

Zero Emission Local Use Vehicles: The Neglected Mode in Sustainable Transportation

Final Report of the Neighborhood Electric Vehicle Demonstration Project

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1. Introduction

Burning fossil fuels as the basis for mobility is not sustainable.

- Direct Cost: South Bay households currently pay over \$1.5 billion annually for gasoline. Current inflation-adjusted gasoline prices are higher than the previous peak in 1981. The long term trend is for continuing price increases.
- Indirect cost: Monetary cost of air pollution in Southern California is at least \$14.6 billion per year.
- Climate impact: Carbon dioxide in the Earth's atmosphere has surpassed 400 parts per million, thought to be the threshold beyond which there will be profound changes in nearly every aspect of life.

In March 2013, California Governor Brown issued an executive order directing state government to help accelerate the market for zero-emission vehicles (ZEVs) in California. "Accelerating the market for ZEVs is a cornerstone of California's long-term transportation strategy to reduce localized pollution and greenhouse gas emissions, save consumers money, and enable continued economic growth. In addition to promoting these vehicle technologies, the state supports ... planning more environmentally sustainable communities that reduce unnecessary vehicle travel and congestion." (ZEV Action Plan, February, 2013) The target is 1.5 million ZEVs by 2025.

In order to meet that goal, the "full range of electric-drive technologies" will need to be deployed. Although neglected in vehicle sales forecasts and passenger fleet projections, short range, slow speed, small size vehicles specialized for local use only,

such as neighborhood electric vehicles (NEV) could become part of the mix that helps meet the goal.

In limited previous studies of NEV usage, the results have been promising. For example, a report from Lincoln, California identified the benefits from NEV use as energy savings, improved air quality, greater mobility for impaired drivers, cost savings, community cohesion, and support of local businesses.

This is a final report on a demonstration of neighborhood electric vehicles in the South Bay sub-region of Los Angeles County. The South Bay Cities Council of Governments (SBCCOG -- a joint powers authority for the 15 incorporated cities plus parts of the city of Los Angeles and unincorporated county areas of the sub-region) received funding from the South Coast Air Quality Management District (AQMD) to design and implement the project.

The active demonstration period was initially for 18 months between May, 2010 and November, 2011. Due to more public interest than expected and a waiting list of 250 applicants, the AQMD extended the project by 12 months in order to accommodate additional participants. The last of the demonstration vehicles was retired and data collection ceased in December, 2012. Fifty-one households participated in the demonstration by driving an NEV for a period of about two months each.

1.1 NEV Definition

An NEV is a zero emission vehicle that can be driven on public streets subject to being registered, having a Vehicle Identification Number (VIN), being insured, and adhering to vehicle safety standards. NEV drivers must have a valid driver's license.

In 1998, the National Highway Traffic Safety Administration (NHTSA) of the Federal Department of Transportation defined street-legal Low Speed Vehicle (LSV) in the Code of Federal Regulations (Rule FMVSS 500). NEVs are recognized as a sub-class of LUVs (local use vehicles), limited to a maximum speed of 25 MPH and restricted to streets with speed zones of 35MPH or less.

1.2 Brief History of the NEV

The concept of a vehicle specialized for local use was introduced 36 years ago in a ground breaking University of California, Berkeley publication entitled Studies of the Neighborhood Car Concept (Garrison and Clarke, Report 78-4, College of Engineering, UCB, 1977). The paper envisioned environmental benefits from small cars, opportunities to devote less land to personal mobility, and a mode of travel that offered to be more in harmony with the community.

At the time, the closest production vehicle to the proposed concept was the golf cart. Golf carts had been popular in the U.S. since the 1950s and had begun to be used in retirement communities for non-golf travel needs.

Yamaha introduced its Sun Classic model golf cart in 1986 oriented toward local personal mobility. The model had a sweeping windshield, integrated roof and automotive headlights. Even though its design was more advanced, it remained a golf cart and Yamaha didn't pursue the regulatory revision that would enable the Sun Classic to travel faster than the 15 MPH golf cart speed.

By the early 1990s, the potential economic and environmental benefits of NEVs began to attract more attention from the university research community, particularly

faculty at UC Berkeley and UC Davis, as well as designers and investors interested in developing vehicles for what was hoped to be an emerging market segment.

William Garrison, the UCB academic who had initiated the conversation in 1977, began in 1991 studying options for small, relatively inexpensive, environmentally benign vehicles specialized for short distance travel. This resulted in a 1993 publication entitled Small Cