportunity charging outside the home. These included topping up on the commute trip to USC Harbor Hospital, a trip Downtown to the California Endowment Foundation; and a trip to Costco. The family did not use DC Fast Charge during their participation in the study.

110 to 220 Home Upgrade:

Heidi and Ernie did not see the need or value to upgrade their home charging from 110 to 220. They recognized that their driving patterns were such that a full-charge resulting from plugging into their home 110 outlet was sufficient to provide the range they needed for their daily trips. However, the family did speculate that "if they purchased or leased an EV" then it might be to their advantage to install a 220 home charging unit to provide "more charging convenience." That is, they could, if necessary or desired, top-off to add extra range for trips at the end of the day. Interestingly, however, the possible loss of range and extra trips was never an issue for the family during the course of the study.

The potential costs associated for upgrading their home to accommodate a 220 charging station was not an issue for the family. Certainly, it was something that they could easily afford and readily install (given the set-up of their garage with nearby electrical wiring for their hot tub); moreover, when compared with their natural gas home-charging station for their Honda Civic NGV it would be "much simpler"…"less of a hassle"…"and less expensive" –than the cost of $6500 the family paid for the NGV charging station.

Driving Patterns and Experience:

Heidi and her family's trips could be characterized as mostly local. The youngest son used the EV as his personal vehicle for commuting to and from school. Others in the household would use the Leaf for local trips for running errands, travel to yoga classes and other activities. Generally speaking, there was a pattern of "trip chaining where multiple destinations were strung together over many hours during the day. In two instances the EV was used to "test" the family's perceived range limits. In the first instance the Leaf was used to replace Ernie's Honda Civic NGV to see how it would work as his commute vehicle.

In the second instance, the family decided to attend the Los Angeles Auto Show – planning a trip to the Downtown Convention Center.

As a commute vehicle the Leaf worked quite well with available 220 charging at Ernie's work location to top-up for the trip home at the end of the day. In terms of traveling from the South Bay to Downtown Los Angeles, the family learned both about the quality of the car as well as the available charging infrastructure that they expected to use to "fill-up" the Leaf's battery for the trip home.

The trip in question was to attend the Los Angeles car show. The family planned for the trip in advance – determining the round trip mileage from their home to the event as well as locating 220 charging stations at or near the convention center where they could "top up" while attending the Show; a worse-case scenario would be to not fill up and have "enough" range to easily return home at the end of the day. It was a surprise that, while the Leaf was comfortably able to accommodate four large men (Ernie, his two sons and their friend) for their trip out of the South Bay, the extra weight, along with the steady and fast highway travel, used up the Leaf's range much faster than anticipated. Upon their arrival Downtown they strongly felt that they "had to" recharge to get home. Ironically, however, they discovered that there were only a few charging stations available at the convention center's car show and all were in use. This realization was somewhat stressful however they thought that they might be able to find an available charging station after attending the Car Show. Several hours later the stations' availability had not change. The family discussed their options about either finding an open charging station nearby or testing the Leaf's range and trying to make it home without recharging. After some debate, a decision was made by their youngest son (the EV driver) that he had enough battery left to "get home" and they did – not however, without some range anxiety as they all watched the battery gauge steadily decline.

As a family they could easily see how a battery electric vehicle like the Nissan Leaf could fit into their household mobility strategy. It would be used for their "local" trips and could readily replace the Honda Civic NGV as Ernie's commute vehicle. However, at this time, they would have to weigh the relative additional costs of purchasing or leasing a new car versus driving the NGV that is already "bought and paid for" as well as their significant investment in the NGV charging station. Whether or not they ever purchased a BEV the Household 23 /Participant 2 family would "still be a three car family" – one car for the husband's commute trip; one car for local trips (possibly an EV) for Heidi's use; and one car vehicle for their son's use. One of the three household vehicles would likely be a larger traditional car or SUV for longer trips and for hauling items locally.

Design/Use:

In terms of the Nissan Leaf's design and the use, the Household 23 /Participant 2 family "liked the feel of it" however they were quick to point out that Heidi's SUV was still "a nicer car." Performance wise, the family was surprised and liked the fact that the Leaf had a "whole lot more pick-up than the Hybrid. Amenities like the heated seats and blue tooth for music were well received and used by the family. However, the family also noticed and paid attention to the fact that standard features for traditional

cars like air conditioning and heating drained the battery; to conserve their the battery and extend the Leaf's range they typically avoided using these amenities.

Rotation #7

Household 24

Participant: Linda Sue Household 24

Age: 48

City of Residence: Redondo Beach

Date: 1/7/14 to 3/13/14

ICE Vehicles: Saturn Vue

EV: Honda Fit EV

EV Start Date: 1/17/14

EV – TOTAL VMT: 844 miles

EV Average VMT per Day: 15.9 miles

Overall:

Linda Sue Household 24 is a single self-employed woman who lives in multi-unit apartment located in Redondo Beach. Linda works from home for a national travel magazine. As a writer, her area of interest and expertise is scuba diving. Besides writing Linda is also a local scuba diving instructor; she teaches part time out of dive shop located at the Redondo Beach pier.

Linda Sue was an exceptionally enthusiastic Study Partner who was eager to test the viability of a full-sized Battery Electric Vehicle (BEV) for her lifestyle – to see "if it would be a real option for her next car." Additionally, as a former participant and driver of a Neighborhood Electric Vehicle (NEV) in the Local Use Vehicle (LUV) Program, she was excited about seeing the difference between the functionality of a full-speed battery electric car versus the speed limited (and route limited) LUV vehicle that she tested.

Linda loved driving the Honda Fit EV. In terms of performance, she likening her BEV driving experience to that of driving her electric motorcycle. Linda described the EV as comfortable car and it met her needs in terms of functionality – "it easily fit two people and all of our dive gear."

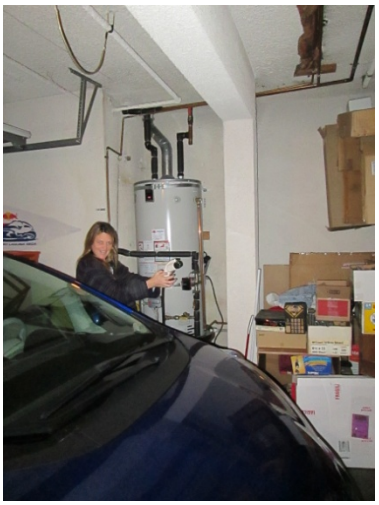
In terms of comparing her experience driving the Wheego NEV and the Honda Fit EV it was "night and day." The Honda Fit EV (for the most part) "met my basic (transportation) needs." That is, her many local trips and the occasional trip beyond Redondo Beach into Santa Monica, Los Angeles or South to Long Beach.

Additionally, Linda noted that the shorter range and unreliability the Wheego meant that she would have to "really plan" how and where she would get to and from her local destinations whereas, with the Honda Fit EV, she did not have to "even think about" local destinations because there was always enough charge to where she needed to go.

As the sole driver of the Honda Fit EV Linda Sue was able to replace most of her trips that she would otherwise have used her Saturn Vue SUV. The EV was used consistantly for her local trips such as running errands for shopping, going to the bank or visiting friends. The Honda Fit EV was also used for Linda Sue's very short commute trips to the Dive & Surf Shop near the Redondo Beach Pier. Longer trips outside the Redondo Beach area included an evening at the Forum in Inglewood, a trip to Hollywood and the House of Blues as well as a day at the Long Beach Aquarium. Linda's travel patterns included both trip chaining as well as short trips back and forth from her home. Additionally, Linda would often combine her trip destinations with opportunity charging – sometimes stopping for a couple of hours at the Hermosa Beach City Hall or in Manhattan Beach to take advantage of "free" 220 charging stations.

Charging Strategy:

In terms of home-based charging, Household 24 charged the Honda Fit EV "under the radar" (of her landlord) in her garage using an available 110 outlet on a wall behind her hot water heater. Linda Sue never felt like she could not charge or that it would be an issue. However, since home-based charging was "mostly at night" and because of her local trip patterns and frequent opportunity charging (outside the home) she did not have to charge every night. Rather, Linda Sue would plug in about "once a week" – especially, in advance of longer trips.



Household 22 Apartment Garage with 110 Charging Set-up

Linda's strategy for opportunity charging was to first find free charging and, if unavailable, then she would be "willing to pay for it." Often, Household 24 would chain her trips to take advantage and use the free Level 2 charging stations located at the Hermosa Beach City Hall or in Downtown Manhattan Beach. On one occasion Linda Sue was able to leverage preferred parking and hotel validation (from the purchase of a soft drink) to opportunity charge at a hotel in Long Beach. The time spent waiting while opportunity charging using a Level 2 charging station was not an issue for Household 24.

Linda did note her disappointment that the infra-structure to support opportunity charging was problematic. She discovered that many charging stations were not operational or that "places where you would think there would be charging stations didn't exist."

110 to 220 Home Upgrade:

The length of the study as well as having to bring up the issue to her landlord did not allow for upgrading from 110 to 220. Moreover, Household 24 did not see the need for home-based 220 charging as a means to have extra daily range (for additional or unplanned trips). This was in contrast to her NEV

experience where additional trips at the end of the day were problematic because of lack of range and the need to recharge before heading out.

Driving Patterns and Experience:

The Household 24 used the Honda Fit EV to replace almost 100% of the trips that they would have otherwise taken using their Saturn Vue. Household 24's driving patterns were very local; consisting of relatively short commute trips to the Redondo Beach Pier and running personal errands in and around the South Bay. On occasion she extended her range to travel North into Santa Monica, Hollywood and South to Downtown Long Beach.

Because Linda Sue worked at home there were days that she did not use the EV. There was not a consistent pattern of trip chaining; rather, there would be short trips made out and back to her home at various times during the day. The Honda Fit EV seemed to be a good match for Linda Sue's lifestyle and transportation needs with enough range to "get her where she needed and back" easily.

Since most of Linda Sue's trips were very close to home there was only one instance where she felt range anxiety. On an evening where she went to the Forum to attend a show she was disappointed to learn that there was no place to opportunity to charge while she was at the show. This later proved problematic as her next stop that evening was the House of Blues in Hollywood where, again, there was no convenient place to opportunity charge. The result was that her home-bound trip later that evening was stressful – "praying" as she drove on the freeway home that she would have enough charge to get back to the South Bay. Her lesson was one of not being able to count on opportunity charging being available as she might have expected.

That being said, Linda Sue liked the experience of driving the Honda Fit EV as well as the benefits and incentives that resulted from using the EV. She likened it to the "Global Entry" pass issued to air travelers that allowed ready and easy access when travelling. Linda Sue noted that she was able to get "preferred parking" or free parking with her EV and the fact that she could top off or fill up her car "using someone else's electricity"; access to the HOV lanes was a very positive incentive for her as well.

Household 24 liked the way the Honda Fit EV drove. It had the maneuverability of her motorcycle and gave her the feeling that she could easily go "in and out" in traffic when she drove. Typically, she drove the EV in the Eco Mode for maximum range. However, Household 24 did point out that knowing what the range actually was took some getting used to. As she pointed out, you had to ask "is it real" when looking at the car's range. A trip of (actual) 8 miles might, at times, read only 6 miles. The difference was something that called "electric miles." Since most of her driving was very local it did not come into play however, for longer trips she did pay more attention to her range.

In terms of range, the Honda Fit EV proved to be sufficient for almost all of her trips. Typically, a full charge provided a range of over 60 miles. On one occasion, however, she was unable to travel to Newport Beach – a one way trip of 37 miles. While wanting to use the EV there was no easy or convenient place to opportunity charge for the return trip. Looking forward, Household 24 suggested that all of her needs would be met if the EV had true range of 100 miles.

By way of comparison, the Household 24 pointed out the challenges she experienced when driving an NEV had to do with planning trips more thoroughly than with the BEV. That is, the Honda Fit EV's much larger range allowed her to not have to think about where "she was going next." Whereas, the limited range of the Wheego Whip necessitated some thought and planning to ensure that she would be able to get to and from her destinations; sometimes, when not planned correctly, resulting in running out of charge and having to plug in at friend's home's or overnight in a store parking lot.

Design/Use:

In terms of the Honda Fit EV's design and the use, the Household 24 was quick to note the Fit EV was a "real car" and that there were no issues in terms of reliability (battery holding its charge or range). Driving a full-speed BEV was noticeable and very much appreciated.

With regards to the amenities the Household 24's didn't see or find "anything missing". Though she rarely used many of the amenities, she appreciated the "bells and whistles." However, what mattered most for her was the utility and cargo room of the EV allowing her to easily haul dive gear for 2 people – an important consideration for her choice of vehicles.

Household 25

Participant: Michelle Household 25

City of Residence: Torrance

Age: 49, 38

Date: 1/7/14 to 3/13/14

ICE Vehicles: Toyota Prius, Nissan Quest

EV: Nissan Leaf

EV Start Date: 1/17/14

EV – TOTAL VMT: 1,247 miles

EV Average VMT per Day: 25.4 miles

Overall:

Michelle Household 25 and her boyfriend Jeremy live in Torrance in the top apartment of a multi-unit building. Michelle is a yoga paddle board instructor and part-time book-keeper and tax preparer who works, primarily, in Redondo Beach. Jeremy is the proprietor of a snow board/paddle board sporting goods store which was conveniently located across the alley from their home (in a small strip mall) on Torrance Blvd. Initially, Michelle thought that she "would love" driving an EV; her stated interest and enthusiasm for participating in the study concerned environmental issues and conservation. Moreover, Michelle was curious about whether the Nissan Leaf would be adequate in terms of space and range to replace her Toyota Prius for her day to day work and personal driving needs. Participating in the study, however, informed Michelle about the realities of driving an electric vehicle to the point where she felt that she "didn't love it (Leaf)." Jeremy's early expectations were minimal as he did not see himself driving the Leaf ("very much") since he needed his van for hauling equipment and paddle boards to customers or to Michelle's yoga classes.

During the course of the study Michelle was the primary driver using the Leaf to replace most of the trips where she would otherwise have taken her Toyota Prius. Generally, speaking Michelle would chain her trips however, she did note that this "linking" of her errands was a "new thing" and suggested that participating in the study provided her with a new way of thinking about her daily travel patterns.

Charging Strategy:

Michelle relied almost exclusively on a home-based charging strategy; she charged each night as well as opportunity charged when she "had a few hours" during the day between errands or work. Michelle used a 110 outlet located on the inside wall of her garage; typically she would plug in after 8 PM and unplug around 5 or 6 in the morning. There was no room to park the Leaf inside the garage as the space was used as a warehouse/storage area for Jeremy's business. The Leaf was parked outside – up against the garage door – with the door closed so that the charge cord could still reach the vehicle while still be secured from theft with the door closed on top of the cord.

Household 25 Home Based Warehouse with 110 Outlet for Charging

On the few occasions that Michelle attempted to opportunity charge outside the home she was disappointed to discover that many of the planned destinations for charging were either unavailable (due to non-EV's parking in the designated spaces) or not working (i.e. "the tap card did not work properly.") Michelle was able to briefly 220 opportunity charge at a local Walgreens; additionally, on one occasion she used the local Nissan Dealership's DC Fast Charge.

Michelle estimated that, over the course of the study, her home electric bill increased by approximately $25 to $30 per month. This was disappointing for her when she considered that, for an average month, her Prius' gas bill was "about the same" amount – Michelle's expectations were that there would be a noticeable difference (or savings) however, in reality, there was "no real" savings in terms of the money she spent for gas versus the relative increase in her electric bill.

110 to 220 Home Upgrade:

Michelle felt that there was no need to upgrade her home 110 to 220 for the purposes of using the home 220 charging station. Her rationale was two-fold. First, there would be an added cost of "several hundred dollars" for the upgrade and secondly, the study (and use of the EV) was too short to warrant such an expense.

Travel Patterns and Driving Experience:

Michelle drove the Nissan Leaf "about 95 percent of the time". Aside from a couple of trips into Downtown Los Angeles Michelle's use of the EV was, for the most part, confined to the South Bay. Typical travel patterns consisted of short commute trips to Redondo Beach where she conducted paddle

board yoga classes followed by errands before heading home. When time permitted, Michelle would opportunity charge at home to "top off" before heading out for other afternoon appointments. Generally speaking, Michelle did not suffer range anxiety as she had enough charge to facilitate all of her travels within the South Bay however when she did venture further afield (into Downtown Los Angeles) this was not the case.

On one memorable occasion Michelle took the car on a work related trip into downtown. Before leaving Torrance she planned the route as well as where she might "recharge" for her trip home. Michelle had identified the Natural History Museum – adjacent to USC as her primary place to opportunity charge on this trip outside the South Bay. Unfortunately, upon arrival, she found that the charging stations were either occupied by other EVs getting recharged or by non-EVs using the space for "free parking." Disappointed, Michelle, continued homeward all the while noticing the diminishing range of her Leaf. En route she used her smart phone App to identify a charging station at Space X in Hawthorne. Unfortunately, upon arrival at the charging stations, Michelle discovered that they were Tesla stations and, as such, she was unable to charge. At this point Michelle had approximately 11 miles of range remaining on the Leaf which "may or may not" have gotten her home. As a result she was feeling "very anxious". Michelle felt "lucky" that there was a nearby DC 3 Fast Charge opportunity at the local Nissan dealership where she was able to recharge in about 20 minutes so that she could easily return to her home in Torrance. Michelle's experience of range anxiety dampened her enthusiasm for using the Leaf on trips outside the South Bay area though it did not preclude her from using the Leaf as her primary local use vehicle.

As a result of her experience of not being able to recharge Michelle became more observant and critical of the state of charging stations available for EV drivers. She noted that the infrastructure to support charging "really wasn't fully developed" and wondered "why cities were building more stations". The difference for Michelle was that her Prius could simply pull in and fill up everywhere there was a "gas station." In contrast, there was no guarantee that she would be able to do the same with the Leaf. Instead there was the distinct chance that the charging stations would be occupied (i.e. while in Manhattan Beach) or occupied by non-EV cars or in disrepair. Michelle offered a couple of solutions to the issue of not enough charging stations in areas where demand was high. One answer was to build significantly more stations. For Manhattan Beach she suggested that instead of 2 charging stations "there should be 50" so that no one would have to wait. Additionally, she suggested that "gas stations should have them" too.

In terms of range, Michelle felt that the "90 miles of range" she had after charging at night was sufficient for her daily trips. Hypothetically, however, for Michelle to give up her Prius, the EV would have to have a range that was closer to the 340 miles; she would want the EV to be able to take long range trips (i.e to Mammoth) outside of Los Angeles. Additionally, Michelle was suspect about the "true" range of the Leaf. She noted that there were significant changes in the range (from 90 miles to 75 miles) by simply turning on the lights. However, even with these issues, Michelle "got used to it" and range was not an issue for hyper-local trips.

Design/Use:

The Design/Use of the Leaf was seen functional by Michelle. Ergonomically "it works" for her daily trips; in a similar fashion to her Prius, Michelle was able to put all her yoga gear, props and other work materials in the Leaf.

In terms of driving the Leaf, it was a "comfortable" experience though the lines of sight "did not provide great viewing." Both Jeremy and Michelle noted that the Leaf had "good pick-up" and was "fun to drive." Typically, Jeremy drove the EV in eco-mode while Michelle did not necessarily use the most efficient mode.

One of the amenities that proved useful was the seat warmers which Michelle used on a regular basis – she preferred to use this feature rather than diminish her range by using the regular heating system. Unfortunately, she found that the on-board app for identifying where to find charging stations (found in the GPS) "was not always up to date."

Household 26

Participant: Mike Household 26

Age: 30

City of Residence: Redondo Beach

Date: 1/7/14 to 3/17/14

ICE Vehicles: Toyota Tacoma, Ford Escape

EV: BMW Active e

EV Start Date: 1/17/14

EV – TOTAL VMT: 264 miles

EV Average VMT per Day: 6.2 miles

Overall:

Mike Household 26 and his finance, Heather, lived in Redondo Beach in a multi-unit building. Both Heather and Mike were enthusiastic Study Partners. As a former LUV participant who had a "great" experience driving the NEV Wheego Whip, Mike was excited to test a "real" car to see what the difference would be from his prior experience.

Mike was the primary driver of the BMW Active e with Heather driving the EV only on the rare occasion. During the course of the study Mike replaced 100% of his commute trips that would otherwise been made using his Tacoma Truck by using the Active e; Mike's commute was a rather short one to Redondo Beach High School where he worked as a Physical Education Teacher. As Mike noted, "my trips are from home to work and back again." Generally speaking, both Mike and Heather characterized their driving patterns as "very local."

For Household 26, driving the BMW Active e was a "cool" experience. It was an opportunity to drive a "great car" and, as Household 26 noted, "there was nothing better than *not* filling up (his truck's) gas tank." The very appreciable result being that he was able to "not drive" his truck during the study and thus saved several hundred dollars in gas costs.

In terms of charging, Household 26 employed a strategy of exclusively charging at home using a 110 outlet located in his garage. Initially, this proved problematic as the outlet had a loose wire which, from time to time, made the outlet non-functional – Mike would plug in at night only to discover that the car hadn't charged as expected. With some challenges he was able to adjust the plug so that it would charge properly. Mike and Heather did not need or desire to opportunity charge outside the home. In fact, with a "full charge they could drive for a few days" without having to charge every night. Sometimes they would not need to charge for 4 days in a row. However, they did make sure that the car was fully

charged each Friday so that they would have ample range for visiting friends or going out over the weekend.

Both Mike and Heather thought that the BMW Active e was a great car for 2 people however it was a little tight for four. However, both of them thought that, given their respective local driving patterns, getting rid of one of their cars and purchasing a BEV would be a viable option. Both agreed that, in the end, they would likely keep a car like the Ford Escape in favor of the Mike's Tacoma Truck (which was used sparingly).

The experience of driving the BMW Active e in comparison to the Wheego Whip NEV was far superior. For Mike, being able to travel faster than 20 mph was the main difference while, Heather noted that the NEV did not feel "very safe" in traffic with other full sized cars. Both noted that the Whip as well as the BMW Active e worked for their "very local" trips however Mike was keen to point out that they were able to use the BEV to visit friends in Rancho Palos Verdes – a location that would be impossible for the Whip to travel.

Charging Strategy:

In terms of charging, Household 26 charged the BMW Active e in their garage which was accessed via an alley behind their home. They charged exclusively at home usually after returning in the evening (after 6 PM). Their travel patterns did not necessitate having to opportunity charge. The very local nature of their trips resulted in a charging strategy of "charging it (the EV) only a few days a week." Household 26 would plug in when the battery level dropped below 40% during the week and would "definitely plug in on Friday night" in advance of weekend trips.

110 to 220 Home Upgrade:

Household 26 lived in a multi-unit building and, as such, did not see that there would be an opportunity to convince his landlord to install a 220 outlet for the short-duration of the project. That being said, Mike did think that (because of his good relationship with his landlord) if he were to purchase/lease an EV that he might be able to make the case for having a 220 charging unit installed. However, given his driving patterns charging using only the available 110 outlet was sufficient; Mike likened charging the Active e to his cell phone, "you just plug it in when it needs to be charged."

Driving Patterns and Experience:

Household 26 used the BMW Active e to replace almost 100% of the trips that they would have otherwise taken using his Toyota Tacoma; during the course of the Study he drove the truck only twice or to move it on street cleaning days. Household 26's driving patterns were very local; consisting of relatively short daily work commuting to and from school. On weekends, he and Heather would take the

EV to visit with friends in the South Bay ranging from Rancho Palos Verdes and San Pedro to El Segundo. Additionally, they would run errands in their neighborhood during other times.

Both Mike and Heather were excited about the opportunity to drive a BMW for the Study. They thought that the experience of driving the BMW Active e was a "great one." Their friends would remark about their participation and the EV as "this is awesome!"

The average range of 70 miles was "enough" for their needs. Since their trips were "very local" they did not have any experience with range anxiety. The closest moment was on a trip to San Pedro via the highway when Mike noticed that fast diminishing range that occurs when the EV is operated at high speeds. While the range of the Active e proved adequate for their daily needs, both Mike and Heather lamented the fact that they did not think it realistic to drive the Active e to Palm Springs – a destination that they would have liked to have travelled to in the EV.

In terms of how the EV performed Mike noted that it had "good" pick-up and he noted that the regenerative brakes took "a little bit of time to get used to" though he appreciated the fact that energy was being put back into the battery because of the dragging effect of the brakes. Both Heather and Mike also commented that the EV was particularly "quiet" yet it did have a "high pitch" that was unique to the car. On the whole the Active e fit their lifestyle and was fun to drive.

Design/Use:

In terms of the BMW Active e's design build, Mike and Heather noted that because it was a sports coupe it was more "comfortable for two but not four" people. They were glad not to have to have had to sit in the back seat. Mike suggested that the "bells and whistles were over-engineered" perhaps because it *was* a BMW. Mike did try and use all of the amenities including the GPS system, Bluetooth and radio – all of which worked well for him. As far as the difference between his experience driving the Wheego Whip and the BMW Active e it was "night and day." The Active e was a "solid" car that could travel much smoother and faster than the Whip – which "could only go 20 mph."

Household 27

Participant: Daniel and Brook Household 27

City of Residence: Harbor City

Age: 41, 38

Date: 1/7/14 to 3/13/14

ICE Vehicles: Honda Fit, Mazda 3

EV: Nissan Leaf

EV Start Date: 1/17/14

EV – TOTAL VMT: 1,894 miles

EV Average VMT per Day: 34.4 miles

Overall:

Daniel and Brook Household 27 lived in a large multi-unit building complex located in the Harbor City area of the South Bay; they lived in an upper unit condo with a two car garage that was used to park the Nissan Leaf that they drove during the course of their rotation.

Daniel worked for a local cable company while his wife, Brook, worked in the South Bay as a County social worker; on occasion, Daniel's children from a previous marriage would join the family. Both Daniel and Brook were very enthusiastic participants siting their interest in participating in the Study as an opportunity to "test drive an EV" in advance of purchasing one for their family; they were hoping that by participating in the BEV study they would confirm what their friends had discovered when "they turned in one of their cars for an EV" – that they could actually "go electric."

Initially, Daniel was the primary driver of the Leaf using it about 80 percent of the time with Brook driving it on occasion during the weekend. Daniel used the EV to replace his Mazda 3 for almost 100 percent of his commute trips. At about the mid-way point of their participation, Daniel had knee surgery and was no longer able to drive the EV. As a result, Brook drove the Leaf exclusively for the balance of the study. They estimated that over the course of their 2 month rotation that they had each driven the EV "about 50 percent of the time."

In terms of travel patterns the Household 27 family used the Leaf during week days to respectively substitute for their regular cars as their work commute vehicles. Daniel's work trips would necessitate highway driving while Brook typically travelled on surface streets to a South Bay office; Brook often would have with multiple site visits during the day. Beyond their respective commute trips the Leaf was used by Daniel to travel to post-work activities that were usually either sports related or for pick-up and

drop-offs of his two elementary aged children. Brook would use the Leaf for household errands as well as for "visits with friends." Both Daniel and Brook stated that they "tried to chain trips" however it was not uncommon that on weekends or (on occasion) after work they would run "out and back" from their home.

Both Daniel and Brook easily integrated a practice of "charging the Leaf whenever possible" to keep it topped up. Having enough time, however, was the critical element of deciding when to plug in. This meant that they would conscientiously "plug in every night" using an available 110 outlet located in their garage; or, in Daniel's commute case, he would need to "fill up" for his return trip so without available charging opportunities at his work location he would use spend about ½ hour "to fill up for his ride home" using a DC 3 Fast Charge (located at a Nissan Dealership) that was conveniently located near his work location. When either Brook or Daniel had time (i.e. "more than a couple of hours") they would opportunity charge using public available L2 charging stations near their destinations.

The experience of driving the Leaf was a "very positive" experience and confirmed their expectations that an EV was "truly a great local use vehicle…a car that is exactly what it's designed for."

Charging Strategy:

The Household 27 Family employed a robust charging strategy of using all available charging opportunities "to keep the car topped up." Each night, after the work day and local errands were completed, they would plug the Leaf into a 110 outlet located in their 2 car garage; there were no readily available outlets along the walls of the garage so Daniel, using an industrial grade extension cord, rigged the charging plug into the overhead outlet that served to open and close the garage door. Daniel indicated that he thought that the cost of using home-charging was being passed on to the condo association as he believed that "the garage outlet was on another meter." It was unclear if they would be allowed to home-base charge given that "CCR rules" state that residents "cannot use refrigerators in their garages." The Household 27 family chose not to investigate this issue choosing to charge at home anyway.

Household 27 Ceiling Mounted 110 Charging Set-up

Over the course of the study both Level 2 and DC 3 Fast Charging opportunities were extensively employed by Daniel and Brook. When Daniel used the Leaf for his commute vehicle his trip would necessitate high travel. As a result his diminished range would

require him to “fill up” for his return trip at the end of the day. Since there was no opportunity to charge at work he quickly discovered that he could “take advantage of the free” fast charging that was available at a nearby Nissan Dealership. Both Brook and Daniel would use publically available L2 charging stations located at destinations where they would have “enough time” to top up. Typically, this meant that they would need a “couple of hours” to make it worth their time - shopping and entertainment destinations were examples of where the Household 27 Family used Level 2 charging opportunities.

110 to 220 Home Upgrade:

Daniel and Brook felt that there was no need to upgrade their home 110 to 220 for the purposes of using the home 220 charging station. His primary rationale was several-fold. First, they found that their strategy of home-based charging using 110 then opportunity charging to “top off whenever they can” was sufficient to support their travel needs using the Leaf. Additionally, the cost to do was prohibitive. Daniel received an estimate that an upgrade to accommodate 220 charging would cost approximately $4,000 – a smart meter (attached to their home meter) would need to be installed followed by the complication of running wiring from a distant location to the garage. Moreover, it was unclear if they would be able to acquire the consent of the condo association (not necessarily something that was guaranteed to be approved).

These issues, along with the short duration of the study, made an upgrade untenable. On the other hand, however, the Household 27s did recognize the potential benefit of having access to 220 home-based opportunity charging that would support “extra trips” by topping up at the end of the work day; something that they would consider if they were to purchase an EV.

Travel Patterns and Driving Experience:

Initially, Daniel drove the Nissan Leaf 80 percent of the time while his wife drove the EV about 20 percent of the time. Daniel’s trips typically included commuting to Cerritos for work with post-work sporting or pick-up and drop-offs of his two elementary aged children. On weekends, Brook would use the vehicle for errands as well as to visit with friends; together they used the EV for recreational activities. At the mid-point of the study Daniel had knee surgery and was unable to drive the Leaf. As a result Brook became the sole user of the Leaf – using it as her commute vehicle as well as for other activities. Both Daniel and Brook tried to plan their trips so as to chain their destinations however, on weekends and because Brook’s work destination was very local, they would sometimes find themselves running errands in an ad-hoc way or returning home for lunch mid-day and then going back out again.

In terms of their driving experience, both Daniel and Brook thought that “driving the Leaf was an incredible experience” for local driving. The car was “comfortable…a very solid ride” and the physical characteristics made them “very happy.” They noted that the car was “peppy” and had “great take-off.”

On the other hand, the Leaf's range as well as the feeling that having to slow down or economize range by "driving the EV in eco-mode" on the highway were two "negatives" (or limitations) that affected the way that Daniel and Brook felt about their driving experience. Surprisingly, Daniel experienced "range anxiety" when, after planning (what he thought to be) a "short trip" to Montebello – about 20 miles away - he noticed the "drop-off" of range from steady and fast highway driving. He noted that this trip started with an 87 mile range and quickly "dropped to 30 or 40 miles" while travelling (for about 10 minutes) at 70 miles per hour on the highway. Upon arriving at his destination he was found that there was only 30 miles of range left – in Daniel's mind this was not enough to get home. Using a smart phone app he was able to top off (add about 10 miles of range) by finding a public charging station at a fast food restaurant; Daniel had a snack while recharging for about 30 minutes. On his return trip, Daniel drove much slower as well as used the Leaf's eco-mode to economize his mileage. Ironically, using this strategy, he discovered that he felt unsafe "as everyone was passing us…at this speed you're just asking to be slaughtered." Since Daniel's destinations often necessitated highway driving he felt that his range was really closer to 20 miles than to what the on-board computer might indicate. For Daniel to feel comfortable and safe with the diminished range that resulted from highway driving he required access to DC 3 Fast Charging or, "at a minimum L2" charging. On the other hand, Brook felt that she could "drive all day around here" – a feeling based on very local travel patterns using surface streets.

Both Daniel and Brook realized that "budgeting the time for charging" was one aspect that they came to understand as being integral to the experience of operating and driving an EV. 110 home-charging worked because there was usually enough time to fully charge the battery overnight however, having access to DC Fast Charge became an important strategy (especially for Daniel) so that could feel comfortable to commute to work or take trips outside the South Bay – using the free DC 3 stations that were available at local Nissan Dealerships was advantageous thought Daniel would readily pay "a dollar or two" for the convenience. In terms of L2, the Household 27s agreed that 220 charging was adequate only in so far as there was sufficient time to make charging worthwhile "where you have the time" – usually being parked somewhere for at least 2 hours.

Design/Use:

The Household 27 found the Design/Use of the Leaf as very functional and "their girls loved it." The Leaf was "very comfortable" and had ample cargo capacity for running errands, shopping and activities that required carrying things for their daughters' or Daniel's sport activities. Both Daniel and Brook used and liked many of the on-board amenities like the GPS system and blue tooth features. On cold days the seat warmers were even better than the heating system.

One of the advantages that the Family discovered was the fact that they "did not have to fill up" their cars as much during the course of the study – both Daniel and Brook appreciating just "how much we had been paying for gas." At the cost of approximately $40 per week they estimated that they had saved over $300 in gas during the course of the study. Overall, the Household 27s saw the limitations of the Leaf as being one of range that could be overcome by a network of DC 3 charging stations. They noted,

however, that the EV was “exactly what it was designed for…a great local use vehicle.” Looking forward they felt that, given their life-style, they would still need some type of vehicle (perhaps a plug-in hybrid) to comfortably give them an extended range beyond local driving.

Rotation #8

Household 28

Participant: Gail and Robert Household 28

Age: 50, 60

City of Residence: San Pedro

Date: 3/7/14 to 5/14/14

ICE Vehicles: Kia Sportage, Buick LaSabre

EV: Nissan Leaf

EV Start Date: 3/14/14

EV – TOTAL VMT: 694 miles

EV Average VMT per Day: 11.5 miles

Overall:

Gail and Robert Household 28 live in a gated community on the South side of San Pedro. The Household 28 Family enjoyed their experience of driving the Nissan Leaf during their time as participants in the study. Gail is retired and works as a volunteer and docent at the U.S.S. Iowa docked at the Port of Los Angeles while Robert worked as a respiratory therapist at a nearby South Bay Hospital. The Household 28 lived in a community that was terraced down a steep hillside with access to a local golf course. Many residents, including the Household 28 owned a Neighborhood Electric Car (NEV) otherwise known as a golf cart; many of the residents drove gas powered golf carts as well; the NEVs were used for transportation up and down the steep streets within the community as well as for travel while playing golf.

Over the course of the study Gail was the primary driver of the Leaf; using it about 90 percent of the time. Robert, on occasion would also drive the EV. The Household 28 were able to "park" their old Buick LaSabre for the duration of the participation; surprisingly, Gail noted that they had to get "a boost" to restart the Buick after 2 months of sitting idle.

Typically, Gail would use the Leaf for "very local" trips. Gail noted that she didn't really travel very far from home – venturing "down the hill to Torrance" for some of her shopping and to work (in San Pedro). Her destinations included many shopping errands as well as routine schedule of volunteer work at the Port of Los Angeles where she served as a docent and administrative helper on the U.S.S. Iowa. Robert used the Leaf to run errands as well and, on occasion to "test it" as his commute vehicle. Both Gail and Robert employed a strategy of "trip chaining" to organize their travel outside the community.

In terms of charging, the Household 28's principal strategy was to charge at home from "about 7 PM to 7 AM" using a 110 outlet located in their carport. Initially, they charged every night however, after learning about their range and discovering that there were places to opportunity charge they cut back their home charging routine to "a couple of times a week." Over the course of the their participation in the study the Household 28 's began to opportunity charge using both Level 2 and DC 3 charging stations. Gail discovered and took advantage of the available free charging stations in the parking lot at the Port of Los Angeles; she would often time her arrival at work "to make sure that she got one of the plugs". While she felt that she had enough power to return home without recharging, "plugging in" and topping up gave her the confidence that she would "make it back up the hill" to get home at the end of the day. O occasion Gail and Robert found that they could take advantage of the DC 3 Fast Charge that the local Nissan Dealership offered; it was a quick way to top off – "especially since I (Gail) like freeway driving."

Household 28 Exterior Carport 110 Outlet for Charging

Charging Strategy:

In terms of home-based charging, the Household 28 used an outdoor 110 outlet located under their carport. Initially, they would charge the Leaf between 7 PM and 7 AM each night. However, the scaled back to just "a couple of times per week" once they became comfortable with the Leaf's performance (range) as well as discovering other places to opportunity charge during the day.

As Gail became more aware of places to opportunity charge she would "plug in" to top off so that she would feel "confident" about being able to return home "up the hill" from work. Gail's routine was to top off at work using the Level 2 public charging stations located in the parking lot at the Port of Los Angeles – near her work location at the U.S.S. Iowa. Gail planned her morning commute trips so as to arrive "just in time to get the last charger" of the four that were available. Being able to opportunity charge was very important to her as it eased her mind from possible range anxiety – find an available charging station was like having "angels" watching over her.

Gail developed a strategy of topping up or "serial charging" whenever there were opportunities (and time) to do so. Other instances for using Level 2 charging occurred while shopping at Sam's Club and enjoying a musical recital at a local college. Additionally, Gail discovered that DC 3 Fast Charging was available at the local Nissan Dealerships; in one instance she was able to quickly charge thereby giving her more confidence and range for her freeway trip. In another instance, the DC 3 charging station was not in operation – which did not curtail her trip but rather gave her an anxious feeling about her range.

110 to 220 Home Upgrade:

The length of the study precluded any thought of upgrading their home charging from 110 to 220. Cost would likely have not been an issue as Robert estimated that it would be about $200 to put in a 220 outlet in their carport. However, it was noted by Robert that "having a home 220 charger would make a difference" if they were to "go without their gas car…it would be a necessity, for sure."

Driving Patterns and Experience:

The Household 28 used the Nissan Leaf to replace all of the trips that would otherwise have been taken using the family's Buick La Sabre. Since the La Sabre was (primarily) Gail's car this meant that the Leaf replaced 100 percent of her car's trips. Typically, Gail's travel patterns were very local. These included local commute trips to and from the Port of Los Angeles; often she would organize her travel to include other errands like shopping before going home – thus, chaining her trips. Robert, on occasion used the Leaf to commute to work – at a local hospital in the South Bay. Though he did not drive the Leaf as frequently as Gail, Robert, in a similar fashion, would chain errands and shopping trips before coming home.

Both Gail and Robert did not use a smart phone and, as such, they did a considerable amount of planning to determine their range and, to locate public charging locations – so as to opportunity charge (if necessary). The strategy of "planning out" their trips proved useful for mitigating range anxiety. However, Gail was always aware of her range and the location of the "nearest" charging station (that she could remember – given that she didn't have a smart phone app available to her) while Robert had "no range anxiety" as it was simply "an adventure" to him. The one instance where they both felt as if they could not get back home occurred early in their participation on a "long trip" to Huntington Beach – approximately 40 miles one way. Gail thought that they could get back (given their starting estimated range of over 80 miles) however she appreciated that they would have a challenge at the end because they would have to uphill to return home. Given that observation they decided "not to chance it" and found a Nissan Dealership near their destination. "In 30 minutes" they were recharged after enjoying a conversation about electric cars with one of the Nissan sales people.

Gail and Robert "enjoyed" their experience driving the Leaf. It was more than adequate as a replacement for the Buick La Sabre. Driving a (relatively) new car was remarkable for them since had been quite some time since they last purchased or thought about driving a new vehicle. Of note was the fact that it had good pick-up and Gail felt comfortable driving it on the freeway. However, this was mitigated by her experience that her range quickly diminished while driving at freeway speeds. Though Robert and Gail did not travel very far afield from their San Pedro home they still considered the limited range to be a "con" in their overall experience. Gail would have liked a longer range as well as "more charging" stations so that she could have travelled (comfortably and without anxiety) to places like

Pasadena. Certainly, in their minds, they would have liked an EV to have had a range where they "could take a road trip however, "as a 3rd car it would be great for local trips."

Design/Use:

In terms of the Nissan Leaf's design and the use, the Household 28's found it very satisfactory. Though they did not use the amenities like the GPS system or Blue Tooth they did appreciate the EV's ergonomics as well as the cargo space – both of which "worked for them" and their life style. On the negative side, both Gail and Robert were quick to note that direct heating (something they used frequently because they lived near the ocean) negatively impacted the Leaf's range (as did their use of the EV's air conditioning. The noticeable impact on range caused them to drive (at times) either uncomfortably hot or cold – something that would not otherwise happen in one of their regular cars.

Household 29

Participant: Elaine and Frank Household 29

Age: 35, 35, 3, 1

City of Residence: Manhattan Beach

Date: 3/7/14 to 5/14/14

ICE Vehicles: Mercedes C300, Audi S4

EV: BMW Active E

EV Start Date: 1/17/14

EV – TOTAL VMT: 2,885 miles

EV Average VMT per Day: 49.7 miles

Overall:

Elaine, Frank and there 2 small children live in condominium located in Manhattan Beach. Frank is a software consultant who works out of an office in El Segundo and whose business typically takes him off-site to clients around the Great Los Angeles Area. Elaine, is a Planning Engineer who works for the City of Redondo Beach; her work often requires her to attend meetings in the Downtown Los Angeles government center. Elaine and Frank have an elementary school aged daughter and an infant child. The Household 29 were enthusiastic participants in the study and enjoyed the opportunity of driving the BMW Active E during their course of their rotation. The Household 29 family's interest in participating in the study was to "test drive" an electric car to see if it made sense for their household both in terms of being a commute car as well for day to day family trips.

Frank and Elaine took turns driving the BMW Active E. In terms of use during the work week Frank estimated that he drove the EV about 60 percent of the time while Elaine used it for about 40% of her commute trips. However, in terms of actual mileage, Frank "guesstimated that Elaine probably put about 60 percent of the miles on the car". On weekends, the family spent time together so almost all their trips used the EV. Over the course of the study the Household 29 family chose to give up Frank's Audi S4, "essentially it was parked." Their rationale for not using his car was that they "only had two pairs of car seats for their children" and "it just made sense to take them out of his car."

During the work week, the Household 29 family's driving patterns were for either Frank or Elaine to use BMW Active E as their commute vehicle. Due to the nature of their jobs this would mean a short commute to their, respective, local office, then (often) a series of work related trips. In the late afternoon, depending upon their schedules, errands would be run as well as pick-up and drop-offs for their daughter's afterschool activities. On weekends, the family would have activities that they would all take part in or travel together to join; the BMW Active E was used almost exclusively for these types of

weekend family events. In terms of travel planning the family's rule of thumb was to "plan trips that we could always come back from…about 40 miles one way." This meant that they considered opportunity charging to really be a fallback or safeguard for getting home to charge.

In terms of charging the Household 29 family had an over-arching strategy to "make sure that the car was always 100 percent charged each morning" (before they began their day's activities). Initially, this meant home-based charging in their subterranean garage using a 110 outlet. After several weeks, the family improvised on this strategy after realizing that a severally depleted battery could not be charged overnight. Together, they figured out a strategy to use the convenient free 220 charging stations located in Downtown Manhattan Beach – then walk home while it was charging. This strategy allowed them to either "fill up completely" or to put enough charge into the battery so that when they plugged in overnight at home the car would be "full by morning."

Both Elaine and Frank were extraordinarily resourceful and used opportunity charging to "top up" almost every day; this allowed them to comfortably extend their range. Their strategy was to take advantage of the many "free" charging stations that were available to them. For Frank, he would, if necessary use his work place for 220 charging; additionally, he would, if time permitted (usually over 2 hours) charge at a client's office. Where Level 2 was available this allowed him to charge completely however, as he noted, "if it was only 110 then it really didn't make much of a difference." Elaine too would opportunity charge though her experience was one where she would charge at public buildings and offices at her off-site destination (or near her destinations). These facilities would offer free Level 2 charging – usually more than enough for Elaine to fill up for her return trip or next leg of her business travels.

Overall, the Household 29 family was very happy with their experience driving the BMW Active E. The EV proved to be a "good commute" vehicle and sufficient for the family to travel as far away as Disneyland or out to visit family in the San Gabriel Valley. Their daughter liked the Active E because "it doesn't make smog."

Charging Strategy:

Initially, the Household 29 family's primary charging strategy was a home-based. Each night they would plug the BMW Active E into a 110 outlet located in their condominium's subterranean garage. Over the course of about 8-10 hours each night the EV would become fully charged.

Household 29 Condominium Parking

The Household 29's goal was to ensure that at the start of each day the "car was 100 percentage charged" for the work day ahead. The family augmented their 110 charging strategy by

using a convenient Level 2 charging station that was located on the street in Downtown Manhattan Beach. On occasion where the BMW Active E's battery was significantly depleted (i.e. it would take longer than an overnight charge to reach 100 percent); they would take the car to the Level 2 charging station and then walk home – retrieving the EV after 2-4 hours either fully charged or in a state where it could be plugged in overnight at home to be fully charged by morning – Frank described what he did as a "valet charging service."

Both Elaine and Frank were extraordinarily resourceful in terms of finding places to opportunity charge their EV. Frank's workplace provided Level 2 charging and many of his clients had Level 2 or Level 1 charging available for him to use when he arrived. Since his consultative work would often take several hours at each site having access and using Level 2 charging proved to be a good match for "topping up;" For those clients that only had an available 110 outlet plugging in was not nearly as useful "although it was always good to have at least a few more miles of range."

Elaine, as well, had access to a 110 outlet at work, however, since it was not authorized for charging use she felt as though she could not use it. On the other hand, her work often took her to the Los Angeles Downtown Government Center where she would opportunity charge for her trip home for the next leg(s) of your work day trips. The family's selection criteria for finding charging available charging stations was to first, find a "free" charging site at their destination or somewhere "not too far away." However, if free charging was not available or as necessary (i.e. late at night), they would "certainly pay". Both Elaine and Frank routinely used their smart phone apps to plan and identify charging stations that they might use while traveling in their BMW Active E.

Driving Patterns and Experience:

The Household 29's made a decision to only use Elaine's Mercedes E300 and the BMW Active E; Frank's Audi S3 was not driven during the course of the study. Together they shared the use of the EV. Frank estimated that he drove the EV about 60 percent of the time with Elaine driving it for the balance; Both Frank and Elaine noted that she probably drove the car the farthest overall. From Monday through Friday the BMW Active E was used as one of the family's commute cars. This meant that at the beginning of the week Frank and Elaine would sit down to negotiate who would get to drive the EV on which day. Generally, this type of planning took into account additional trips – like pick-ups and drop-offs of their children from child care or afterschool activities – the goal being to choose the right person to drive the right car based on their schedule and estimated range that might be necessary to accomplish the extra after work trips. The Household 29 spend a good deal of time planning their trips so as to be as efficient as possible thereby conserving their range or topping up so as to extend their range. Weekday trips would be to their respective office followed by additional work related trips; weekends consisted on family activities using the Active E as their car of choice.

In terms of range anxiety the Household 29 were conservative at first. Venturing less than ½ the estimated range for each trip – less than 40 miles one way; this precluded a trip to Disneyland during their first week with the EV. However, as they became more aware of available charging stations for

opportunity charging and they learned about how the BMW performed (when they drove it) they ventured further afield. Elaine's confidence grew and she "conquered her range anxiety" after travelling to El Monte for an evening business meeting. With only 39 miles remaining she called Frank to alert him that "she might not make it home." She decided to stop at her mother's house in Monterey Park on the way home – potentially to charge the car. However, after arriving at her mother's she realized that she had 40 miles left – "just enough to get home". Elaine realized that it would "take a long time" to recharge" using a 110 outlet at her mother's home. Braving the distance, she got back in the car choosing not to use the AC or any of the other amenities to conserve range. She drove home, surprising herself when she exited the freeway in Manhattan Beach with 20 miles of range left. At that point Elaine felt comfortable that she could go to most places local places that she needed to. Shortly thereafter, the family ventured to Disneyland where they used one of the available Level 2 charging stations to recharge while they enjoyed a day at the theme park.

Both Frank and Elaine thought that the BMW Active E was more of a "commute car…than a real car" – it was a good car for their daily trips however each one thought that a "real" car would have a range that was "200 miles" so that they could easily go on longer trips.

Design/Use:

In terms of the BMW Active E's design and the use, the Household 29 family found it quite functional; certainly, the total space was very "similar to their other cars" with small cargo capacity - although they did have to use their "tetris" skills to put their infant daughter's stroller into the trunk. The Active's amenities were more than adequate as Elaine thought the Blue Tooth feature a great tool for hand's free conversation and they both liked the overall performance of the car on the road as it "handled like a BMW

Household 30

Participant: Billy Household 30

Age: 50, 50, 21

City of Residence: Torrance

Date: 3/10/14 to 5/13/14

ICE Vehicles: Toyota Prius, Sienna

EV: Honda Fit EV

EV Start Date: 3/14/14

EV – TOTAL VMT: 619 miles

EV Average VMT per Day: 18.2 miles

Overall:

Billy Household 30 lives with his wife and (on occasion) his adult son on the Eastern side of Torrance. The family lives in a multi-unit apartment/condominium complex; each unit has its own private lower level 2 car garage. Billy is an aerospace engineer who works on the Northrup Grumman campus located in nearby Manhattan Beach. His wife, Shirley, works at Los Angeles International Airport in an administrative job for one of the major airlines. Their son was not in the household during their participation in the study.

The Household 30 family drove the Honda Fit EV during their rotation. Billy enthusiastic about participating in the study however he was very analytical and somewhat reserved about expectations about whether or not an EV would make a difference in replacing one of the family cars. Billy's wife was interested in the study however she was non-committal and thought of this as (mostly) "Billy's project." Given their divergent interests it was no surprise that Billy drove the Fit EV almost 100 percent of the time with his wife "test driving" it just once to go local grocery store. During the Household 30 family rotation they took advantage of saving the expense of fuel by having Shirley drive Billy's Prius. Thus, they essentially parked the low-mileage Toyota Sienna for the duration of the study.

In terms of travel patterns, Billy reflected that his trips were very local in nature. About 90 percent of his trips were commute trips to and from his Manhattan Beach workplace – with the occasional stop enroute to run errands or go shopping. About 10 percent of his travels involved "other trips" – that is non-work related travels like picking up his father in Hollywood to attend a basketball game in Downtown Los Angeles or local household errands on weekends. Billy noted that the Fit EV's typical full

range of 92 miles is suspect and varies widely by the type of driving (surface roads versus freeways); it was really more like 80 miles. This was "fine" for local driving – "a good car for getting around Los Angeles." However, to relieve any anxiety, he would have liked the EV to have a range without "high variation" – an EV whose range was consistently closer to 100 miles.

Billy's daily trips were very local with most of his travel involving commute trips to an employer that supported alternative transportation with Level 2 charging stations on its campus. As such, Billy's initial strategy was to use home-based charging; plugging in each night using a 110 outlet located in their condominium garage. However, Billy soon realized that there was an opportunity to charge at work for free using the company's Level 2 charging station. Billy, on occasion took advantage of this opportunity charging scenario. However, he did this infrequently as he saw "no need" to charge every day since his daily travels did not deplete the Fit EV's range. Beyond these two charging options Billy did not use nor did feel the need to opportunity charge at other locations.

At the end of his participation Billy liked driving the Honda Fit EV and considered that an electric vehicle might work for his family and his local driving. However, because the cost was still more expensive than his hybrid Prius and his Prius could travel further afield he could not envision making a change to the cars that his family currently drove.

Charging Strategy:

Household 30 Townhouse Parking and Charging Set-up

Billy Household 30 used a strategy of charging his Honda Fit EV both at home at the workplace. Initially, he would plug in at night using the 110 outlet located in his condominium's garage. Soon thereafter, Household 30 realized that this employer – a local aerospace company – supported alternative vehicles by providing a bank of Level 2 charging stations on their campus. Employees could charge for free using these stations. Since Billy's trips were very local he did not see the need to charge every day. Rather, as needed, Billy would recharge as was convenient. His decisions were loosely based on "looking to see he needed to recharge." With such hyper-local driving, Billy did not use nor did he seek to opportunity charge at any other locations.

110 to 220 Home Upgrade:

Three factors precluded the Household 30 family from upgrading their home 110 charging to 220. Billy, did not to pay for something that he would not use after the study; the length of the study; and, the fact that Billy's employer provided free Level 2 charging.

Driving Patterns and Experience:

Billy was the primary driver of the Honda Fit EV. The family's choice to not use their Toyota Sienna minivan meant that Billy replaced almost 100% of his trips that he would other have made using his Hybrid Prius; Shirley, during the course of the study drove the Prius to work and for her other trips. The Household 30 family travel patterns were very local. Weekday trips involved commuting to local destinations; respectively, to Manhattan Beach for Billy and Los Angeles International Airport for Shirley. Typically, both Shirley and Billy would organize additional trips so that they were chained; stopping enroute to run errands or go shopping.

Initially, Billy discovered a "bit of anxiety" when he took the Honda Fit EV on the highway for the first time on a trip to UCLA. He noticed that the range "dropped right away." While this was unsettling he quickly got used to the variation of range (the difference between what the on-board computer would indicate when he started the EV and what it would shift too after he began driving). While Billy's trips were still hyper-local, his comfort level increased to where, on occasion, he would venture further afield with the Fit EV to visit family as well as attend local basketball game. On a couple of occasions he drove into Hollywood to pick up his father then Downtown to the Staples Center returning the same way after the game. For Billy, the (approximately) 80 mile range of the Fit EV was more than enough range to accommodate both highway and surface travel for these kinds of trips as well as his daily commute.

On the other hand, Billy noted that the "variation" of range was something that he wished "was more consistent." He would have liked to have taken the Fit EV on a family weekend trip to Ventura however, because he wasn't sure how far he could travel (on the highway) and whether there were Level 2 charging stations available at his destinations, he and his wife decided, instead, to take the family's Prius. To relieve any anxiety, in Billy's mind this meant a "true" range of at least 100 miles.

Shirley's limited experience was one "test driving" the Honda Fit EV to go to a local shopping center. During her short trip she stated that she "wasn't confident about the range" and was happy to just drive her Sienna or the Prius instead.

As far as driving the Honda Fit EV was concerned both Billy and his wife didn't see much difference between their family cars and the EV – it was "a car." Billy did note, however, that it was a smooth ride and he had no concerns other than the range.

Design/Use:

In terms of the Honda Fit EV's design and the use, Billy liked the amenities. In particular (though he did not use it) he liked the GPS function which located charging stations. Billy noted positively that there was more cargo space than their Prius. While the EV fit his driving needs and was comparable to his feelings of driving his Prius, Household 30 did note that there were issues with regulating the air conditioning and the heating functions; he found this as well as the door locks to be "annoying" features of the EV. Billy did download the smart phone EV and charging apps but did not use them.

Household 31

Participant: Michael Household 31

Age: 42, 43, 4, 2

City of Residence: Redondo Beach

Date: 3/3/14 to 5/14/14

ICE Vehicles: BMW 350, Infinity

EV: Nissan Leaf

EV Start Date: 3/14/14

EV – TOTAL VMT: 295 miles

EV Average VMT per Day: 5.0 miles

Overall:

Michael Household 31, his wife and 2 small children live in a condominium near the beach area of Redondo Beach. Michael is the owner of an import/export business and works out of an office building in the LAX area of Manchester. His wife is a medical sales representative whose home office is located in Long Beach; her work consists mostly of "hopping all over the place" to make sales calls to doctor's offices. Michael was the sole driver of the Nissan Leaf. As such, the trips taken in the Leaf replaced those that would otherwise have been made using his BMW 350. Most of Michael's trip patterns were commute trips with the occasional errand or pick/drop off while enroute to or from work. Michael sited his interest in participating in the study as wanting to see if "an electric car made sense for his family"; to see if they might replace one of their family cars with a battery electric vehicle to save on gas and maintenance costs.

Michael, initially, was an enthusiastic participant in the study stating that the Leaf felt "comfortable" and that he liked the EV's "utility." However his enthusiasm for the project was tempered by an incident of feeling as if he did not have enough range to take care of a medical emergency (involving his father) while driving the Leaf. Without workplace charging Michael was unable to drive from North of Los Angeles International Airport to pick up his father in Palos Verdes to take him (in a timely fashion) to his doctor in Harbor City. As Michael noted, "I would not have been able to get there and would have run out of power, for sure." Fortunately, he was able to drive home, swap cars and take care of the family emergency. The result, however, left Michael, feeling that he could not simply drive the Leaf any time he choose; rather, he made the decision to not take the Leaf on days that his ill father had doctor's appointments or when his father's caregiver had a scheduled day off.

Michael's charging strategy was to use (almost exclusively) home-based 110 charging. The Leaf was charged using a convenient outlet located in his two car garage. Initially, Michael would plug-in every night however, "after a little while" he decided that his travel pattern of commuting back and forth to

work via surface streets did not warrant "topping up" each night. Instead, Michael would wait until there was "about 1/3 charge left" at which point he would plug in to charge overnight. In terms of a schedule, this strategy resulted in charging "about every other night." Since workplace charging was unavailable Michael became "hyper-paranoid" to make sure that EV was fully charged.

Michael was only able to take advantage of opportunity charging once. While dinning out at the "Rock and Brew" restaurant he used the free 220 charging that was available while he and his family enjoyed dinner at the restaurant. On a couple of separate occasions he attempted to charge outside his home

Charging Strategy:

Household 31 Townhouse Parking Beneth Home

Work place charging was not an option for Michael and, as such, his primary strategy became one of plugging in at home. For charging, Michael would use a 110 outlet located in the 2 car garage under their family condominium. Initially, he would charge the Leaf each night plugging in in the early evening and unplugging the EV before heading off to work the next day. After a couple of weeks Michael realized that his consistent trip pattern of commuting about 16 miles round trip to his office did not necessitate him having to plug in every night. Instead, Michael, choose to change his charging strategy to one of "about every other day." He would charge when there was "a little more than 1/3 charge left" on the indicator. He was careful to monitor the charge because he was "hyper-paranoid" about running about of charge and "getting stuck."

In terms of opportunity charging Michael was only able to do so one out of the three times he tried. In the instance that he was successful he was able to use the "free" 220 charging station located on the street outside the "rock and brew" restaurant; he charged while he and his family enjoyed having dinner. On two occasions, however, he was unable to charge at a public charging station (outside Costco) because the parking spaces designated for charging use were taken by non-electric vehicles. Michael's disappointment with not being able to charge was expressed as "the guy…should get a ticket" for parking there.

110 to 220 Home Upgrade:

Michael noted that the length of the study and associated costs of upgrading and installing a 220 home-based charging station precluded any thought of upgrading their home charging from 110 to 220.

Driving Patterns and Experience:

The Household 31 family's experience in the BEV study was one of initial enthusiasm tempered by the challenges of the Nissan Leaf's range. Michael's wife, though enthusiastic about electric cars, decided not to drive the EV. She stated that her work travel patterns - commuting to Long Beach followed by sales calls throughout the South-East Los Angeles area - along with the fact that charging was not an option at her workplace nor was there time between sales calls to "top up" precluded her from using the Leaf. For Michael, he embraced the chance to drive the Leaf. It was an opportunity "to test" whether or not an EV would be a good choice for him as a replacement for his BMW 350. The Nissan Leaf, thus, replaced, only trips that Michael would have made in his car.

Michael's used the Leaf as his commute vehicle. His travel patterns to work consisted, primarily, of traveling through the beach cities to his office just North of Los Angeles International Airport. Often, he would chain other errands while traveling to and from work. Michael's use of the Leaf, however, became problematic. On the occasion of having leave work early in the EV to pick up is father who was having a medical emergency Michael suffered range anxiety. While driving to get his father Michael noted that he "did not have enough charge" to pick up him up in Palos Verdes and then take him to his doctor's office. He was "freaking out" and he felt very stressed that wouldn't be able to get there. Michael solved this problem by coordinating with his wife to use her car (his was getting repaired). He stopped at home while on the way to his father's house to change cars before continuing on. Michael noted that he just couldn't "get stuck" again and, as a result, changed his driving preference to using his BMW on days that he felt he needed to be available for "dealing with his father."

Critically, Michael noted that he "loved the car" except for the range. The estimated range (when fully charged in the morning) was "totally off" and the "incident with his dad disappointed him." For Michael, it brought home the fact that he would only consider purchasing an electric car if it had a "true" range of 300 miles – though a range of 200 miles would "make him feel less anxious.

As far as his family was concerned, they too loved the Leaf, his elementary school daughter called the Nissan Leaf the "silver bug because bugs like leafs!"

Design/Use:

In terms of the Nissan Leaf's design and the use, the Household 31's found it very satisfactory. Michael used the on-board amenities like the GPS and blue tooth system with ease. The cargo capacity was good and offered enough utility for him to use as a family car – for shopping as well as picking up and dropping off his daughter for her activities. The Leaf was comfortable and drove "very well." Noticeable impact on range caused them to drive (at times) either uncomfortably hot or cold – something that would not otherwise happen in one of their regular cars.

Rotation #9

Household 32

Participant: Graham and Amy Household 32

Age: 31, 36

City of Residence: Redondo Beach

Date: 5/5/14 to 7/17/14

ICE Vehicles: Mazda 3, Honda Motorcycle

EV: Nissan Leaf

EV Start Date: 5/19/14

EV – TOTAL VMT: 1,103.8 miles

EV Average VMT per Day: 18.7 miles

Overall:

Graham and Amy Household 32 are a young (soon to be) married couple who live in Redondo Beach. They lived in a multi-unit apartment complex with a 1 car garage located behind the building – accessible from the road via an alley. Graham is employee at a medical staffing firm located in Culver City and Amy is an account executive at a digital advertising firm in the Manchester area near Los Angeles International Airport. The Household 32 family is a one car household (a Mazda 3) that is used by both Amy and Graham for commuting as well as personal trips; Graham also has a small motorcycle that we would use for the occasional commute trips but mostly for "fun" outside of work – however, during the course of their participation, the motorcycle was in disrepair and not used.

The Household 32 family came to the study after observing friends who participated in both the Local Use Vehicle (LUV) program and an earlier rotation of the Battery Electric Vehicle (BEV) project. "They loved it and we wanted to try it too." The motivation for both Graham and Amy was to test their Nissan Leaf to see if it could replace their family's car. Additionally, they were keen to see how much money they might save by driving an electric car.

Using the Mazda 3, Graham and Amy had a prior travel routine of carpooling about 65 to 75 percent of the time with Graham taking his motorcycle to work on other days. On days that they carpooled, Graham would drop Amy off at her office and continue on to his location (not far away) in Culver City. During the course of their participation in the study, they continued this pattern (though without driving the motorcycle). Thus, Graham and Amy were able to fully substitute all of their commute trips using

the Nissan Leaf that they might otherwise have made with their Mazda 3. Graham was the primary driver in the family as they estimated that he drove the Leaf about 90 percent of the time and Amy about 10 percent of the time. Over the course of the study the Household 32 s stated that they "became much more organized around their travel" and started planning to "link" their trips (errands as well as travel to friends' homes) together – a strategy to conserve their range and economize their trips.

The family used an exclusive pattern of home-based charging. Each night they would return home and plug in using the 110 outlet located on the garage wall. Power to their garage was not attached to their household meter. As a result, the cost for charging was passed through to the landlord. This, however, was not an issue as Graham, noted that "she hadn't noticed or said anything" about it.

Since the Household 32's trips were very local – "inside their local bubble" – home-based charging was sufficient; they did not feel the need to opportunity charge while traveling about the South Bay. Moreover, both employers did not provide Level 2 charging opportunities nor were there any readily accessible 110 outlets that could be used during the work day.

As a result of participating in the study the Household 32 family discovered that the vast majority of their trips were hyper-local and that the Nissan Leaf (or another EV) would be a "perfect second car for their household. They would use it almost exclusively for their daily trips while reserving their Mazda 3 for longer trips outside their "local bubble." The Household 32 s were amazed to find that they had significant gas savings simply by driving the Leaf for the study – they estimated that they saved almost a two hundred dollars a month and that over a year this would be a savings of about $2600.

Household 32 Single Garage with Charging Set-up for Nissan Leaf

Charging Strategy:

The Household 32 family exclusively charged at home using a 110 outlet located in the family's one car garage. On most nights, Graham and Amy's ritual would be to plug in so that they would have a "full charge" in the morning. Since they carpooled to a (relatively) close workplace this meant that they would plug with the battery needing only to charge 50 or 60 percent – by charging overnight they could easily fill up to 100 percent by their next commute trip in the morning. On the rare occasion that they did not charge at night the result would be range anxiety the next day. As a habit, the couple always charged on Friday night to make sure that the EV was ready for their weekend (local) adventures.

Graham and Amy did feel the need to charge at work and, after beginning their driving experience, realized that they could not have done so anyway – both employers did not provide any kind of workplace charging opportunities. Further, because their trip destinations were very local, they had more than enough range so as not to need any of the public charging stations located in the South Bay

area. On the other hand, Graham speculated, that were they to take the Leaf on a road trip (outside of the area) then he would have looked for Nissan Dealerships so that he could have used their DC 3 Fast Charge stations as well as other places to opportunity charge.

110 to 220 Home Upgrade

The Household 32 s did not feel the need to upgrade their home charging from 110 to 220. To do so would have necessitated having to inform their landlord about their use of the garage's common plug – something that they didn't want to do. Additionally, they did not want to incur the extra costs for the upgrade. In practicality, because of their short trips, 110 was sufficient for their needs.

Driving Patterns and Experience:

Graham and Amy were "surprised" to discover that their daily travel for both commuting and personal trips was mostly local. As Graham said, it was very much like being in a travel "bubble." Before participating in the study the Household 32 s had already put into place a commute strategy of carpooling to work – travelling via surface streets, Graham would drop off Amy in a business area near LAX and then continue north to his work location in Culver City. The family did this about 75 percent of the time with Graham using is motorcycle about ¼ of the time. After the arrival of the Nissan Leaf this pattern did not change but rather became enhanced as the Graham and Amy made a conscious decision to "not drive" their Mazda 3 to work. Moreover, they also began to plan their trips (by linking or chaining them together) to conserve the range of the Leaf. Thus, they would often chain their trips so as not to be more efficient with the EV and their time. On weekends, they would find themselves using the EV to run errands, go to the gym or visit with friends in the South Bay.

For the most part, the hyper-local nature of their trips meant that they always felt that they had sufficient range to meet their travel needs. This feeling of comfort was based on the fact that they had a ritual "plugging in each night." Ironically, even though their travels were very local when they did not plug in (or left the house with less than a 100 percent charge) then range anxiety occurred. In one instance, Amy took the car to visit with friends on Sunday afternoon but forgot to plug it in that evening. They commuted as usual on Monday morning however, he noticed that he only had 15 miles of range left by the time he arrived at work. Doing the math he realized that they had left the house with about 29 miles of charge. This left Graham anxious – more so, because he had left the 110 portable charging unit at home. At the end of the day, felt range anxiety as he "theoretically" calculated that he couldn't get home. However, he also realized that he would be travelling on surface streets during rush hour so there was a "possibility" that he might make it. As a precaution, he called a friend to be "on standby" to deliver his portable 110 charger and set off to drive home. Surprisingly, he was able to conserve his range by putting the Leaf into "eco-mode" as well as taking advantage of the "stop and go" traffic which allowed the Leaf to regenerate the EV's charge. Graham made it home with about 4 miles of range to

spare. Subsequently, he and Amy would "double-check" each night to make sure that the Leaf was plugged in and charging.

In terms of their experience driving the Nissan Leaf, they both enjoyed it. Ironically, even though their trips were very local and that they usually had sufficient charge from home-based 110 charging, both Graham and Amy would have liked to have had a longer range of about 100 miles. Ideally, however, if they were to purchase an EV Graham would like it to have a range of about 130 miles and for Amy the ideal range would be about 200 miles. On the other hand, they "loved" the fact that they hadn't "been to a gas station" in a long time and relished that they had saved several hundred dollars during the course of their participation in the study.

Design/Use:

In terms of the Nissan Leaf's design and the use, the Household 32 s were very satisfied and felt that the EV was had very similar features to their Mazda 3 stating that "it was car." Both Amy and Graham liked the Leaf's navigation system and the touch screen for accessing on-board information. As far as cargo space was concerned the Leaf was sufficient for their needs and comparable to that of their Mazda 3 – together, they loved the exterior design of the car and the look of the headlights.

Household 33

Participant: Jens Household 33

Age: 37

City of Residence: Redondo Beach

Date: 5/5/14 to 7/17/14

ICE Vehicles: Kia Sportage

EV: BMW Active E + Honda Fit EV

EV Start Date: 5/19/14

EV – TOTAL VMT: 243.8 miles

EV Average VMT per Day: 6.7 miles

Overall:

Jens Household 33 is a single Assistant Principal at Redondo Union High School. He lives in a multi-unit apartment located about ½ mile from the school at Redondo Beach. Jen's car is a small SUV Kia Sportage which he parked in an adjacent parking structure near his apartment building. Jens interest in participating in the study came, as a referral from a former participant who was an athletic instructor at the school – he witnessed his colleague and friend driving both a Local Use Vehicle (NEV) and, subsequently, the BMW Active E Battery Electric Vehicle (BEV). Like his colleague, Jens was interested in participating to see if he could find a more "eco-friendly" car that he could use for his South Bay life style.

Over the course of his participation in the study Jens drove both the BMW Active E as well as the Honda Fit EV; the later he drove for only 1 week. During this time Jens was able to replace 100 percent of his trips that he would have otherwise taken using his SUV. In other words, he "parked his car" for the entire time that he drove an electric vehicle. Surprisingly, Jens learned what he had already suspected in that almost all of his travel (by car) was very local. Aside from a trip "up to Hollywood" to visit a friend all of his trips were either very short commute trips to school or a series of linked "close by" trips to run errands, go shopping or to participate in extra-curricular school activities in the South Bay.

Though it required some scouting and creative tactics, Jens was able to charge in his apartment building's parking structure. The structure had a limited number of 110 outlets at either end of the building. Jens initial thought was that he could move his Kia Sportage to outdoor parking and be able to run the BMW Active E's charge cord to the outlet. Unfortunately, it would not reach. As such, Jen's changed parking spots (without permission) and was able to finally charge his EV. Since his travels were never really that far he discovered that he did not need to charge every night but rather did so about 1-2 times per week. Moreover, Jens never felt that he needed to opportunity charge though he did inquire about work place charging and was told that it was not available (though Level 2 charging stations were

being considered as a future addition to the solar panels that the school had installed over their parking area.

Jens' experience in the study taught him that "he could get away with an electric car" for all of his local trips – which, indeed, he discovered they were. He also realized that unless the range of the EV were to improve so that he could easily go to "San Diego" one way then he would still consider the EV to be a "second car."

Charging Strategy:

Jens charged both the BMW Active E and the Honda Fit EV using a 110 outlet located in the parking structure of his apartment building. Initial inspection of the parking structure informed Jens that, unfortunately, there was no readily available 110 outlet near (enough) to his assigned parking space; there were two 110 outlets located at opposite ends of the structure near exit doors. This was problematic as the EV's charge cord could not reach the plug and the use of an extension cord was not acceptable. Work Place charging was not an option either. To resolve this issue Jens did two things: First he made his assigned parking space available by moving his Kia Sportage to an available outdoor parking space. Secondarily, Jens then took an (as yet assigned) available parking space next to the 110 outlet. He did so without informing the apartment manager stating that, "he would deal with it if they ever asked." In the interim, to mitigate any possible parking issues he would put a note on the EV's window stating his telephone number, his available space (nearby) and words to the effect that "he would move his car if necessary." There were never any issues with either other tenants or with management; power to the garage area was to a common "house" meter and as such, was "free" for Jens for the duration of the study.

Household 33 Designated Parking Spot without 110 Outlet

Based on his travel patterns Jens soon recognized that there was no need for opportunity charging – either at work or at other locations; his routine ritual of home-based charging every evening was more than sufficient for this hyper-local travel needs. While he did not need work place charging, Jens did inquire as to its availability. He discovered that Level 2 charging was not available and that there was not a "safe and secure" way to use the outdoor 110 outlets that might be available. Jens learned that, "at some point," the School would be exploring the idea of installing Level 2 charging stations at the base of the solar array that covered the school's parking lot. The time-frame for this addition was not known and did not occur during his participation in the study.

110 to 220 Home Upgrade:

The circumstances of living in a multi-unit apartment complex and (surreptitiously) using the building's electricity made any inquiries for installing a 220 charging station prohibitive. Moreover, Jens did not feel that he needed it given that 110 charging was more than sufficient for his travel needs.

Driving Patterns and Experience:

For Jens, he confirmed what he had already suspected in that most of his travels were very local. His typical weekday involved a short commute to his work place at the local high school with a short trip home in the evening. From time to time he would, on his way home from work, use the electric car to run errands, go shopping or take part in extra-curricular school activities. On weekends, Jens' travel patterns did not stray too far from his home. He recalled that his longest trip was "to visit a friend how lived up in Hollywood." Initially, the trip outside the South Bay was "a little nerve wracking" has Jens noticed how quickly his range diminished while driving on the freeway. However, his fears about not having enough charge to make it to his destination and home were mitigated by the fact that he wound up travelling on surface streets in stop and go traffic. His range held steady as the Active E regenerating electricity through consistent braking. Jens was able to return home confident that he could travel, if necessary, to other parts of Los Angeles.

As a "single guy with no family" Jens' experience driving only an EV showed that he "could get away with something smaller." He always figured that he needed a bigger car but his experience driving both the Active E and Honda Fit EV suggested otherwise. Additionally, Jens realized that his driving habits had changed during the course of his rotation. He became "a little more cognizant of his driving" using the eco-mode and regenerative breaking to conserve his EV's consumption and, thus, extend the range of his car.

In terms of mobility choices, it was clear for Jens that the experiment of only driving an electric car was sufficient for his daily use; to "just jump in and go" wherever he wanted or needed to go. Ideally, however, he would want an EV that would also allow him the opportunity to travel regionally to other places outside the South Bay – he noted that having a range to go 80-90 miles one way (to San Diego, for instance) was what he would consider regional travel. Beyond that, Jens noted that he would "fly" to destinations far away.

Design/Use:

Jens liked both the BMW Active E and Honda Fit EV's design and the use however he was quick to point out that the Active E was, indeed, a BMW; it drove like one and felt just like the sports car that he was expecting to drive. On the other hand, the Fit EV was a "small little hatchback" that he could appreciate but was "not his style." In terms of each car's respective amenities Jens favored the set-up and on-board

computer and feel of the Active E; he thought that the Fit EV was functional though not as sophisticated as the Active E.

Household 34

Participant: Vicki and Byron Household 34

Age: 65 and 45

City of Residence: Redondo Beach

Date: 5/5/14 to 7/17/14

ICE Vehicles: Jeep 2000, Toyota Prius

EV: Nissan Leaf

EV Start Date: 6/18/14

EV – TOTAL VMT: 312.9 miles

EV Average VMT per Day: 6.9 miles

Overall:

Vicki Household 34 and her Partner Byron own and live in a multi-unit apartment building located in Redondo Beach. Formerly, they owned and operated a charter fishing company however today their business is that of managing multiple rental properties (that they own) in the South Bay as well as participating in many South Bay volunteer activities. Vicki's interest in participating in the study was to "see if they might integrate" an electric vehicle into their family's fleet of cars with the idea that they might purchase an electric car at some point in the near future; as Vicki noted, "especially, since they (their cars) are getting older and will need to be replaced." Vicki and Byron both indicated that their interest in electric cars was piqued by the fact that they had seen many of the "small GEM" neighborhood electric vehicles (NEVs) around the beach cities and they wondered if something "bigger" might work for them.

The Household 34 household drove the Nissan Leaf during their participation in the study. The Leaf became a secondary option to the Household 34 primary car, the Toyota Prius. Generally speaking, Vicki and Bryon drove together for their daily errands. This meant that either the Leaf or the Prius would be parked while they took the other car. As such, the Leaf never fully replaced the Prius for their trips. Both Byron and Vicki suggested that they would choose to drive the Leaf "if they remembered" to do so or if they "didn't have to shuffle their cars around." Together they guessed that, during the course of the study that (when they had a choice), they would drive the Leaf "about 50 percent of the time; the Prius about 48 percent of the time; and, the Jeep about 2 percent of the time. Typically, Byron would do about 90 percent of the driving. Their Jeep, on the other hand, "stayed parked" unless they had to tow their large boat or take their dog to the dog park.

Vicki described their pattern of trips as very local with the occasional longer trip outside of Los Angeles (for instance, to San Diego). Her intention each day was to "plan ahead" and plot out her route – so as to

be more efficient – however this usually never came to be. Rather, the reality of Vicki and Byron's work like meant that they took a lot of short trips – either in the Leaf or in the Prius - back and forth from their home to run errands for servicing and maintaining their properties or for Vicki's volunteer activities at the local Women's Club or at the American Legion. Vicki estimated that she and Byron would run out and back "at least 15 times a day." Over the course of the study, they often choose to use the Leaf for running errands that did not have to do with the maintaining their properties; for items like dirt or hardware they would use their Toyota Prius. They saw the Leaf as "car that they could tool around town in."

In terms of charging and range, the Household 34 s employed exclusively charged at home using an outdoor 110 outlet located between two ground floor apartments. Charging each night was more than sufficient to meet their hyper-local travel patterns. While they had more than enough charge for each day's use of the Leaf both Vicki and Byron lamented the fact that the range varied and wasn't as stated on the computer when they started the EV in the morning. Byron stated that he felt that the computer "lied when it said 85 miles and it wasn't." Even with this variance they realized that the Leaf's range was more than enough to accomplish their daily errands, however, what they discovered was that they did not think that it would be worth their while to purchase one given that "between their Jeep and their Prius they didn't really need another car; their Prius could be used just as economically short trips while giving them the flexibility to travel out of town at any time.

Household 34 Exterior 110 Outlet for Charging Nissan Leaf

Charging Strategy:

The Household 34 s charged exclusively at home In terms of home-based using an available outdoor outlet located between two ground floor apartments. Each night Byron "was in charge" to plug in the Leaf so that it would be fully charged the next morning. Since the Household 34 s' use of the EV was very local they did not recognize any need to opportunity charge either away from their home using a publicly available Level 2 charging station or at home during the day between trips. As Vicki suggested, "they only traveled about 20 to 40 miles each day" and their trips were "little tiny short hops" which would not provide enough time to take advantage of opportunity charging.

110 to 220 Home Upgrade + Upgrading Issues as a Property Owner in the South Bay:

The length of the study as well as the fact that they had more than sufficient range for their use of the Leaf, precluded the Household 34 s from considering an upgrade from 110 to 220 home charging

station. Moreover, there was another important consideration for the Household 34 s in terms of upgrading to provide for 220 home charging. As owners of multiple rental property owners they were in the unique situation of having to consider any upgrade in relationship to the regulations and laws that governed rental properties; they had to weigh their interests and the costs associated with upgrades with the regulations that affected ownership of multiple properties within the City of Redondo Beach. In their case, they pointed out that if they were to invest in charging stations for one of their properties then they would be responsible for doing so for all of their properties. This would necessarily mean that they would have to pay for the cost of upgrading each property's electricity to provide for 220 and, at the same time, pay for the cost of multiple charging stations. Given the current state of their properties wiring and the location of the electrical panels Byron estimated that this might run upwards of $10,000. Additionally, the idea of having to provide for "special" parking as well as dealing with City Inspectors and permitting was something that both Vicki and Byron felt not worth their time or the "aggravation." Lastly, as far as they were concerned – as property owners – there was no demand for this kind of amenity and they could not see the return on investment (i.e. higher rents or better tenants) were they to install 220 charging stations. As Byron stated, "so why do it?"

Driving Patterns and Experience:

Vicki and Byron used the Nissan Leaf to partially substitute trips that they would otherwise have made using their family's Toyota Prius. This was about ½ the time because they either fell into the habit of simply "taking the Prius" because "that's what they always take" or they would have had to "shuffle cars" around. Often it came down to, as Vicki suggested, whether or not they "remembered to use the Leaf." Together they estimated that (during the course of their participation) they did use the Leaf about 50 percent of the time. In terms of travel patterns the Household 34 s made many "tiny hop" trips in and around the South Bay. Vicki estimated that she averaged about 10-15 per day and though she would plan to link her trips (so as to be more efficient) she wound up doing otherwise; typically, travelling out and then back home and out again, repeatedly. Generally speaking, Vicki and Byron would travel together for these daily errands with Byron driving the EV about 90 percent of the time. Often their trips would consist of running errands as property managers or for Vicki to attend to the many functions she had as part of her volunteer work.

Since the Household 34's trips were very local they "really didn't have any range anxiety." Rather, to mitigate whatever anxiety that might have had, they used a strategy from their days at sea (as Charter boat captains). As Byron noted, "a boat driver always makes sure that there's at least 1/3 of a tank at all times" reserved to make sure that they could get back to land. So too did he and Vicki plan and use their Leaf's range so that it never dropped below 30 percent of charge; they diligently watched their gauges to make sure that they never were far from home.

For Byron and Vicki the Leaf turned into a "third car" that they could use for "tooling around the South Bay." It was "great for local trips" and had a "lot of pep" however in terms of versatility they thought

that their Toyota Prius would be just as economical and allow them to “escape” out of town at a moment’s notice.

Design/Use:

In terms of the Nissan Leaf’s design and use the Household 34 s felt that it was comparable to their Toyota Prius. However, because they did not own the EV they felt as though they could “not mess up” the interior of the car (by travelling with their dog or hauling items) thus, they really didn’t use the car as they might otherwise have. Byron noted that the car was “comfortable even for a big guy like me” though Vicki was somewhat disappointed that the use of amenities like the air conditioning and heating depleted the range more “quickly” than she had anticipated. Vicki and Byron did not use nor did they have any use for the on-board GPS system or other amenities feature with the Leaf.

Household 35

Participant: Household 35 Lisa

Age: 51

City of Residence: Redondo Beach

Date: 3/31/14 to 6/17/14

ICE Vehicles: **Nissan** Murano

EV: Honda Fit EV

EV Start Date: 4/11/14

EV – TOTAL VMT: 744.8 miles

EV Average VMT per Day: 14.3 miles

Overall:

Lisa Household 35 is a single-mother who lives with her high-school aged son in a duplex located in Redondo Beach; her son lived with her part of the time while spending time at his father's home located nearby. Lisa works from her home-based office as an interior decorator and design consultant. Lisa's interest in participating in the study was one of curiosity; Having read about and seen electric cars she had a genuine enthusiasm for the idea of "testing" this new technology; she wondered if and EV might be a viable option for her and her life-style. Her experience of "test driving" the Honda Fit EV provided that opportunity as it replaced all of her trips that she might otherwise have made in her Murano SUV.

Her work life is structured so that she spends 2 days working from her home office and 3 days on the road meeting with clients, purchasing products or looking for samples for her projects. Lisa prides herself in her abilities to plan and organize her day around work and other activities. As she says, "I'm on the road a lot so I don't have time to come home and go back out again." In jest, she referred to herself as, "a bag lady…I carry all my stuff in my car for whatever activities might be next." Her organizational strengths of using her car as a "mobile office" came in handy in her experience of driving an electric car.

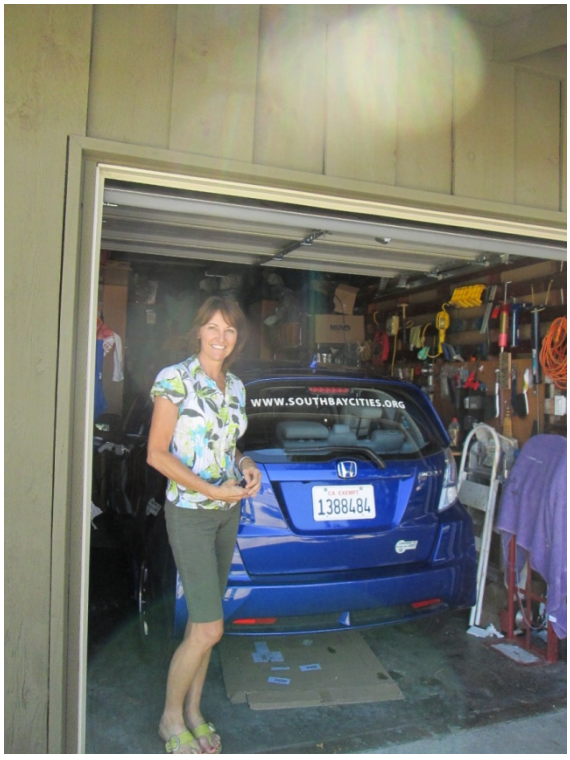
Lisa embraced the idea that, with good planning she would "try to use the Fit EV" just as she would her Murano. That is, take the EV on her work trips across the Greater Los Angeles Area – one some days north to Calabasas and Thousand Oaks and on other days southward into Orange County. Her goal was to "really test the car to see if it was possible" to use it every day. In so doing Lisa would spend a good deal of time planning her EV trips. She did so in two ways. First, as she would have done using her regular car, she would set up her day as a series of stops – so as to chain or link together her trips – packing accordingly so that she could have her work related material as well as "partying clothes" available to her in her car. Second, she plotted out and planned possible places to opportunity charge so that she could extend the Fit EV's range; Lisa would try to take into account and estimate the necessary time it would take to "top up" while on the road.

Lisa used both 110 home-based charging as well as a systematic and planned strategy of Level 2 opportunity charging. Each evening Lisa would plug the Honda Fit EV into a 110 outlet located on the interior side wall of her garage. Her goal was to have 100 percent range by the start of the following morning. She was also very meticulous and, somewhat fearless, in planning out where (and importantly, how long) she could stop to charge while on the road. Using her computer or her smart phone apps Lisa would often find multiple Level 2 charging stations that she could use while traveling during the day. As she said, "I would always have a plan A, B and C." There were several occasions, however, where she had to improvise to find other charging opportunities – usually these instances occurred because the charging stations she had intended to use were either in disrepair or occupied by other vehicles.

Though Lisa was an enthusiastic participant she came to realize that the Honda Fit EV was "good for local driving" however, her driving "was not very local." As she said, it wasn't really a "good fit." Rather, she would keep her Murano SUV because it can do everything she needs or, at some future time, she might consider purchasing a plug-in hybrid which would give her great range.

Charging Strategy:

In terms of charging, Lisa embraced and used every option available to her. Each evening she would plug in the Honda Fit EV into a 110 outlet located in her one-car garage so that she would have a "full charge" at the start of each day. Lisa both planned ahead and was pragmatic in her use of opportunity charging during the day. If time permitted or there was absolute necessity (i.e. not enough charge to return home) she would charge. Using her computer at home as well as her smart phone apps (while on the road) she would identify charging stations that might be along her route or which might "come in handy" at some point during the day. Lisa explored and used Level 2 charging stations that were located in many different places, including: Big box shopping stores like Ikea; smaller grocery outlets like Wholefoods; public agencies like Hermosa Beach City Hall; and, car dealerships, like the BMW facility in Calabasas. Additionally, Lisa always took her portable 110 charger so that, if necessary, she could plug in using a standard 110 outlet; she was not bashful to do so and for longer client meetings (at homes or business locations) she would plug into an available garage outlet to "top up."



Household 35 Very Small Garage for Honda Fit EV

110 to 220 Home Upgrade:

Given the length of the study and the possible costs associated with upgrading her home from 110 to 220 Lisa did not feel the need upgrade. Moreover, her robust strategy of using available Level 2 charging – both in her neighborhood and further afield – suggested to her that 110 home-charging was "good enough" for her.

Driving Patterns and Experience:

Lisa Household 35was a one-car household (her son occasionally drove a car that belonged to his father). As a result, the Honda Fit EV replaced all of the trips that might otherwise have been take in Lisa's Murano SUV. As an enthusiastic participant, Lisa embraced the challenge of "trying to figure out" how she could maximize her use of the Fit EV. Initially, her local trips in the South Bay posed no problems for her as the range of the Fit EV allowed her to easily travel to and from local destinations. However, because her job required her to travel much further afield (several times a week) she quickly realized that she would have to put to use her planning and organizing skills to best determine the most efficient and effective way to maximize the Fit EV's range – by choosing routes on highways and surface streets – as well as to strategically plan and target charging stations that she could use while en route during her work-related travel days. To do this she would consult different charging applications like plugshare.com, chargepoint.com as well as the blink.com. Additionally, she would also check the Honda Fit Ev's on-board GPS system for other charging stations. Because Lisa's driving pattern consisted of a series of string or chained trips (usually to destinations outside of her home area of Redondo Beach) Lisa was diligent to "plan ahead" so as to be able to extend the EV's range so that she could get to her destinations and, importantly, get home.

Lisa had to make choices concerning "what was doable" using the Honda Fit EV. Early in her rotation she considered traveling via the EV to an evening event in San Dimas – noting that there was a Park & Ride facility nearby where she could charge. Not feeling quite confident with the Ev's range and with the availability and integrity of the information about public charging stations, she chooses not to use the Fit EV but to take her Murano SUV. As part of her investigative nature, she did look into whether the Park & Ride charging stations were available and discovered that they were not – ironically, the gate was locked after business hours so that those wanting to charge their electric cars could not gain access. Lisa was relieved that, in this instance, she had made the right choice.

As Lisa's experience progressed she pushed and extended the range of the Honda Fit EV through her use of Level 2 charging stations along her trip route. Often she would stop for "a cup of coffee" and simply "work out of her mobile office" while she waited (often a 2 plus hours) to top off the battery. This strategy proved successful though on another occasion, it became problematic. While traveling north for a meeting in Calabasas, followed by an evening of dancing nearby, Lisa, found herself on the freeway at rush hour with very little charge left. Before the day's journey began she had identified several charging

stations located at a library and a shopping mall as places that she could charge. The challenge though was that these charging stations were either not working or were occupied. To further complicate the matter she was driving on the freeway through hills and her range was very quickly diminishing. At this moment she said that she felt "range anxiety." Fortunately, she resolved this challenge when she discovered a series of car dealerships – just off the freeway. Stopping at the BMW dealership she was able to plug in and charge up. Lisa anxiety was relieved as she noted, "they were very helpful and happy to let me charge."

Contrary to her friends opinions that "stopping to recharge (for several hours) was a pain in the ass" Lisa embraced the experience with a sense of adventure, good patience and a sense of humor. As she said, "I'll pack a lunch." That being said, however, the challenge of extending the Honda Fit Ev's range did where on her and she eventually began to cut back her routes to those that she felt she could easily handle or that might prove less stressful. Critically, she noted that the "state of (EV) charging infrastructure was pathetic" and that DC 3 Fast Chargers would have made a difference in both her use of the EV as well as a way to mitigate possible range anxiety.

In terms of range, Lisa learned that the Honda Fit EV was good for "local trips" however as she noted, "most of my trips are not really local." Moreover, Lisa became frustrated with always having to calculate or consider the inherent tradeoff that electric cars present to the driver, one that she described as "do I want to go fast or do I want to go far." In the future, were she to consider a new car, she would not choose a BEV but rather a plug-in hybrid – a car that would both be environmentally friendly yet have a greater range than the Honda Fit EV.

Design/Use:

Lisa liked the design build of the Honda Fit EV's and considered it as "a cute little car." In comparison though, with her Murano SUV, she felt as that she did not have enough cargo capacity which would be a limitation for her job – that is, picking up fixtures and interior decorations. In terms of the Honda Fit EV's amenities, Lisa was comfortable and used all the features, stating that they "worked fine" for her. She did note, however, that the on-board GPS system for identifying the location of charging stations needed to be updated because "the information wasn't always right."

Household 36

Participant: Mady and Ana Maria Household 36

Age: 73/73

City of Residence: Torrance

Date: 5/16/14 to 7/17/14

ICE Vehicles: Toyota Camry, Mercedes Benz E320, Toyota Sienna

EV: Honda Fit EV

EV Start Date: 5/16/14

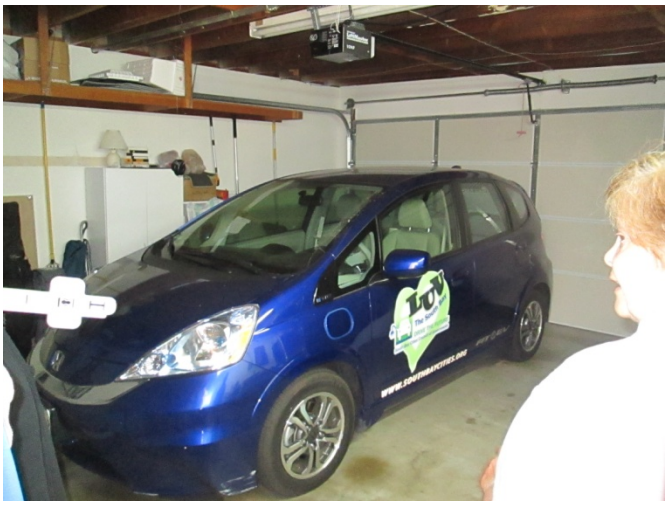
EV – TOTAL VMT: 441.6 miles

EV Average VMT per Day: 14.3 miles

Overall:

Mady and Ana Maria Household 36 live in a duplex located in Torrance. Mady has a home-based engineering business that produces estimates and plans for (world-wide) projects involving the use of rebar. The Household 36 family also owns several multi-unit buildings in the South Bay that function as adult assisted living centers. Ana Maria and Mylene (her daughter) are in charge of managing and the day to day operations of these facilities. As former participants in the Local Use Vehicle (LUV) Program, they were excited about the seeing the difference between the functionality of a full-speed battery electric vehicle (BEV) versus the speed limited (and route limited) Miles Wagon NEV that they had previously tested.

Both Mady and Ana Maria "loved" their experience of driving the Honda Fit EV stating that it was "perfect" for their family. For the first 3 weeks of their rotation Ana Maria drove the EV 100 percent of the time (while Mady was travelling). Upon Mady's return, he drove the Fit EV approximately 75% of the time. When the choice was made to drive the EV it replaced either Ana Maria's Toyota Sienna or Mady's Mercedes Benz for their respective trips. Mylene did not drive the EV as it was not easy or comfortable for her to fit



Household 36 Parking for Honda Fit EV

into the vehicle.

In terms of contrast to their NEV experience, the Household 36 s' BEV experience was superior. Referring to the difference Mady suggested that it was a "nicer car" and not a "tin can" (i.e. it was seen as safer). The fact that it was relatively not limited by range, speed or posted speed restriction was a huge difference between the two experiences. That being said, both vehicles proved useful and well used by the family during their respective rotations.

With the exception of one family trip to Irvine to visit a cousin the Household 36 s travel patterns were very much confined to the South Bay and could be considered hyper-local. Typically, the travel consisted of organizing their day(s) to be as efficient as possible. They did so by chaining multiple trips over the course of the business day. The trips reflected destinations that were both personal as well as business. According to Ana Maria and her daughter their daily trips were a "mish-mash" of all kinds of errands; Ana Maria estimated that it was about 50/50 in terms of personal vs work related destinations. Examples of such trip chaining would be running errands to the local bank for personal banking followed by a trip the store to purchase groceries for both the household and for their Assisted Living Centers; then lunch followed by transporting residents to doctor's appointments in the afternoon.

Household 36 Townhouse Charging Set-up

Charging Strategy:

The Household 36 s exclusively employed a home-based strategy for charging the Honda Fit EV; usually the Fit EV was plugged in at night or at the end of the day until the next morning. The only exception to this pattern was a trip to Irvine for a family function. In order to return home they used a 110 outlet in their cousin's garage. Very early in their rotation the Household 36 s decided that they did not need to charge the EV every night. Rather, they simply charged as needed or when the battery "was getting low" – around "20-30 miles" of range remaining. The rationale for not charging every night was that their trips were "not that far" and that they knew that they would be able to get home if necessary. Opportunity charging at their Assisted Living Homes was possible but not easily accessible nor convenient given their schedules.

110 to 220 Home Upgrade:

Given the length of the study as well as their successful charging strategy Mady and Ana Maria did not see the utility nor need to upgrade from 110 to 220. Additionally, in order to reach a 220 outlet they would have had to clean out and reorganize their garage – something that they were not prepared to do. However, they did suggest that, should they purchase/lease a new BEV, they would "seriously" consider installing a home 220 charging unit for convenience and faster charging, if necessary, during the day.

Driving Patterns and Experience:

Usually, when Ana Maria chose to drive the Honda Fit EV it replaced the Toyota Sienna; when Mady drove the EV it replaced trips that would otherwise have been taken in his Mercedes Benz E320. Mylene drove the EV only once to discover that it was uncomfortable and not practical in terms of her role of shopping transporting residents of the Assisted Living Centers to doctor's (and other) appointments.

The Household 36 s reflected that they learned to plan and chain trips during their experience testing the Miles Wagon NEV. This strategy continued during their rotation with the Honda Fit EV with many local errands (personal as well as for business) being linked from one to another before returning home later in the day. As Mylene observed an example of planning would be, "on Mondays and Tuesdays we have to plan our trips because it's supply day" (for the Assisted Living Facilities) – meaning there would be a lot of different stops to shop and pick up supplies during the course of the day; in terms of spending time in the car, they needed to be as efficient as possible on these days.

The experience of driving the Fit EV was positive for both Ana Maria and Mady. As Ana Maria stated, "it was great!" There were no real issues in terms of range anxiety although both Ana Maria and her daughter did note that they wound up with only 16 miles of range after traveling to Irvine. Both women observed that using the headlights as well as freeway driving had a negative impact on the range. On the return trip to Torrance they made sure to use the Eco Mode rather than the Normal mode to maximize their range.

Design/Use:

The Household 36 s liked the design build of the Honda Fit EV's. For Ana Maria, it was "perfect" because, as a short person she felt as though she was "sitting up high" so that she could easily see over the steering wheel. Mady liked the feel of the car and thought that it was "great." While the hatch-back provided "a lot of room" there was not sufficient room to use the Honda Fit EV for the day-to-day transportation needs for their Assistance Living Centers; the car was not designed to easily load someone who uses a walker or who might need to take their wheel chair with them. On the other hand, there was plenty of cargo room for household shopping and carrying incidentals for their business. Neither Ana Maria nor Mady used the EV's amenities like the radio, GPS or other on-board electronics.

Certainly, in contrast to the Miles Wagon, they noted the fact that it was a "real" car which felt safer to them than their experience of driving an NEV on busy streets.

Rotation #10

Household 37

Participant: Marcya Household 37

Age: 48

City of Residence: Redondo Beach

Date: 7/3/14 to 9/18/14

ICE Vehicles: Chevy HHR,

EV: Nissan Leaf

EV Start Date: 7/21/14

EV – TOTAL VMT: 1,023.3 miles

EV Average VMT per Day: 18.2 miles

Overall:

Marcya Household 37 is a single mother with two sons; a middle-school child who lives with her and an older teen who lives with her part-time. On occasion, her father who lives in Orange County would drive up to watch her son while she worked and to "help out around the house." Marcya lives in a multi-unit apartment building located in Lomita and works as a nurse in a local health clinic in Wilmington – about 8 miles from her home. Marcya came to the study with the idea to "test" an electric vehicle to see if it made sense as a substitute for her Chevy HHR; as a way to "help the environment" and to, potentially, save money.

During her participation in the study, Marcya was the sole driver of a Nissan Leaf. As a single car household this should have meant that 100 percent of her trips were substituted with the EV and that her Chevy HHR was not used, while she drove the Leaf. This was, however, not the case. Her father's visits to assist her were often timed to support her with son's activities. Marcya worked long shifts and would use the EV as her commute vehicle. Her father, rather than drive is truck, would use her Chevy HHR to drive her son to his activities or to assist her with household errands.

Most of Marcya's trips were "pretty local." During work days she would commute to her Wilmington office either returning straight home after work or running a series of errands while on the way home. As Marcya stated, "her life (and her trips) "are pretty simple." She would go to work, run errands, attend church and participate in local South Bay service organization activities. Surprisingly, even though most of her trips were short, she still logged over a thousand miles of local South Bay trips in the Nissan Leaf .

Marcya charged, almost exclusively, at her home using a 110 outlet located in the carport at the rear of her apartment complex. The apartment carport had a limited number of 110 outlets available for use by tenants. Marcya discovered that her assigned spot was not close enough for her to reach an available plug. As a result, she approached her friend and neighbor and asked if she would "mind changing parking places" for the course of the study. Her friend agreed and Marcya was able to park in a spot adjacent to an available plug; she parked her Chevy HHR on the street during her rotation. Marcya noted that the "plug was a common outlet." She decided not to get permission nor were there any questions from her landlord or property manager about her use of the 110 outlet during participation in the study. For Marcya, home-based charging proved sufficient as she realized, after testing a Level 2 charging station for an hour (at a local Porsche dealership), that she did not like to wait around for the car to recharge; as Marcya stated, "my time is valuable," it took too long to charge.

While it took "a little while" for Marcya to get used to driving the Leaf she learned that it could meet her needs for her local trips. However, that being said, she felt that she could not simply substitute or "only have" an EV for her only car; for Marcya to change over to "only have an EV the 80 mile range of the Leaf was a liability. Though her life was mostly centered in the South Bay, she still felt that she needed to have the "flexibility" to simply get in her car so that she could travel farther afield to Orange County to easily visit her family or for regional vacations to places like Palm Springs. To sell her Chevy HHR and purchase an EV the car would have to have a range of about 300 miles (like the car that she owned now).

Household 37 Exterior 110 Plug Against Wall (Neighbor's Parking Spot)

Charging Strategy:

Marcya's charging strategy was, almost exclusively, to use a 110 outlet located in a carport at the back of her apartment complex. If the car was parked at the apartment she would plug it in to either recharge it overnight (after work) or to top up (after running local errands).

Each apartment parking space was assigned however the building's outdoor electrical wiring did not provide for an outlet for each tenant to use (at their assigned parking spot). Marcya, when she began the study, realized that her assigned space did not have a plug and, as such, she needed to find another space where she could have easy access to a plug. To do so, she approached her friend and neighbor with the plan that they would switch parking places for the duration of Marcya's participation; Marcya would then park her Chevy HHR on the street. Her neighbor agreed and Marcya was able to charge each night or whenever she would return home from local errands. Marcya noted that "the plug was a common one" and that her landlord and property manager did not know (or seem to care) that she was using it for charging the Nissan Leaf. As such, she did not have to pay any additional charges for the use of the apartment's electricity.

Over the course of her participation, Marcya did not feel the need to opportunity charge outside her home. The basis for her decision was two-fold. First, she noted that her trips were rather short and that she had sufficient range to drive where ever she needed to each day without having to stop and charge. Second, Marcya tested what it would be like to opportunity charge by locating an available Level 2 charging station at a local Porsche dealership. She pulled in, plugged in and waited for about an hour after which she realized that it would take more time to completely charge – time that she did not have or want to spend charging. As she stated, "my time is valuable and I don't want to wait to have to charge."

110 to 220 Home Upgrade:

Marcya Household 37 did not feel the need to upgrade their home charging from 110 to 220. To do so would have necessitated having to inform their landlord about their use of the garage's common plug – something that she didn't want to do. Additionally, because her trips were short ones, 110 was sufficient for her needs.

Driving Patterns and Experience:

During the course of her participation in the study Marcya Household 37 used the Nissan Leaf as a substitute for all of her trips. This did not mean, however, that her family car was not used. On occasion, her father would commute up from Orange County to assist her with taking care of her young son while she worked; he would use her Chevy HHR while she drove the Leaf to work during the day.

Marcya's driving patterns were very local. On week days she would use the EV to commute about 8 miles to her work place – a local health care facility – in Wilmington. Marcya would either return home directly after each work day or she would run her family errands as a series of stops while on the way home. Marcya prided herself as being "well organized" so that she could be as efficient as possible with her time – chaining or linking her trips was an example of how she structured her trips in this way.

Initially, it took Marcya a "little while" to get used to driving the Leaf. She noticed that when she traveled on the freeway or even used the air conditioning that the range dropped (significantly). Since her trips were so local this wasn't an issue it however, it did give her pause as she noted that she "liked using the AC." For Marcya, on any given day, she never really depleted the battery thus she never felt that she had range anxiety. However, she did change her driving behavior with the Leaf to use the "eco-mode" so as to conserve the EV's range.

Marcya was able to get pretty much everywhere she needed to however she did lament the fact that, because of the Leaf's 80 mile range, she could not drive to visit her sister who lived in Chino Hills about 50 miles away; she was unsure that she could easily get there – given that it was mostly highway driving which would quickly diminish her range – and, once she was there that she would be able to opportunity charge so that she could return home later in the day. Moreover, in terms of making or considering

longer trips throughout the region Marcya was suspect of the charging infra-structure. She was "surprised at the lack of charging stations" stating that she "saw them all the time before" but not that she was driving an EV she didn't see them anymore. On the other hand, Marcya's schedule and daily routine was all South Bay oriented.

Design/Use:

In terms of the Nissan Leaf's design and the use, Marcya as well as her son, Vicenzo, both agreed that they liked the car. It had plenty of cargo space and they liked many of the amenities like the GPS system. One of the surprising qualities to them was just "how quiet" the EV was. In one instance, Vizenzo had to remind his mother that the "car was still on". As Marcya noted, "it was so quiet I had parked it and didn't turn it off."

Household 38

Participant: Dan Household 38

Age: 51, 44, 11, 7

City of Residence: Hermosa Beach

Date: 7/3/14 to 9/16/14

ICE Vehicles: Scion XD, Ford Truck, Electric Scooter

EV: Nissan Leaf

EV Start Date: 7/20/14

EV – TOTAL VMT: 1,120.3 miles

EV Average VMT per Day: 19.3 miles

Overall:

Dan Household 38, his wife Becky and their two children live in a single family home located on one of Hermosa Beach's walking streets. Dan is a retired project manager from Toyota and Becky works as an airline attendant for one of the major airlines flying out of Los Angeles International Airport. Dan currently works as a stay-at-home dad and manages 2 additional rental properties that the family owns. The Household 38 family came to the study as "avid environmentalists." Dan, learned of the both the Local Use Vehicle (LUV) and Battery Electric Vehicle (BEV) studies through is work as a volunteer at the South Bay Environmental Service Center. As a family that would "rather walk" than drive they were excited to test whether or not they might (at some point) replace the family's gas powered Scion with an electric vehicle.

At the time of the study the Household 38 family had 3 vehicles that they drove. Becky's primary vehicle was the Scion XD which she used as her commute vehicle to LAX. Dan chose to drive his electric scooter whenever possible; his Ford Truck was reserved for "hauling stuff" – either for family errands or equipment for sporting events. A Nissan Leaf was introduced to the household and was primarily driven by Becky – becoming her vehicle of choice for commuting to and from her work at LAX. On occasion, Dan would use the Leaf to pick-up and drop-off his children at various activities near their home or to run errands in the South Bay.

The Household 38 family thought of their driving patterns as "hyper-local." That is, "almost all of their trips were within 8 miles of their home." Typically trips by both Dan and Becky involved a series of chained or linked errands to local stores in the South Bay; pick-up and drop-offs of their children for various after school activities as well as longer visits to see Dan's parents who lived in Pasadena; both Dan and Becky tried to be as "efficient" as possible in where they drove and would use a strategy of trip chain or linking their destinations so that they "wouldn't have to go back out again" once they returned

home. Becky would also use the Leaf to replace some of her commute trips to LAX. While the Household 38s used the Leaf to replace trips that they might otherwise have taken using either their Scion or Electric Motorcycle they stilled preferred to walk whenever possible. Because of their home's location – on a walking street in near local stores, the beach and public schools – they would often "just walk" to wherever they needed to go. Unlike many of the family's with school aged children, the Household 38s rarely pick-up or dropped off their children at school; rather their "kids walk to school."

The Nissan Leaf was parked in the Family's two car garage that was accessible from the alleyway behind their home. Initially, they would charge every night using a 110 outlet located on the inside wall of their garage – with power that was generated from an array of solar panels that they had installed to power their home. As the Household 38s became familiar with the range of the Nissan Leaf and their driving patterns their charging strategy changed. They no longer would charge every night. Additionally, on many of their frequent trips to Costco they would use the available Level 2 charging station to top off before returning home. Soon thereafter, they discovered that (across from Costco) there was a DC 3 Fast Charge station located at the local Nissan dealership. Both Becky and Dan took advantage of "filling up fast" so that they could either extend their day's range or not have to "trickle charge" at home for several days, thereafter. Over the course of the study, the Household 38s learned that they could extend their range beyond the South Bay up to Pasadena. To do so they would employ a strategy of leaving their home on a full charge; arrive at their parent's home and top up using an available 110 outlet near their garage; then, on the way home, after depleting their charge, they would stop at the Nissan Dealership to fill up again – thus, arriving home with almost a full charge.

While the Leaf was used in a very practical and efficient way by the Household 38 family they were clear that, it would not be their choice as a car to replace their family Scion. Rather, they learned that they would want an alternative vehicle with a longer range. As Becky stated, it was fine for "running around locally" however she lamented the fact that they would not be able to travel to regional destinations (further afield) like San Onofre or up to the mountains for family camping trips. Dan too felt that "until the range" were extended then they had "almost the right mix of vehicles…except for his truck" for the family's lifestyle – unfortunately, Dan felt that he "still needed his truck for hauling things."

Charging Strategy:

The Household 38s used a multifaceted strategy of home-based 110 charging as well as available opportunity charging options using Level 2 charging as well as DC 3 Fast Charging stations.

Initially, the family would charge every night plugging the Nissan Leaf into a 110 outlet located in the family's two car garage. Uniquely, the "trickle charge" was fueled by the array of solar panels that the Household

Household 38 Parking and Charging Set-up

38s had installed several years earlier.

As the Household 38s came to understand their travel patterns and the range of the Leaf they began to change their charging patterns; they no longer felt that they needed to charge every night and would instead charge "maybe one or two times per week." One of the reasons that they no longer felt the need to charge so frequently was that they discovered that they could charge for free at both Costco and, soon thereafter, at the local Nissan dealership. Respectively, this meant that the Household 38s could "top up" at Costco's Level 2 charging station during one of their frequent family shopping trips; not necessarily getting a 100 percent charge but more than enough for them not to have the plug in at home. The DC 3 Fast Charge also provided for "topping up" however because the waiting time was significantly shorter the Household 38s were able to use it both as a way of extending the Leaf's range as well as to top off. On four occasions the family would travel outside the South Bay to visit Dan's parents in Pasadena. They would leave fully charged from their home, top off in Pasadena using an available 110 outlet at their parent's home, then, on the way home, "fill up" using the Nissan dealership's DC 3 Fast Charge – thus extending their trip and providing for more than enough charge that they would not have to plug in when they arrived home.

Household 38 Solar Panels for Home-based Electricity

110 to 220 Home Upgrade + Upgrading Issues as a Property Owner in the South Bay:

The Household 38s did not see the need to upgrade their home charging from 110 to 220. As Dan noted, their charging strategy – home-based 110 plus Level 2 and DC 3 options – "were working for us." Further, he stated that he, did not "mind sitting at the Nissan dealer for 15 minutes" to charge.

Uniquely, the Household 38s were also owners and property managers of a small apartment building as well as a duplex. As "environmentalists" they would, if their tenant(s) approached them, consider the option of upgrading to provide home-based Level 2 charging for their EV charging needs. However, as Dan noted, he would "split" the costs and place the charging station on "their (tenant) meter". Dan felt that as an owner of rental properties his mindset was different from being a home owner. He noted, that upgrading for a tenant is different as a tenant does not have a "long term commitment" to the property and, potentially, the upgrade might not be used by the next renter – Dan saw it as an amenity that would not necessarily improve either the value of the property or the quality of his tenants.

Driving Patterns and Experience:

The Household 38 family considered their travel to be "hyper-local." That is, most of their trips were either in their beach neighborhood or within 8 miles of their South Bay home. As Dan estimated, 95 percent of their family trips were on bicycle, 4 percent using his electric motorcycle and, about 1 percent using their gas-powered Scion XD. The addition of the Nissan Leaf did not change the nature of their family trips though it did change the choice of vehicles that, respectively, Dan or Becky would chose; the family made a conscious effort to "test" whether they might be able to (eventually) substitute the Leaf for the Scion.

Both Dan and Becky prided themselves as being well organized, environmentally sensitive and efficient in their planning. Their driving patterns reflected this mindset as they would chain a series of errands to local stores with pick-up and drop-offs of their children with other family or household activities. Typically, because their trips were so local, the Household 38s would have more than enough range to run a series of linked trips, return home and use the EV later in the day.

Both Dan and Becky noted that they "really didn't have any range anxiety" because of the local nature of their trips. As they began to experiment with travel outside the South Bay (to Pasadena) they became sensitive to the challenge of diminished range due to steady freeway driving. To mitigate any possible anxiety they would "top off" at their destination and also refill (using a DC 3 Fast Charge) on their way home. In one instance, however, they did experience "some anxiety" because they were not able to "top off" when they arrived in Pasadena. They were still able to return home and stop at the Manhattan Beach Nissan dealer to fill up using the DC 3 Fast Charge though, this time, the Leaf's range was well below their learned comfort level.

For the Household 38 family they liked their experience of driving the Nissan Leaf. Becky felt that is was like "driving a little spaceship." Moreover, she liked the fact that it was "a car" and not a motorcycle – a debate within the family about whether or not Dan should keep his 2 wheeled vehicle (even though it is electric). Both Dan and Becky liked the fact that they "didn't have to stop for gas" and that "sometimes their (regular) cars don't move for 3 days". On the other hand, though Dan saw the Leaf as a "good local vehicle" he was reserved, as he considered that the "market was still changing" and that the "holy grail" for alternative travel was the fuel cell vehicle – something that he would likely wait for or, should they need or want to replace their Scion they would choose a plug in electric like a Volt for their family's needs. Dan lamented that he "would still keep his truck for hauling things" for his apartments…or camping" and other activities.

Design/Use:

In terms of the Nissan Leaf's design and use, the Household 38 family that that it was "functional enough" for their family's local needs. There was sufficient cargo space for shopping at Costco and

carrying equipment for their children's afterschool activities. However, Dan did note that there wasn't enough room to put "another passenger" along with all of their family. Additionally, he would have liked the Leaf to have had a roof rack so that he could transport his "surf boards" or items from "home depot." There were no other issues, positively or negatively, with the Leaf's other "bells and whistles" – as Dan stated, "they worked fine."

Household 39

Participant: Kathleen (Katie) and Luke Household 39

Age: 51, 21

City of Residence: El Segundo

Date: 7/8/14 to 9/18/14

ICE Vehicles: VW Jetta

EV: Honda Fit EV

EV Start Date: 7/19/14

EV – TOTAL VMT: 1,172.3 miles

EV Average VMT per Day: 19.8 miles

Overall:

Katie Household 39 is a single mother whose college aged son, Leo, had returned home and was living with her during the course of the study. Kathleen lives in a rented single family home located in El Segundo with a detached garage and outdoor parking space that is accessible from a rear alley. Katie works for a financial hedge fund company whose office is located in Century City – about 12 miles from her home. Katie came to the study with idea that it would be a great opportunity for her to "test drive" a Battery Electric Vehicle (BEV) to see if "it was a car that might (ultimately) replace her VW Jetta. Fortuitously, for Katie, having another vehicle in the household meant that "it would work out" that her son could have "drive her Jetta

Over the course of the Household 39 rotation they drove the Honda Fit EV. Katie made the decision that she would drive the Fit EV most of the time to see if she could substitute "all of her trips" that she would otherwise have taken using her VW Jetta. Katie drove the Fit EV daily and was able to experience what it was like to "not drive" her regular car; she was able to substitute almost all of her trips – both in terms of her daily commute as well as for personal trips for shopping, entertainment and visiting friends. On occasion, her sun Luke would take the EV to visit friends in El Segundo or to run errands for the family. Katie estimated that they split the use of the Fit EV with Katie using it about 80 percent of the time. While Katie used the EV her son was given permission to use her car as his personal vehicle – for the length of their participation in the study.

Generally speaking, Katie's travel patterns consisted of daily work commutes from her house in El Segundo to her office in Century City – she noted that it was "exactly 12.7 miles" one way. Usually she would travel straight home in the late afternoons though, on occasion, she would stop to run an errand

or go shopping. On weekends Katie would use the Fit EV for personal trips to visit with friends, go shopping or run errands that she did not have to time to do during the week – on most of these occasions she would use a strategy of chaining or linking her trips. Katie thought of her trips as being "mostly local" with a drive to the Palisades as her longest journey.

Uniquely, for the Household 39 household, they did were not able to do any kind of home-based charging. Katie's original plan to charge the Honda Fit EV was to use a 110 outlet located on the inside wall of their detached garage. Upon inspection, after beginning their rotation, she discovered that the outlet was "not grounded and didn't work." The cost to have an electrician fix it was something she did not want to spend and the opportunity to have "a friend repair it" did not work out. Additionally, the distance between a working household 110 outlet and where the Honda Fit EV would be parked was too far away and would not allow for a strategy of using a long extension cord. Without 110 home-based charging Katie had to create an innovative and opportunistic charging plan so that she could use the Honda Fit EV each day.

Katie's charging strategy thus evolved into a routine of work place Level 2 charging as well as "as needed" opportunity charging closer to home. In terms of her work place charging Katie initially would charge every day, however, after several weeks she decided that she was comfortable enough to not "have to charge every day." Her Century City office building had a working bank of charging stations that were regularly available for Katie's use; she suggested that her (very) early arrival time one reason that she had no trouble finding an available place to park and charge. Katie did not feel that the $1/KwH charge (approximately $4.00 to charge up) for using her work place charging station was excessing – especially, since it was so convenient and that she could not charge at home.

Since charging at home was not possible Katie was very pragmatic on weekends and on work days (that when she had not charged at the office) to find opportunity charging to top up the battery on the Fit EV. On several occasions she would take a yoga class in downtown Manhattan Beach and use the free free public charging station to top up; on another occasion she would plug in at her friend's home using a outdoor 110 outlet to charge while visiting; and, lastly, she "shuttle with her son to fully recharge the Fit EV – that is, Katie would have Luke meet her at a local charging Level 2 charging station located at Walgreen's and have him wait with the EV while she returned home using her VW Jetta. Between work place charging and creative opportunity charging near her home Katie was able to "pretty much make it (driving the EV) work."

Katie and Luke's experience of driving the Honda Fit EV was good. As she described her participation in the study, "it was pleasant…and it was fun." Overall it started out as a being "frustrating but got easier as time went by." However, that being said, she did not think that a BEV would be a good fit (for a future car) for her or her family.

Charging Strategy – 100 Percent Opportunity Charging:

Household 39 Exterior Parking Off Alley – With No 110 Outlet

The Household 39 household did not have the capability to charge the Honda Fit EV at home. Initially, Katie thought that she would be able to simply "pull the car into the parking space behind the garage" and that the Fit EV'sportable 110 charge cord would then reach the 110 outlet – located on the inside wall of her garage. After receiving the EV Katie quickly discovered that her strategy would not work – that parking the EV, so as the charge cord could reach the plug, was problematic; and, most importantly, the 110 outlet was not grounded and in disrepair. As a result, the Fit EV could not be charged in this manner. Katie explored the cost to have an electrician fix the plug however the cost was something she did not want to incur; as well, she reached out to have "a friend repair it" however, that too did not work out. Lastly, she and Luke discovered that using an extension cord would also not be feasible as the distance between a working household 110 outlet and where the Honda Fit EV would be parked was too far away and would not allow effective and safe charging. Without 110 home-based charging Katie had to create an innovative and opportunistic charging plan so that she could use the Honda Fit EV each day.

Effectively, for the Honda Fit EV to become Katie's primary vehicle, she had to improvise a routine of opportunity charging options that would allow for her to both commute regularly to her work place in Century City (about 13 miles) and to give her sufficient range so that she could continue with her post-work and weekend activities – including yoga classes, shopping, visiting friends, etc. Katie's initial strategy was to charge every day using her the Level 2 charging station located at her work place. The cost for using the station was $1.00/KwH or about 4 dollars each time; surprisingly, to Katie, when she "forgot to come down and unplug the car" after it was finished charging then she would continue to be charged "just because it was plugged in." On several occasions she wound up paying "11 dollars for 4 hours of charge." Katie suggested that the issue of moving cars "when they are finished charging" might be dealt with by a "valet service" which would allow many more users to charge and not over charge people who can't get back to their EV in time. Moreover, given that she couldn't charge at home she suggested that there by "more charging stations in places like shopping malls…where people spend several hours." Certainly, places that she would have liked to have the chance to have used.

110 to 220 Home Upgrade:

Since there was no impetus to improve and make functional the 110 outlet for basic charging the question of upgrading to provide for a 220 home charging station was moot.

Driving Patterns and Experience:

Katie Household 39 used the Honda Fit EV to replace almost 100% of the trips that they would have otherwise taken using her VW Jetta. Her son Luke would, on occasion, also drive the Fit EV however Katie estimated that she used the Fit EV about 80 percent of the time. Generally speaking, Katie's travel patterns were very consistent and, as she stated, "pretty local." For Katie, local meant both her commute trips – the "12.7 miles to work "as well as her travels around El Segundo and out to the Palisades. Monday through Friday she would leave early to commute to work, charge the EV and return home in the early evening. On occasion, she would stop on the way home to shop or to go to yoga. On weekends Katie's driving routine would often be to chain or link her trips; traveling to visit friends followed by errands and shopping. Since charging at home was not an option Katie and her Luke would often incorporate opportunity charging into their travel patterns. An example of this would be Katie driving to downtown Manhattan Beach to attend a yoga class - while there, she would take the opportunity to charge the Fit EV using the free Level 2 charging station. If time permitted, Katie would "top up" on visits to nearby friends – taking the opportunity to use the Fit EV's portable 110 charger into an available household outlet at her friend's home.

Initially, this pattern of driving and charging was frustrating as it required some consideration and attention to how much range the EV had and answers to where and when to charge the electric car. Over time, however, the Household 39 became more comfortable about the EV's range and, subsequently, Katie began to charging the EV "about every other day." This comfort was short lived, when she experienced a serious case of range anxiety. On one occasion, Katie "forgot to charge the car one night." She arose early the next morning – on a cold foggy day and noted (before starting out) that she "only had 20 miles of range left to get her to work. Katie quickly considered that she could "easily make it to work to recharge" because, as she noted, while the actual trip was 12.7 miles, the "Fit only uses about 6.6 miles of range to get there" – a calculation based on her experience of comparing the actual odometer reading to the on-board computer's estimate of (range) miles left in the battery. She noted that this conservation of the Fit EV's range was "probably was because she took surface streets to work."

Katie started off to work all the while using the car's defogging amenities, lights and heater so that she could safely see. Unbeknownst to Katie her estimated range had precipitously dropped while driving. She looked down to see that "all of a sudden the car's range was at 1 mile and then 0!" She was still several blocks from work and the ability to recharge using her work place Level 2 charging station. Katie "flipped out." As she put it, "It was the most stressful few blocks she's ever driven." She fully expected to be stranded and not make it to her job (one that she had only recently started); as she said, "she could not afford to be late and she didn't have time to sit around and wait for a tow if she was stranded." Thankfully, to her surprise, she discovered that "0" miles left wasn't a "true" reading and that she was able to pull in to her building's parking lot and recharge without being late for work. For Katie, this experience was not pleasant and, to some extent, helped shape her thoughts that a BEV would not work for her life-style; as she said, "thinking about where and when to charge was too stressful."

Design/Use:

In terms of the Honda Fit EV's design and the use, the EV was very practical. The Fit EV was "fun to drive and zippy" with good lines of sight. Luke commented that the rearview camera "was a nice feature." Overall they both gave it a "thumbs up." Critically, Katie was surprised at how much energy "little things" like windshield washers and the defogger used (i.e. depleting the Fit Ev's range). She thought that the on-board system needed to have "better information" to alert users about how much their range was being affected by using different components in the car – certainly, a lesson learned from her experience of range anxiety.

Household 40

Participant: Derek Household 40

Age: 30, 27, 7, 1

City of Residence: Inglewood

Date: 7/7/14 to 9/18/14

ICE Vehicles: Dodge Ram Truck, Chevy Malibu

EV: Honda Fit EV

EV Start Date: 7/17/14

EV – TOTAL VMT: 1,327.5 miles

EV Average VMT per Day: 22.1 miles

Overall:

Derek Household 40, his wife Nicolle, infant son and elementary school-aged daughter in a multi-unit condominium building located in the City of Inglewood; the Household 40 family did not own their condo but rather sublet it through a property management group. Derek became interested in participating in the Battery Electric Vehicle (BEV) study from their knowledge of the program as staff at the Social Justice Learning Center of Inglewood – a non-profit whose mission includes environmental issues for inner city residents. Both Derek and Nichole were very enthusiastic about the opportunity to "test whether they could make the change to being a one car electric vehicle family." Driving the Honda Fit EV gave them the opportunity to for a "real life" test of this idea.

Just prior to beginning their participation the Household 40's Chevy Malibu car needed to be placed in the shop to be "serviced." As a result, the family had begun to drive the "big gas guzzling Dodge Ram Truck." Derek was excited about the opportunity to drive "something smaller…and more affordable" – especially so, given that Nicolle had just given birth to their son. Under these conditions, Derek became the "family driver" and, was happy to drive (almost exclusively) the Honda Fit EV for the duration of the study. Except for a few occasions where Derek was required to haul or pick up large items for his work or community outreach programs – he was able to use the Fit EV to substitute trips he would otherwise have taken in the borrowed truck.

Derek and Nicole both commented that their travel patterns were "very local." In terms of work, "it was a four minute drive" on local Inglewood surface streets; Derek would also use the Fit EV for short, work related trips, like going to City Hall or to pick up materials at a local printer. As a family, most of their other activities – running errands, visits to their doctor's office, pick-ups and drop-offs of their daughter for afterschool programs and going out for entertainment – were all within Inglewood or, perhaps a little bit "further afield" into Santa Monica, Culver City or South Central Los Angeles. Generally

speaking, Derek employed a strategy of "planning" his trips and travel routes to be as efficient as he could with both his time and to maximize the range of the Fit EV. As Nicolle admirably said, Derek "is good at planning the day." Over the course of the study Derek began to develop a "feel" for planning how to both economize on the cost of charging the Fit EV by "not charging every night" and to maximize the EV's range through his driving habits through the use of the EV's "eco-mode".

The Household 40 family charged the Honda Fit EV in their subterranean garage using a 110 outlet that was "not so conveniently" located on their dining room wall of their second story apartment. Initially, Derek had intended to use a convenient and available outlet (one of only a few in the garage) to charge the Honda Fit EV. However, after learning that this would require the Home Owner's Association's approval and that he would have to personally pay for an electrician to "run the electricity from his meter (so that the building would not be have to pay for charging his vehicle) he decided to "take matters into his own hands" by purchasing an "industrial extension cord" that would allow him to use his own outlet through running the extension cord out the window and down to his EV (about 40 feet away). Aside from "testing" a Level 2 charging option in the Santa Monica Mall, the family exclusively charged at home – initially overnight, then as they became comfortable with the Fit EV's range, "about a couple of times per week."

Over the course of the study, the Household 40 family learned that their travel patterns, life-style and mobility needs were "very local." Optimally though, Derek considered that he would like to have an EV with a range "like my Chevy Malibu" or that of "a Tesla" for trips to San Diego, Las Vegas or the Central Valley however, realistically, he thought a BEV would work for his family's local travel needs; Derek's experience confirmed that driving a BEV would allow them (his family) to "go 100 percent electric" in the future.

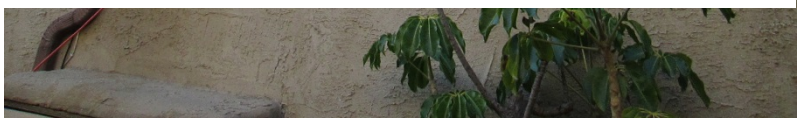
Charging Strategy:

Aside from one instance of "testing" a Level 2 charging station in the parking structure adjacent to the Santa Monica Mall, the Household 40s used a home-based 110 charging strategy for charging their Honda Fit EV. Initially, the Household 40 family charged every night, plugging the EV in after 10 PM to find that the EV was fully charged when the left for work in the morning. After several weeks of driving the Fit EV, Derek learned that "he didn't need to plug it in every night." Rather, he would wait until the Fit EV's range was about ¼ of "a tank" or less. At this point, Derek would be sure to charge the car so that he could easily drive to his destinations the next day. By charging less than every night, the family also saved money on their electric bill thus increasing their net savings through not having to purchase gasoline – something that Derek and Nicolle were enthusiastically trying to do.

Household 40 Apartment Charging Using 110 with Extension Cord

Charging at home, however, was not as simple as merely plugging the Honda Fit EV into an available 110 outlet (in the apartment building's subterranean garage; a strategy that the Derek wanted to do "under the radar" but one that his wife thought differently. Nicolle's suggestion was that, because the 110 outlet was a "common" plug and not on their meter, that they should (as apartment renters) seek out approval by the Home Owner's Association so that they could avoid any issues that might "get them kicked out of the building." With this in mind, Derek first approached his leasing agent and then, subsequently, the Home Owner's Association (H.O.A.) Board. He was advised that, he was not to use the common 110 outlets and that should he want to charge his EV he would have to do so using an outlet attached to his own electricity meter. Derek was further advised that he would have to use an H.O.A. approved contractor to do the rewiring and that the work would have to "first be approved by a full meeting of the H.O.A. Board. Derek explored the costs for this project and estimated that it would be more than $1000 to do the work plus a lengthy period of time to get approval. Under these circumstances, he chose an option to "do it himself." After researching charging cords he bought an industrial grade extension cord that allowed him to safely connect (about 40 feet) the Honda Fit EV's charger to the inside wall of his dining room – located above the garage on the second floor of the building; a solution that was cost effective (approximately $40 for the extension cord) and relatively easy to use. In the interim, after Derek had made his request, the H.O.A. Board had all of the outside 110 outlets either sealed or locked so that tenants could not access them.

Household 40 110 Charging Using Extension Cord from Second Floor Dining Room Outlet



110 to 220 Home Upgrade:

The length of the study, prohibitive costs for electrical work as well as the prohibitive H.O.A. approval process were all issues that Derek took into account when considering the reasons why he did not choose to upgrade from 110 to a 220 home charging station. Moreover, Derek realized that his driving was "very local" and that 110 charging was "working just fine."

Driving Patterns and Experience:

Just before starting their participation in the BEV study Nicolle gave birth and, subsequently, took maternity leave. As a result she did not drive during the family's rotation meaning that Derek was the

sole driver. Derek's suspected that most of his driving would be "very local" and that by using the Honda Fit EV the family would be able to substitute most of the trips that they would have otherwise taken – for work or personal – using the Dodge Ram truck. Their goal was to be a one-car "all electric" household. Aside from the few trips that Derek took using the truck – carry large items or material for his office or for community outreach events – they were able to do so.

Derek and Nicolle considered local travel to be just that "local…mostly in Inglewood" An example of what local meant, in terms of work, was Derek's "4 ½ minute commute" or other work related trips (like going to pick up materials at a nearby printer). The same could be said, as well, for the family's personal trips – where a long trip would be to the Santa Monica Pier and 3rd Street Mall in Santa Monica or to Culver City to have dinner.

Derek prided himself in terms of organizing and planning his trips so that they were linked or chained together. For Derek, pre-planning his daily trips, was an opportunity to maximize the EV's range while trying to be as efficient as he could with his time. Often he would have a series of trips to run errands, go shopping or attend to pick-up or drop-offs of his older daughter. Derek would then return home and, possibly, go out once again to run another series of errands later in the day. As Nicole said, "he's good at planning the day."

The ability to strategize and plan his travels and charging patterns – along with the fact that most, if not all, of his trips were local – mitigated any range anxiety that Derek might otherwise have felt and made him feel good about his experience driving an electric vehicle. After about one week Derek stated that "he felt comfortable with the Fit EV's range and he began to experiment with the frequency of how often to charge the EV. His rule of thumb was to treat the Honda Fit EV as "an electronic device (like his cell phone) knowing that he would "run it down" then have to recharge it at some point. His feeling was that he could economize on his electricity costs by figuring out how far he could drive so that he could plug in less than every night and go where he needed to go each day. As Derek whimsically noted, the Fit EV became like a "giant electric toy" that he was figuring out. Once figured out, Derek was able to charge less frequently (about 1-3 times per week) and, as a result accrue more net savings "by almost not having to go to the gas station at all" during the project – Derek estimated that he saved about $200 per month on gas that he might have had to purchase for his "gas guzzling" truck. Additionally, Derek also learned how to maximize the Honda Fit EV's range through conserving the EV's battery via the EV's regenerative break system. Again, for Derek this became a game-like as he "played with" trying to add more power to the battery by using his breaks in stop and go traffic. Moreover, he also switched to an all "eco" driving mode which helped to maximize the Fit EV's range. For the most part, this strategy was, almost always successful. However, on a couple of occasions Derek lamented the fact that by the time he got home he did not have "enough range to go back out again." While Derek regretted these moments they did not deter him from a positive experience driving the Honda Fit Ev.

Design/Use:

In terms of the Honda Fit EV's design and the use, the Household 40 family felt that it was good but "not perfect." As Derek noted, for his growing family, "it's a small car and we made it work." Import to the

Household 40 family was the back seat and cargo space capacity of the Honda Fit Ev – which proved to be enough room for them to place car seats for their children and a baby carriage in the back for their infant son. They liked the other amenities and Derek found the "music and other stuff" was good. One feature that Derek found interesting and fun was the Honda Eco feedback feature that showed (using the on-board computer) a visual indicator of "how green" his driving was by the number of green leaves that would appear. Derek noted that he was "shooting for 4 leaves but had only gotten 3 ½ so far

Rotation #11

Household 41

Participant: Jayme Household 41

Age: 24

City of Residence: Redondo Beach

Date: 9/5/14 to 11/5/14

ICE Vehicles: Toyota Corolla LE, Toyota Rav 4

EV: Nissan Leaf

EV Start Date: 9/19/14

EV – TOTAL VMT: 375.9 miles

EV Average VMT per Day: 15.0 miles

Overall:

Jayme Household 41 is a single student in her mid-twenties who is doing advanced studies in kinesiology and massage therapy in Irvine. She lives with her mother on the north east side of Manhattan Beach in a single family home with a detached garage which is accessible from an alley behind their home. Jayme commutes 3-4 times per week to school and works part-time in her father's accounting firm in West Los Angeles. Jayme came to the study with great enthusiasm for the opportunity to "see what electric cars were all about." As Jayme noted, by the time of her graduation she will "be in the market for a new car" and her hopes for participating in the study was that she would learn if an EV would fit her life-style and needs. Her experience of driving the Nissan Leaf gave her this opportunity.

Jayme's life could be described as very busy. Mostly, it was structured around her experience of being a full-time student while working part-time in her father's office. For entertainment she would travel to her boyfriend's home and venture out to local malls to enjoy meals or, when she had time, movies. Weekdays were spent commuting about 40 miles to and from her school in Irvine. On some days she would return home or go directly to her father's office in West Los Angeles to work part-time as his administrative assistant. Because of her schedule and the fact that some of the household errands were being taken care of by her mother, Jayme's trips were not really chained but rather a series of travel legs with stops – usually for several hours.

The Household 41 household consisted of Jayme and her mother (her father lived elsewhere). Jayme was, for all intents and purposes, the sole driver of the Nissan Leaf with both her mother and father

"test driving" the EV only once on short local trips. For Jayme she had "mixed feelings" about her experience as an EV driver. There was, as she described it, "some frustration and a learning curve" for driving the Leaf. It took her several weeks to get comfortable with the Leaf's range, planning her trips and how the Leaf "actually worked." On several levels having a "new car" with different technology was intimidating and required more organization and time than she might otherwise have had.

The first basic challenge for Jayme and her mother was where they would charge the Leaf at home. The family garage had become a storage unit for the family – a repository of extra furniture, boxes of personal items and household fixtures that were used infrequently. There was no room to park the Leaf inside the garage. It took Jayme some time to reorganize the garage so that she could find enough room to charge the EV using an available 110 outlet in the garage. Moreover, because she was not familiar nor was she comfortable with the Leaf's technology and range she was very "conservative" about where and how far she would travel. Her initial desire was to "use the car to commute to and from school" however because she was not sure of (or had confidence in) the Leaf's range she choose not to use it in that fashion. Rather, many of her early trips were "very local" and on her longer commutes she would "scout" to see where and how she might be able to charge (if necessary).

Eventually, over many weeks, Jayme became more comfortable with the Leaf and was able to substitute more trips that she would otherwise have made using her Toyota Corolla. Jayme would use a strategy of plugging in at home whenever she felt it necessary – about 2-3 times a week. Using smart phone apps to identify both Level 2 and DC Fast Charging stations Jayme's confidence grew and, as such, she began to travel further afield. In terms of gaining confidence and using the EV for more of her trips, Jayme identified "time" as the key factor. This meant that, because of her busy schedule and her (new found) understanding of the electric vehicle technology (i.e. charging) that she would need to find destinations where she would have the time to "stop and charge". Going to the movies and plugging into a public Level 2 charging station was an example of this behavior. On the other hand, as a "poor student" Jayme was sensitive to the cost of electric charging noting that "paying $8.00 to charge using a DC Fast Charge Station at the Irvine Nissan dealership was not very economical given that her "Corolla got 34 miles per gallon and that the cost of gas was only $3.50 per gallon" – her travel to school would then cost almost the same but she would need to spend ½ or more waiting to charge.

While there was a "learning curve" for Jayme she did feel that the experience was a "positive one" and, that she had a much better understanding about how the technology worked and how it might possibly work for her in the future.

Household 41 Using Ceiling Mounted Garage Door Opener for Nissan Leaf Charging Set-i[p

Charging Strategy:

Jayme used a strategy of both home-based 110 charging as well as opportunity charging using both Level 2 charging stations and DC 3 Fast Charging. In terms of her home-based charging, Jayme charged the Nissan Leaf in her family's detached garage – accessible from an alley behind their home. The garage did not have readily accessible 110 outlets so Jayme had to creatively plug the Leaf's charging cord into the overhead outlet used for the garage door – additionally, because the garage was full of household items she would have to leave the garage door open so that the Leaf could be oriented for charging. This required Jayme or he mother to always be around or near the EV while it was charging (for fear that items might get stolen from their open garage). At times Jayme would fact this challenge by using the time to "sit in the Leaf to do her homework."

Over time Jayme became more comfortable with her understanding of the Leaf's range and the different methods to charge the EV. She downloaded and signed up for several EV charging apps which she used to access public charging on trips where she would have "enough time to charge the Leaf." In one instance, she went to the movies with her boyfriend at the galleria mall. Planning ahead, she identified that there were Level 2 charging stations that she could use to "recharge while she was at the movies." The experience "worked very well" and the cost of $1.00 per KwH to use the service was not an issue. Jayme also discovered that the DC 3 Fast Charging stations found at Nissan dealerships was a "great way to quickly recharge, as Jayme said, "it spoiled me" in terms of how fast it took to charge. Over Jayme's participation in the study Nissan changed their policy from one of making their DC 3 Fast Charging stations available for free to one of using a tap card that was fee based. As Jayme learned, the cost to use this service was $8.00 per charge. For Jayme, this was a nominal price though it did cause her to consider that it was "almost a breakeven" strategy for longer trips – given the cost of gasoline and the miles per gallon that her Toyota Corolla now gets; the only difference would be the time she would have to spend waiting for the Leaf to recharge.

110 to 220 Home Upgrade:

Given the length of the study as well as the additional costs involved Jayme and her mother did not see the advantage of upgrading from 110 to 220. Jayme did speculate however that, were she to purchase an electric car in the future, having 220 at home "might be a good idea."

Driving Patterns and Experience:

Jayme Household 41's experience of driving the Nissan Leaf was a "mixed one." Initially, she was frustrated and perhaps "intimidated" by the technology. That is, before she could feel comfortable to use the Leaf to replace the trips she would have taken in her Corolla she needed to learn and understand the EV's range and the challenges of charging the Leaf outside her home. It took it several weeks to begin to feel that she could drive the Leaf further afield.

For Jayme, one of the reasons that she wanted to participate in the study was to see if she could commute to school (in Irvine) using an electric car. She thought that, if so, she would be able to save on gas. In planning to do this she inquired if her school had charging stations and was told that they were in development and would soon be available. This excited her and seemed to be well timed. Jayme had begun to get more confident and, as a result, her trips using the Leaf were further afield. When the school's charging stations did open Jayme was excited about the possibility of commuting to school. There were two charging stations that might be available for her to recharge while she was attending class. Planning ahead, she scouted the availability of the new charging stations; observing whether or not they were taken when she would arrive on campus mid-morning after her commute from Manhattan Beach. To Jayme's disappointment, the charging stations were always in use and, as such, she felt that she could not drive the Leaf to school and expect to plug in using the school's charging stations. The lack of charging stations did deter her from using the Leaf for her daily commutes to school however it did not stop her from experimenting to see what other options might be available to her for a longer trip where she would (necessarily) have to charge in order to return home. To test this experience, she identified a Nissan dealership in Irvine and was able to drive to school followed by a ½ hour charging stop, fill up using the dealership's DC 3 Fast Charging station. The cost to do so was $8.00 rather than having an opportunity to charge up for free using the school's Level 2 charging station. Jayme felt that the price "seemed reasonable" if "you used it only once in a while."

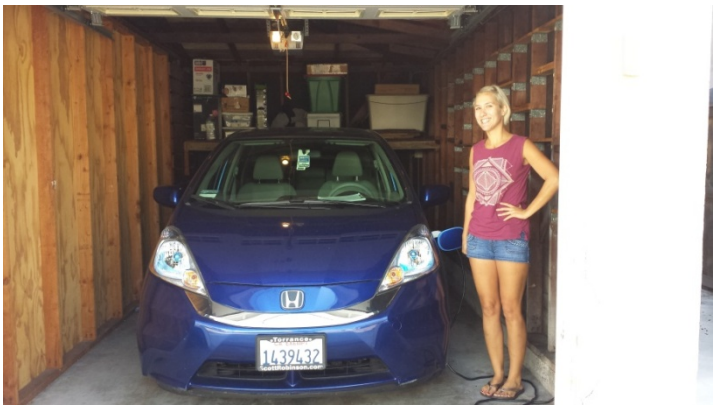
Interestingly, Jayme never "really felt range anxiety" during her time driving the Nissan Leaf. As she said, "her goal was to never get below 30 miles of range" left on the Leaf. She would plan her trips accordingly, making sure that there were opportunities too charge along the way. Additionally, she became proficient in using the regenerative breaking of the EV to "put energy back into the car." For Jayme, her "anxiety was all about time." She speculated that, because of her busy schedule, she would become anxious thinking about "how much time it would take to charge the car." As her understanding of charging became better (based on her experience) she became less anxious.

Overall, Jayme discovered that the Nissan Leaf can make "a huge difference for local driving." She thought it would make a "good car for working within 20 miles of home" or for "mom's running kids to school" or activities.

Design/Use:

In terms of the Nissan Leaf's design and the use, Jayme thought that the Leaf was comfortable and that she liked the Leaf's "cool features." For her, the trunk space was good, "sort of the same as a minivan." Critically, however, she noted that she did not like the "car's blind spots" and that she would have preferred to have some sort of training or better interface so that she could understand "and figure out the (car's) interactive gauges" – she wondered if the computer reading was right questioning if, 50 miles (of range) might not be 50 miles."

Household 42



Participant: Karen Household 42

Age: 29

City of Residence: Hermosa Beach

Date: 9/4/14 to 11/6/14

ICE Vehicles: Ford Ranger, Toyota Camry

EV: Honda Fit EV

EV Start Date: 9/18/14

EV – TOTAL VMT: 921.9 miles

EV Average VMT per Day: 20.0 miles

Overall:

Karen Household 42 is a single self-employed woman who lives in multi-unit apartment located in Hermosa Beach. Karen shares her apartment with a roommate – though, because of their schedules, they are not often home together. Their apartment is located very close to the beach, and as such their one car garage – located off an alley at the rear of their terraced building is an important asset for weekend or holiday parking; either as a place to be park off the street for one of them or so that they can leverage an additional parking space for friends who want to visit and go to the beach. As roommates they would share the use of the garage so that each would use it every other week or, as in the case of this study, they would both park on the street so that the Honda Fit EV could be parked and charged within their garage.

Karen had several jobs. She worked as an Administrative Assistant for two different individuals who lived within a few miles of her home. As such, she was able to do some of her tasks using her home as a base or, if the task was required, she would travel to their respective homes to assist them. Besides office work she would also have to "run errands or pick up and drop off" her clients' kids (very much as a nanny's job might be). Often Karen would have to use one of her client's vehicles to do these tasks. Additionally, Karen would commute to the Hawthorne airport where she would work part-time in the evenings as a hostess at the airport's restaurant. Karen came to the study with the hope that she would be able to see "if she an electric car could replace her truck." – she was excited about the idea that she might be able to test drive an EV to see if this was a real option for her.

Over the course of the study Karen drove the Honda Fit EV. As she noted, her "travel (as an Administrative or Personal Assistant) was "very local." When wearing this work-hat, she would organize her day around "trying to be as efficient as possible" while running the requisite errands or pick-up and drop-offs of her client's children. To do so, she would chain or link her trips together. Her pattern often looked like short trips to her clients' homes, then depending on the tasks at hand, she would run a series

of chained or linked errands, or perhaps she would travel home then out again – later in the day – to run her errands (i.e. go shopping, pick-ups and drop-offs, etc.). Often Karen would have to make choices as to which vehicle she would take. While she would have preferred to use the Honda Fit EV for 100 percent of her trips she would, in some instances, choose another vehicle; a decision based on her client's wishes or the logistics of the specific trip (i.e. carrying a large cargo or children needing child seats). Karen's other frequent trip would be her commute to the restaurant located at the Hawthorne airport. On occasion she would use the Honda Fit EV to travel "down to Huntington Beach" to visit with her boyfriend - a longer trip that necessitated charging the Fit EV so that she could return home the next day.

In terms of charging Karen used both home-based 110 charging as well as free Level 2 charging stations. Initially Karen thought that, when she would have to charge everyday however, her experience of mostly local driving led to the realization that she could plug in "about every other day." For home-based charging, she would plug in at the end of the day using an available 110 outlet located just inside her one-car garage. While this was sufficient, Karen experimented with using local (near her home) free Level 2 charging options. On several occasions she would pull into the City Hall Parking of Hermosa Beach to use their Level 2 charging station; or, more frequently, she discovered a free Level 2 charging station just outside Becker's Surf Shop – not too far from her home. In both cases she would run errands or get something to eat while the Fit EV charged for a couple of hours. When travelling further afield to Huntington Beach, Karen would take advantage of the fact that she would be staying overnight and, subsequently, use an available 110 outlet in her boyfriend's garage to charge the Fit EV back up for her trip home the next day. Disappointingly, Karen would have liked to have charged at the Hawthorne Airport – as they airport only provided a Tesla charging station.

Over the course of the study, Karen discovered that she "really liked" driving the Honda Fit EV. She suggested that she might (in the future) be able to "give up her truck for an EV." Though she recognized that she would need to be creative about using other mobility options – like renting a truck for hauling items or to go camping off road. Certainly, with the "since gas cost is high" the option of driving an electric car was more appealing to her than ever.

Charging Strategy:

During her participation in the study Karen Household 42 used both 110 home-based charging as well as Level 2 charging. Karen was pragmatic in terms of not feeling like she did not have to charge every day. Rather, she would watch the car's range and, when it got below 50 percent

Household 42 Apartment Single Garage Charging Set-up for Honda Fit EV

(range) remaining, she would look for a place to charge. At first watching the range diminish would "freak her out" however she quickly became comfortable with using both home and local Level 2 charging to refill or top up the Fit EV's battery.

At home she would plug in "about every other day." Her charging routine, on the days that she did charge at home, was to plug in overnight using a 110 outlet that was located on the inside wall of her one-car garage. Karen suspected that "she did not have to pay for the cost of charging at home" because the plug was not on her meter.

A couple of weeks after beginning the study Karen began to experiment with finding opportunity charging outside her home. Using the EV charging station app on her smart phone she discovered that she could use the Level 2 charging station at Hermosa Beach City Hall – their 2 hour limit of free charging would allow her to top up; similarly, she would also frequent the Level 2 charging station located on the street outside Becker's Surf Shop near the Redondo Beach Pier. In both instances, the relatively fast charging (versus her home's 110 outlet) and the fact that it was free were incentives for Karen to use these services. On the occasion when she traveled to Huntington Beach she brought the Fit EV's portable charging unit so that she could plug into his home's 110 outlet; thinking that this would be "no problem" Karen discovered that the cord would not reach from the EV to the outlet – an anxious moment (since it was only 25 miles from home but because it was freeway driving "it took a lot of miles" in range to get home) that was resolved by using an extension cord to bridge the distance.

110 to 220 Home Upgrade:

Karen lived in a rental apartment and, as such, she would have to notify her landlord for permission – something she did not want to do. Moreover, because most of her trips were "very local" her strategy of combining home-based 110 and local Level 2 charging was sufficient for her needs.

Driving Patterns and Experience:

Karen Household 42 used the Honda Fit EV to replace trips that she would otherwise have taken using her Nissan Truck. Her goal was to try and use the Fit EV for 100 percent of her trips – a goal that she aspired to but could not do because of her work as a Personal Assistant. At times she would have to use her client's gas powered vehicles to accomplish the specific tasks at hand. Whenever possible though, Karen would enthusiastically choose to use the EV for her trips. For Karen her daily travel pattern would involve travelling to her clients' homes where she would pick up her assignments for the day – either working there; travelling home to work on projects using her home office; or, running errands – including shopping, pick-up and drop-offs of her client's children and other domestic or business related errands. As Karen observed, most of her travel for work was "very local" and she would organize her day around the tasks so that she could efficiently travel from one location to another to save time and

energy. Beyond the local nature of running errands for work she would travel further afield. In the evenings Karen would commute to the Hawthorne Airport travelling via surface and freeways.

Karen's "learning curve" for using the Honda Fit EV was very fast. In just 2-3 days she felt "comfortable" in her understanding of how the EV drove, the range it had and her options for charging. Part of her feeling of ease was based on the fact that she had survived a scare of range anxiety when on a very hot day she had used the Fit's air conditioning and watched as the range dropped precipitously – she arrived home to charge and observed that "even on the hottest day with the AC on" she could (readily) get home from almost anywhere she travelled to charge back up again. Her comfort was a significant part of her positive experience in testing the Fit EV.

Design/Use:

In terms of the Honda Fit EV's design and the use, the Karen was quick to note that, ergonomically, it was not like her truck – sitting lower (in the Fit EV) was much different than sitting "up high" in her truck It was a feeling that she never really got used to. Though, she did like the fact that "it was much easier to park than the truck" – something she was very much appreciative given the amount of street parking that she needed to do while running errands for her jobs. Karen also liked the Fit EV's performance as well as some of the EV's design features like the cup holders. Unfortunately, she was disappointed that there were challenges with the Blue Tooth system which she would have like to have used. On the whole, however, she "really liked" the Fit EV.

Household 43

Participant: Dina Household 43

Age: 55

City of Residence: Manhattan Beach

Date: 9/5/14 to 11/5/14

ICE Vehicles: Toyota Yaris

EV: Nissan Leaf

EV Start Date: 9/20/14

EV – TOTAL VMT: 1,155.2 miles

EV Average VMT per Day: 25.1 miles

Overall:

Dina Household 43 is a single middle-aged woman who lives in multi-unit condominium located in Manhattan Beach. Commuting to Hamilton High (near Culver City) Dina works as a high school teacher in the Los Angeles Unified School district. She was an enthusiastic study partner and came to the program looking to learn about electric cars so that she could "share what she learned" with her advance placement environmental studies students – "she wanted to walk the walk". To make additional income, Dina had a part-time "after school" job teaching science to younger kids at a school in the Pico/Robertson area. Uniquely, Dina's goal was to "not drive" her Toyota Yaris "at all" for the duration of the study but rather "see what it was like" to "go electric 100 percent" by only driving the Nissan Leaf - Dina did just that. She parked her Yaris and only moved it so that she would not get a ticket on street cleaning days.

Dina's daily travel patterns were pretty consistent and varied only in so far that she changed her route "so that she wouldn't get bored" or, "so that she could experiment with understanding the Leaf's range when under different conditions – i.e. she would take surface streets winding her way around Los Angeles International Airport on one day and on the next trip she might travel, more directly via the freeway. Her trips could be characterized as commuting to work and home. On days where she worked her second job she would go straight from school to her work nearby work location returning home at the end of the day. Dina would, on some days, stop on the way home to run errands, exercise or go shopping – very structured and organized series of trip destinations. On weekends, Dina would plan activities in a similar fashion; leaving her home to "take care of all the things she needed to get done but couldn't" during the week. In short, Dina learned that an electric vehicle could be a "100 percent solution" for her commute around town – though "she would keep her Yaris" for longer trips. During the course of her participation in the study, Dina felt as though she could "pretty much" go anywhere she needed although she did feel that the Honda Fit EV could not get her to golfing outings in Orange County – an activity that, when weather and schedule permitted she liked to participate in.

As far as charging the Honda Fit EV was concerned, Dina established a routine of plugging in each night after her return from work. Except for a few occasions she would charge overnight and have a "full charge" available to her for her morning commute. On the occasions she forgot to charge she was still able to use the EV for all of her trips – albeit, on one occasion she wound up arriving home with only 6 miles of range left". Home-based charging made sense for Dina because, as she said, "I don't go to malls" or other places where she might find a Level 2 charger and, at this time, her school did not offer work place charging. On one occasion, Dina tried to experiment what it would be like to charging using the DC 3 Fast Charging station located at the nearby Nissan dealership. Thinking that it was "free" she was surprised to learn that Nissan had changed their policy and required DC 3 Fast Charge users to pay using a tap card. Not having the proper tap cad, Dina was disappointed that she could not use this system.

Overall, Dina learned that the experience of replacing her Yaris was a positive one and could readily do so for approximately 95 to 97 percent of all her trips – especially those that occurred Monday through Friday during the work week. For Dina, the challenge to 100 percent EV driving would be the occasional weekend trips to regional destinations like San Diego or for her gold outings in Orange County – trips that she did not feel confident (or that she had the time to use) an electric car.

Charging Strategy:

Dina Household 43 charged her Nissan Leaf using an exclusive 110 home-based 110 charging strategy. Each night, upon returning from work she would pull the Nissan Leaf into her condominium's subterranean garage and plug in using an outlet located on the side wall of her garage. Aside from a couple of days where she "forgot" to plug in, Dina was consistent. She thought that having a "routine" was a good strategy to make sure she had enough charge to get to school each day and take care of any additional stops or places that she might need to go on the way home from work

Household 43 Townhouse Charging Set-up for Nissan Leaf

Though Dina would like to have had the option for work place charging not having the ability to plug in on campus proved inconsequential to her experience nor did it affect her travel choices or patterns. Similarly, on one occasion she tried and was unable to use the DC 3 Fast Charging station at the local Nissan dealership – though disappointed that she could not "test" this service it did not affect her travels that day nor did it preclude her from any activities that she might otherwise have driven the Fit EV.

110 to 220 Home Upgrade:

For Dina, 110 home-based charging was sufficient for her charging needs during the study. Moreover, she felt that – even if she owned an EV – she would not invest in upgrading her home until she had "finally paid it off" – something that, within the next few years, she was anticipating.

Driving Patterns and Experience:

Dina Household 43's driving patterns were very consistent. Basically, on weekdays she would commute from her home in Manhattan Beach approximately 12 miles to Hamilton High School off the 10 freeway near Culver City. Dina tried to incorporate different routes to "break up her routine" and would sometimes take the highway and other times vary her route by taking surface streets. On days where Dina worked her "second job" she would live the High School and continue on to a neighborhood location where she would teach an afternoon science class to younger children. On most nights following work Dina would return straight home however, where there was occasion to run errands she would organize her travel to go from location to location – chaining her trips – to economize her time. On weekends, she would use the Fit EV to run – in a similar chaining fashion – "all the errands that she did not have to time to accomplish during her work week.

Generally speaking her strategy of charging home-based charging along with trip chaining proved very successful for Dina – giving her a sense of confidence and ease about where she could drive the Fit EV – mitigating any experience of "range anxiety." On one occasion, however, she "forgot to charge the night before" and realized that when she left for school she only had about 31 miles of range. Normally, this would have been sufficient for her to commute home however, on this day, she had extra trips that found her in Marina Del Rey with "less than 11 miles of range left." As she said, "she was a little anxious" so she turned off "the extra juice" and ultimately returned home with a reading of 6 miles of range. This experience did not diminish or change or behavior but rather made her aware of two things. First, that surface street driving can extend or conserve the battery's range. Secondly, she began to wonder if the on-board computer's estimated range was "true."

Overall, Dina learned that by driving an electric vehicle she could fully substitute all of her work day commute trips – about 95 to 97 percent of all the trips she might take. The balance of her trips – to places like Orange County to play golf or to San Diego to visit friends she would need a gas vehicle like her Yaris. Dina was intrigue though that, at some point, she might find an EV lease program like the one offered by Fiat where the customer is offered a free rental car to meet his/her occasional long distance trips.

Design/Use:

In terms of the Honda Fit EV's design and the use, the Dina found the Nissan Leaf to be "too big." In comparison to her Yaris she was more comfortable in her compact car. Though design features like the arm rest were appreciated - as was the quiet nature of the car - she thought that the "huge blind spot" was a problem. As for performance, she didn't seem to notice any difference between her Yaris and the Leaf however, that being said she was quick to point out that driving an "EV was better than driving a car with gasoline." As Dina noted, "it's the future."

Household 44

Participant: Tamah and Greg Household 44

Age: 52, 51

City of Residence: Manhattan Beach

Date: 9/4/14 to 11/6/14

ICE Vehicles: Toyota Yaris, Toyota Corolla, Acura

EV: Honda Fit EV

EV Start Date: 9/18/14

EV – TOTAL VMT: 376.6 miles

EV Average VMT per Day: 8.1 miles

Overall:

Tamah and Greg Household 44 live in a duplex located on the north east side of Manhattan Beach; there are two grown children who are either in college or who live elsewhere but visit from time to time. Both Greg and Tamah work locally in Manhattan Beach. Respectively, Tamah is the Executive Director of a local synagogue while her husband was an engineer at Northrup Grumman - a nearby aerospace company. Tamah was very enthusiastic about participating in the study after witnessing her friend and neighbor who "had a great experience" as a participant in both the Local Use Vehicle (LUV) and Battery Electric Vehicle (BEV) studies. Tamah liked the idea that she could "test out" whether or not an electric car might work for her – perhaps to, at some point, replace her aging Toyota Yaris.

The Household 44 family home was the back half of a large duplex. A long one-car wide driveway led to a two car garage attached to their home. With 3 family cars and a garage that was rather full of household items, parking and charging their Honda Fit EV was, on occasion problematic. Often they would have to move or shuffle one or more of their family cars to allow the EV access close (enough) to the garage or to park inside it. What they discovered, was even when they pulled "up close" or pulled inside the garage they did not have an available 110 outlet that would reach the Fit EV. To resolve this issue Greg strung an industrial extension cord through the garage and out the door to reach the Fit EV's portable charging cord. At first the family would charge each evening however, after realizing that they "didn't go very far" their pattern changed to one of charging "as needed" – a couple of times a week. On one occasion they used a Level 2 charging station as part of "test" to see if the Honda Fit EV would allow them the opportunity of visiting with their son – who was living and going to school in Claremont; using a smart phone app they were successfully able to locate a public 220 charging station and, while they were having dinner, the car was being charged for their trip home; it was a successful experiment, albeit one that necessitated, "having an extra drink" because the car wasn't fully charged when they had expected to leave. As Tamah said, "it wasn't so bad to have to wait a little longer with a drink."

Over the course of the study Tamah estimated that she drove the Honda Fit EV "about 95 percent of the time." The EV replaced all the trips that she would otherwise have taken using her "old Toyota Yaris." Greg, on the other hand, seldom drove the EV. On rare occasions he would use it to either go to work or run an errand. One of the things that Tamah suspected and later confirmed (as a result of her participation in the study) was that her travel patterns and that of her household were "very local." AS she stated, "surprisingly, we didn't drive far."

On weekdays she would commute to her office at the Synagogue which was "only a few miles away." Subsequently, she found that she would run multiple errands or have business trips in and around the Manhattan Beach area – all of her trips either being strung together or back and forth from her office. Often, her work travel pattern would consist of "5 or 6" of these trips; logging them as part of the research made her think that "maybe she should get a travel allowance" for all the trips she takes using her regular car. Greg, in a similar sense, would commute to the Northrup Grumman campus that was "just around the corner." He too, would work out of his office but find himself taking multiple small trips to other areas or buildings on the campus for work related projects – sometimes upwards of 10 such trips a day. Only on one occasion did the family venture out of the South Bay to visit their son in Claremont about 50 miles away. As part of their family's religious observance, they choose not to drive any of their vehicles on the Sabbath (from Friday evening through Saturday evening) or on religious holidays; rather, they would walk to wherever they needed to go.

For Tamah, her experience of driving the Honda Fit EV was enlightening. She "liked it a lot" and, importantly for her, she learned that "it (an EV) could fit into their lifestyle." On the other hand, when Greg and Tamah considered what a new car might mean for their family they less enthusiastic, noting that "we only buy used cars" and that they could not see purchasing or leasing an EV until the price was closer to "7 thousand dollars" or closer to that of Tamah's Yaris.

Charging Strategy:

In terms of home-based charging, The Household 44 family charged the Honda Fit EV using an available 110 outlet that was located just inside their home in the washing/dryer area of their home – adjacent to their two car garage. Since the Honda Fit EV could not be oriented or get close enough to the 110 plug they had to improvise a strategy to bridge the gap. As an engineer, Greg took matter into his hands to run an industrial extension cord from the

Household 44 Charging Set-up Using Extension Cord from Family Dryer

usable outlet through their garage so that the EV's 110 portable charger could be powered. Though not an "elegant" solution, the improvised charging system worked "just fine" for their needs. Over the course of the study, the family would exclusively charge the EV using this system. Knowing that they did not travel far or using much range they quickly learned that they did not have to charge every night. Instead, they would charge "as needed" which, for the Household 44 family was about 2 or 3 times per week. On the occasion that they "tested the car's range" they used a public Level 2 charging station located at their destination in Claremont. They were able to identify the station and pay for the charge using the Charge point app that they had downloaded prior to their trip. The cost for recharging was $1.25 per KwH or about $6.00 for fill up 100 percent for their trip home; as Greg noted it was cheaper than the $10.00 he estimated it might have cost if they had to pay for gas.

110 to 220 Home Upgrade:

For the Household 44 family they recognized that "for the work and lifestyle" that did not have to upgrade to 220; rather, "110 was just fine."

Driving Patterns and Experience:

The Household 44 family split their use of the Honda Fit EV with Tamah driving the EV about 95 percent of the time and her husband, Greg, using it about 5 percent of the time. For Tamah as well as Greg they came to characterize their travel patterns as being "very local." To Tamah's surprise she noticed that "we don't drive far." In her case, what this meant was that from Monday through Friday she would commute a few short miles on surfact streets to a local Manhattan Beach Synagogue where she worked as an Executive Director. As part of her job she would make short business trips during the day to other locations in the South Bay, often returning to her office before going back out for another errand or meeting. The same can be said for Greg who (when he did drive the Fit EV) would make multiple work related trips during the day to different buildings or places on the Northrup Grumman campus. As far as trip patterns for their person life, Tamah would, on occasion try and chain her trips however the proximity of shopping, yoga, and other destinations often gave her the opportunity to return home before going back out again.

Both Greg and Tamah felt at ease and comfortable with the Fit EV's range and, as such, they did not suffer or experience "range anxiety." Part of this feeling of range confidence can be attributed to their basic understanding that their trips were never far away from home – and the opportunity to charge at any time. Another aspect, though, that added confidence to their experience and lack of anxiety over the range was that they were able to "push the range" of the EV by taking a trip out to visit their son in Claremont – about 50 miles away via freeway driving; they did this rather early in their rotation. In preparation for this "adventure" Greg purchased a 50' industrial extension cord "just in case they had to plug into (their son's) dorm room." While enroute, both Greg and Tamah monitored the range and experimented with what happened to the estimated range when the used the air conditioning, radio or

other features of the Fit EV. Arriving in Claremont they had 9 miles of range "to spare" which turned out to be more than enough to locate (via the Charge point smart phone app) an open and available Level 2 charging station. Over a long dinner and a few extra drinks they were able to full charge the Fit EV for their return trip back to Manhattan Beach; arriving home wiser for the experience and with a better understanding of what was comfortable in terms of how the Fit EV's range. As Tamah noted, the "trip to Claremont pushed the edge of her comfort level" and that, for her, "she would never let the range go below 25 miles" before recharging – something she learned was possible on their trip yet something she preferred not to experience in the future (without planning for it).

Overall, both Greg and Tamah enjoyed their experience of driving the Honda Fit EV. For Tamah, she could see how an electric car "could fit into their lifestyle." The excitement of this discovery however was mitigated by the fact that until the "price goes down" (i.e. to that of the price of used Toyota Yaris – about $7,000) for EVs or that the market for used electric cars develops the family will continue to use their "old cars." – Vehicles "that still run fine and are already paid for."

Design/Use:

In terms of the Honda Fit EV's design and the use, the Household 44 family liked the EV and thought it was a "solid" and "heavy" car compared to Tamah's Toyota Yaris. Tamah appreciated the EV's pickup though she commented that she thought it was too big for her driving needs preferring, instead, the size and feel of her "little zippy small 'acorn'" Yaris. Both Greg and Tamah also noted that the Honda Fit EV was "very quiet" and that they had to be "careful" when backing up because "no one could hear the car" however, they also noted that the Fit EV seemed "noisier" than they had expected – especially at higher speeds or on the highway. Both Tamah and Greg appreciated and found the smart phone apps (for EV charging) to be helpful. In terms of understanding how the EV worked, Greg wished that "the car's manual would have been better written" and easier to use.

Rotation #12

Household 45

Participant: Robert Household 45 & Margret Participant 2

Age: 65, 63

City of Residence: Palos Verdes Estates

Date: 10/29/14 to 1/5/15

ICE Vehicles: Honda Civic Hybrid, VW Passat

EV: Nissan Leaf

EV Start Date: 11/2/14

EV – TOTAL VMT: 1,310.6 miles

EV Average VMT per Day: 21.8 miles

Overall:

Robert Household 45 and his Partner Margret were enthusiastic participants in the Battery Electric Vehicle (BEV) study. Margret and Robert reside in single family home located in Palos Verdes Estates - "not too far up the hill." They are both retired and have a very active and highly structured "volunteer work life" that takes them out to various activities during the day. As a household, they came to the study after learning about the program while attending a local environmental community fair. Robert was anxious to "test" an EV to see if it might "make sense" as a vehicle to replace Margret's aging VW Passat.

Since both Robert and Margret were retired neither one had typically "commute" pattern of going to work and then home at the end of the day. Rather, the couple had a very organized and structured routine of travelling out from their home to attend to their various volunteer activities, household errands (i.e. shopping) or attend to their, respective social activities. Whenever possible they would try to organize their trips by linking or chaining them often returning home, at some point during the day before going out again. Often, Margret's travels would begin in the morning and she would return later in the day while Robert's trips usually started after she returned – sometimes it would be the opposite.

The addition of the Nissan Leaf complemented their respective travel patterns as they the Leaf was "seemingly" in use all the time by the couple. The couple's rule of thumb was that the "first one out the door would get to use the EV" first. When she/he returned (later in the day) the other would "get to drive it." This rotating pattern was something that worked very well for their lifestyle. Moreover,

because their destinations were “very local” this meant that they would take multiple trips during the day without having to recharge.

Over the course of their participation Robert and Margret exclusively charged at home using a 110 outlet that was located in the family garage or an outdoor 110 outlet on the rear wall of their home. As Robert said, “the last one (driving) home at night would plug in.” so that, in the morning, the Leaf would be fully charged for the “first person out the door” to use the EV. Even with multiple destinations (for each person) during the day the family’s daily trips were (for the most part) “never far from home” thus, they never had or nor felt the need to opportunity charge during the middle of the day; rather, they always felt that they had enough range or miles to “get home” if necessary.

Robert and Margret’s experience in the study taught them that their travel was “pretty much a 10 mile circumference” from their home – that their daily trips were “very local.” As a result they felt that a BEV would “make sense for them” – a vehicle for most of their trips though, they would still keep their Honda Civic Hybrid for longer trips that they would take each year – road trips to San Diego and Minnesota.

Household 45 Exterior 110 Outlet for Charging

Charging Strategy:

During the course of their participation in the study Robert and Margret only charged their Nissan Leaf at home. The couple used the Leaf’s portable 110 charging unit to plug into one of two locations at their home. Given the placement their family cars in their driveway they would either plug the Leaf into a 110 outlet located on the outdoor rear wall or they would pull the Leaf into their garage where they would plug into a 110 outlet on the inside wall of the garage. Typically, the “last one home” would plug in at night “between 6 and 10 PM” so that the Leaf would be fully charged in the morning when their daily travels would begin.

The couple never felt the need for opportunity charging during the day using a Level 2 charging station or plugging back in at home because most of their trips were within a 10 mile radius. On one occasion Margret was going to “test 220 charging at Costco” however, because she couldn’t find anyone to help with accessing the charging station she did not do it. This experience was not an issue for her as she noted that “she had more than enough range to get home.” The experience of living on a hill also made it feel as though, for Robert, he needn’t worry. As he observed, “all of their trips started downhill” and, as a result, they would “gain a few extra miles of range”. Margret however noted that this was illusory as she was quick to point out that “you lose those miles coming back up the hill” going home.

110 to 220 Home Upgrade:

Neither Robert of Margret felt that they needed to upgrade their home to allow for 220 charging. Rather, both noted that their 110 home-based charging strategy was working "fine."

Driving Patterns and Experience:

Robert Household 45 and Margret Participant 2 spilt their use of the Nissan Leaf "about 50/50." Each person would, respectively, replace all of the trips that they would have otherwise have taken using their individual cars. For Robert and Margret, because they were retired, they would split the use of the Leaf between each in relation to their schedule of daily activities. Usually, their daily routine would consist of regularly scheduled volunteer activities, running errands, or meeting with friends – each going about their days independent of one another – Margret often leaving the home first followed by Robert later in the day after Margret returned. In terms of using the Leaf this translated into "the first one out the door" gets to drive the Leaf first. As a result, Margret would often use the EV in the morning then return home so that Robert could use it later in the day. Happily, their respective schedules complemented their strategy of "splitting" the use of the Leaf during the course of their participation in the study. The Leaf then was "seemingly in constant use" during the day; this meant that, at any one point during the day, one of the family's regular cars would be parked while the trips that they would have otherwise taken using their respective cars would be fully substituted by the Leaf.

The family quickly realized that "most of their trips were very local" and, as a result, they did not experience "range anxiety." On the one occasion that Robert ventured further afield he felt comfortable and at ease with the "car's range" because he had "planned ahead" knowing that he could "easily" make it home. In this instance, his trip was to visit a hospital in Downey (as part of a volunteer program). He went on-line to learn that his destination was a 50 mile round trip and that "fully charged" (with 70 to 75 miles of range) it would be "no problem" to make it home without any issues; planning ahead was what gave Robert confidence and mitigated any (potential) issue of range anxiety for him.

Over the course of the study, the family "really liked driving the Nissan Leaf" and, importantly, learned that their travel was "very local." They observed that "it (destinations) were within a 10 mile circumference" from their home. This was enlightening for the couple in that they realized that an electric car would be a "good fit" for their family – certainly to replace one of their regular cars (likely Margret's aging VW Passat. Both Robert and Margret agreed though that they would have to keep the Honda Civic Hybrid so that they could take their longer trips – to visit with friends in San Diego and their annual summer road trip to Minnesota.

Design/Use:

Both Robert and Margret enjoyed driving the Nissan Leaf. For Margret, it was "like driving a new car" – something that she had not experienced in a "very long time." The family both noticed that "it (Leaf) gets up and scoots" and they appreciated that it was a "quiet car." Critically though, Robert noted that, though comfortable (for someone "as tall" as he was) the Leaf was "funky looking" and that he "wouldn't buy it because of its design." Rather, he would like a EV that had similar (or more) cargo room but was "more like an SUV." Additionally, both he and Margret felt that the "car had a significant blind spot" and that the "car seats did not really let you see out the back" – limiting your view while driving.

Household 46

Participant: Jim Household 46 and Family

Age: 51, 48, 14 and 12

City of Residence: Rancho Palos Verdes

Date: 10/29/14 to 12/10/14

ICE Vehicles: Honda Odyssey, Acura RDX

EV: Honda Fit EV

EV Start Date: 11/9/14

EV – TOTAL VMT: 279.3 miles

EV Average VMT per Day: 8.7 miles

Overall:

Jim Household 46, his wife Felicia and two teenaged children live in a single family home located in Rancho Palos Verdes. Jim is a Marketing Director at Honda USA and his wife runs the household – often doing many of the daily pick-ups and drop-offs of their children to school and their respective busy activities. The Household 46 family came to the study through reading about the program in a South Bay Cities Environmental Service Center flyer; additionally, he had some knowledge about the program through his contacts within Honda that were responsible for the Honda's development, marketing and leasing of their Honda Fit EV – Honda's first electric car in the California market. Feeling that it "might be best" if he was seen driving the Fit EV (rather than a Nissan Leaf), Jim and his family test the Honda electric vehicle.

Though Jim and his family were very enthusiastic about participating in the study, they had limited time to test the EV; their limited time was because of Jim's busy travel schedule, Thanksgiving Holidays and the fact that the EV had to be returned due to the end of the project. Even with the short time period Jim was able to test the Fit EV; he was able to "get a good sense" of how an electric vehicle might fit into their family's mix of cars.

Over the course of the study, Jim was (essentially) the sole driver of the Fit EV. While driving the Honda Fit EV he was able to substitute all of the trips that he would have otherwise taken using his primary vehicle, the Honda Odyssey. Typically, Jim's travel patterns were almost all work related as the Fit EV served as his commute vehicle on this 7 mile trip "down the hill" to his office in Torrance; on one occasion he used the Fit EV for a work-related trip to Disneyland – a trip that resulted in a bit of "white knuckles" as he wondered if he would have enough charge to make it back to his home "up on the hill." Felicia, on the other hand, only drove the Honda Fit EV for 1 day. Her travel pattern with the EV was, as Jim noted, "just like the trips she takes using the Acura RDX," that being, a series of errands or pick-up and drop offs of their children to their various activities. Though Felicia only drove the Fit EV once, it

was enough for her to understand that, because of fear of living on a hill and "possibly running out of charge" she would rather drive her regular car - a vehicle that she was more comfortable and familiar with.

In terms of charging the Household 46 family used a combination of 110 home-based charging at night as well as Level 2 workplace charging during the day. Initially, the family would charge at home using a 110 outlet located in the family's 2 car garage – filling up for the commute to Jim's office the next morning. Ironically, Jim reflected, "the trip is downhill" so even without fully charging he was able to use the Fit EV's regenerative breaking so that "by the time he got to work" he had (mostly) a full charge. This meant that Jim didn't need to fully charge his EV when he got to work. As he stated, "I only needed a couple of hours to fill up." Initially, to do so, he signed up to use the employee charging station – an outdoor bank of Level 2 charging stations that "was always full." Honda's policy was that employees could charge on a "first come first served basis" for 2 hours then they would be responsible for moving their EVs so that others could charge. Users of the system were identified when they plugged in and if they did not move their vehicles at the appropriate time were notified by text to do so; failing that they would be contacted "in person" to move their EV. As Jim noted, there was far more demand than charging stations and so it became a "bit of a club" as to who would or could use the facility to charge. Jim was critical that "plug in hybrids were allowed to charge – even though they didn't need to" while "people who commuted from places like Huntington Beach" in a Battery Electric Vehicle (BEV) sometimes had to wait or didn't get a chance to use the charging stations. After experiencing this system, Jim discovered that there were other charging stations on campus (located in an underground garage) available to senior Honda management – Jim was able to "take advantage" of this so that he could charge without "any hassle."

Though Jim liked the experience of driving an electric vehicle he felt that the EV's limited range would not make it suitable for either he or his wife to give up their regular cars. For Jim and Felicia, the range would have to be about 200 miles to make such a substitution viable; additionally, for Felicia, the EV would have to "be bigger" as she felt that a "car like the Fit EV was too small".

Given the 80 mile range he experienced, Jim considered that, "as a third car it would be fine" it might be something that they would consider "to let their kid drive" because they couldn't "drive far." Looking ahead though, Jim did consider that a plugin hybrid might give the family more range while offering fuel and emission savings.

Household 46 Charging Set-up for Honda Fit EV

Charging Strategy:

In terms of charging the Jim Household 46 used a combination of home-based 110 charging as well as Level 2 charging that was available at his workplace. Typically, at the end of the day, Jim would plug in the Honda Fit EV

into a 110 outlet located in the family's two car garage. Generally the strategy of overnight charging would give him 100 percent range for his morning commute. Interestingly (and somewhat ironically) Jim's commute was "downhill" which, as he noted, meant that "he could add even more charge" using the Fit EV's regenerative breaking. Jim would thus arrive at his workplace "not really needing" a full charge.

That being said, Jim did take advantage of the fact that Honda USA offered employees free Level 2 charging – available to those that drove BEV's like Jim's Honda Fit EV or others that drove plugin hybrids (PHEV) like the Chevy Volt. Honda provided 4 charging stations that could be accessed by "signing up" for their program. Employees would be given a specific pin (code) to unlock the station where they could then charge their EV or PHEV for a period of 2 hours or 4 total (if no one was waiting). The challenge, however, was that there was far more demand than available stations and that, as Jim noticed, "people would arrive early" or "there was a bit of club" as friends and colleagues would assist one another by rotating their vehicles back and forth to ensure that they "got charged." Jim lamented that "it wasn't right that plug in hybrids got to use the charging stations" since they didn't need to recharge – like someone who might drive a BEV. Moreover, he didn't like the system as, on one occasion (because he was busy working) he was unable to move his Fit EV in the required time. He felt it was annoying and inefficient that "someone had to actually come up to his office to tell him to move his car." As he suggested, "there has to be a better way to rotate EVs that are charging." Subsequent to this experience, Jim learned that there was another bank of charging stations set aside in an underground parking structure that were dedicated for only senior management. After a couple of phone calls, he was able to use to charge "without the hassle."

110 to 220 Home Upgrade:

Due to the length of the study Jim did not consider upgrading his home from 110 to 220. His combination of 110 home charging and Level 2 charging at work was sufficient for his travel needs.

Driving Patterns and Experience:

Jim Household 46 and his wife Felicia both drove the Honda Fit EV; Jim drove it about 95 percent of the time while Felicia used it only for one day. For Jim, this meant that, on the days he used the Honda Fit EV, he was able to substitute all of the trips that he would otherwise have made using the Honda Odyssey. During the course of the study Jim noted that the household travel pattern "didn't really change." In other words, Jim's travel consisted mostly of commuting 7 miles "down the hill" to the Honda USA campus and returning home at the end of the day. On occasion, he would take work related trips for off-campus meetings at the offices of Honda's Corporate Partners (like Disneyland); additionally, from time to time (before heading to work), Jim would also be responsible for the early morning school drop-offs of their children. While Jim's travel patterns were mostly to and from work, Felicia's travel would consist of a series of chained trips to run errands, go shopping and pick-up and

drop off their children for various activities. Often, she would return home from a series of errands and then go back out again later in the day.

Generally speaking the family's travel patterns could be characterized as local – mostly commuting to Torrance or "doing things near their home." However, on one occasion, Jim used the Fit EV to attend a meeting in Anaheim at the Disney Corporate Offices. Jim suspected that the EV was not fully charged when he left his home however, based on his prior experience of adding charging (while going downhill) on his commute, he was confident that he could "top off at work" then easily make it to Anaheim. Further, he was "confident" that Disney would have a place for him to recharge his EV while he was in his meeting however, he learned that the only Level 2 charging station that Disney had was not located near the corporate office – as such Jim could not use it. With this information, Jim resolved that he could still get to his meeting and back again. However, what he did not fully appreciate was "how quickly the range dropped" while driving on the freeway. As he said, "it (range) burns fast on the freeway." Travelling with a colleague from work Jim arrived at Disney with 45 miles of range left. He calculated that he needed 30 miles to get home. At first he felt confident that he could do so however he soon realized that he had not considered the extra trip along the way home (to drop off his coworker). Moreover, he knew that he needed about 20 miles of range to "get back up the hill to his house from the bottom of the Palos Verdes Peninsula. Jim felt uncomfortable and, as a result, he described his trip as "a bit of white knuckle adventure." At first Jim felt that there was "no way" that he would get home and, while driving, he began to think that he might have to stop back at work to recharge – simply to get home. However, this scenario never occurred since the "stop and go" of rush-hour traffic helped him conserve the Honda Fit EV's range. Eventually, Jim arrived home with less than 10 miles of range. The experience taught him about the "lack of available charging" which, if it were available to him, would not have resulted in his experience of range anxiety.

Both Jim and Felicia felt that driving the Honda Fit EV was "fun" however they noted that an EV would not be a suitable choice to replace either of their family cars. Rather, because of the EV's limited range, they saw an EV as "a third car" – one that they might get for their children to use – that "they couldn't drive too far away" or a "car that they could use locally"

Design/Use:

In terms of the Honda Fit EV's design and the use, the Household 46 family was quick to point out that the EV was "small" for their family needs. Moreover, Felicia, who was used to driving a much larger (taller) car, felt that the Fit EV "was unsafe." Jim did not feel the same as he "was used to driving smaller cars." However, in terms of the Fit EV's cargo capacity he would have liked it to be larger and set up so that the seats could "fold down flat" – a configuration that would have allowed him to take transport his bike for his cycling excursions. Other features, like the radio and defroster met his expectations though "it was a little annoying" that the Fit EV's Blue Tooth didn't work as expected.

Household 47

Participant: Linda and Michelle Household 47

Age: 50, 22

City of Residence: Torrance

Date: 10/24/14 to 1/11/15

ICE Vehicles: Ford Ranger, Toyota Camry

EV: Honda Fit EV

EV Start Date: 11/9/14

EV – TOTAL VMT: 184 miles

EV Average VMT per Day: 3.9 miles

Overall:

Linda Household 47 is a single mother who lives with her college aged daughter, Michelle, in a single family home located in Torrance. Linda works at a nearby hospital as a nurse; often schedule is one where she works consecutive shifts of 3 twelve hour days followed by multiple days off. Linda's interest in participating in the study came as a result of having seen the Battery Electric Vehicle (BEV) program advertised at a local community fair; her hope was to "learn about electric cars" and inform herself about the technology – perhaps considering an EV "the next time she bought a car."

Over the course of her participation in the study, Linda was the sole driver of the Honda Fit EV. The EV replaced all of the trips that she would have otherwise have made using her Ford Ranger SUV. Her daughter did not use or test the Fit EV noting that she didn't think "it would work for her trips" to and from school in Long Beach as well as to her part-time job in Venice Beach.

For Linda, the Honda Fit EV proved to be a useful "local car" as it she was able to use the EV for all of her short commute trips. Generally speaking, on days where she worked, she would go to work and come home – preferring to "run her errands" and other trips on her days off. Most of her non-work related trips consisted of short local excursions to go shopping, run errands, visit with friends or go to the gym. On weekends, that Linda was not working, she would (sometimes) leave town. Travelling to her family's cabin "up in Big Bear." For these trips she would leave the Honda Fit EV at home and take her SUV noting that "it was too far away for the Fit" to go and "that there was probably no place to charge it along the way."

In terms of local charging though, Linda was able to meet all of her needs by charging at home using an available 110 outlet located in her washing and dryer in the room directly behind the family's two car

garage. In the evening she would pull in and plug the car into the outlet to recharge. Linda also inquired about workplace charging only to learn that it was unavailable; she was "disappointed that a big hospital would not have electric charging" at this time. However, because her commute was "only a few miles" it was inconsequential that she could not charge at work.

Initially, Linda would charge every night at home however, as she became more confident of the EV's range and began to appreciate that her daily trips were "not very far" she found that she did not have to "plug in every night." Rather, she changed her charging strategy to "plug in as needed" which, for Linda was 2-3 times per week.

Linda also learned that charging could, at times be challenging – especially so, if (as she did) on an evening when she had decided "that she didn't need to recharge she left the "car's lights on." Linda learned that (even though) the Fit EV was "turned off" the lights do not "turn off automatically." As Linda noted, this design feature proved problematic. When she went to start the car (after several days following a weekend trip out of town) Linda discovered the battery "was dead." Not wanting to take a chance on "jumping the battery herself" she called AAA Roadside Assistance. They were able to jump the "starter" battery (a small complementary battery) so that the electric engine would begin – she learned that it was "the starter battery" which had failed and that once the Fit EV could start then it had "almost as much range as when she parked it (with the lights on); the EV could then be properly recharged.

While the Honda Fit EV "made sense" for Linda's daily commute and local trips she did not see how it could replace her SUV; especially, since she liked the idea "of being able to get out of town" when her work allowed. She considered then that a possible solution (for a new car) might be a hybrid – one that would give her better mileage locally but still let her take trips up to Big Bear or wine country.

Charging Strategy:

In terms of home-based charging, Linda charged the Honda Fit EV using an available 110 outlet on a wall behind her washer and dryer – located in an interior room just behind her family 2 car garage. Because her trips were "very local" Linda did not need nor did she look for any Level 2 opportunity charging stations. Rather, she had "more than enough" range to get home to charge "if she needed to."

Initially, Linda would charge each evening to "make sure" that the Fit EV was fully charged for the following day. However, as Linda began to recognize her travel patterns and understand the Fit EV's range she was

Household 47 110 Outlet for Charging Honda Fit EV

able to charge less frequently. This translated into charging "as needed" or 2-3 times per week.

Though Linda inquired about workplace charging – which, she was told "was unavailable" – she realized that it was a "moot point" simply because her commute was "just down the street" and she always had "more than enough battery" to get to "where she needed to go."

110 to 220 Home Upgrade:

The length of the study as well as the very "local nature" of her driving precluded Linda from considering upgrading her home charging from 110 to 220.

Driving Patterns and Experience:

As the sole driver of the Honda Fit EV, Linda was able to replace 100% of the trips that she would have otherwise taken using her Ford Ranger SUV. Linda Household 47's patterns were very local; consisting of a relatively short commute trip to a nearby Hospital/Medical Center in Torrance. On work days – usually 3 consecutive days with 12 hour shifts – she would simply go to work and then return home. On her "off days" she would, if in town, "do the things that she didn't have time to do" because of her work. That is, she would run errands, go shopping, visit with friends or go to the gym. Often these non-work related trips would be linked or chained together – a technique that Linda used to maximize her time.

The EV's range limitations meant, for Linda, that she "could not take the car on trips out of town." For Linda, she anticipated and enjoyed these "get-away" excursions and could not see how she could "realistically take the Fit up to place like Big Bear." As she noted, "it was almost at the farthest range" of for the EV and, importantly, the "last stretch would be uphill" – making a trip like that impossible without stopping (to recharge) along the way.

For Linda her use of the Honda Fit EV was limited then to local trips all of which were uneventful with no anxiety about being able to return home to charge. However, though Linda's trips were uneventful she did have a challenge with the Fit EV when she returned home and forgot to turn off the car's lights. Upon arriving home after a long day, she pulled into the garage and decided that she did not need to "plug in." As she described, "I just needed to chill out" so I didn't "think to turn off the car's lights." Rather, she just assumed that, like most cars, the lights would simply turn themselves off when the car was turned off. This was not the case, however, with the Honda Fit EV. Returning later (several days in fact – as she left town for "a few days") she discovered that the battery was – she thought - "completely dead" and that the "Fit would not start." This was disconcerting and troublesome as she needed to call AAA Roadside Assistance to give her the "Fit a jump." The problem was quickly resolved when the "starter battery" was recharged allowing the Fit EV to start and access the EV's larger battery; leaving the lights on did not drain the main batteries but rather the smaller battery – it was a "failsafe" so that, in the event that the lights are left on then the larger batteries or EV's electronics would not be damaged.

Though Linda Household 47 liked driving the Honda Fit EV and found that it was a “great little car” for her local travelling and commute trips she did not think that it would work for her stating that she “needed a larger car or SUV for going up into the mountains” or for other trips out of town.

Design/Use:

In terms of the Honda Fit EV’s design and the use, Linda thought that the “car was cute.” She liked the sporty quality and thought that it was “a great car for getting around” town. The amenities were “fine” however, as Linda was quick to point out, “the car’s poor design (for turning off the lights)” was a problem that should be “addressed”.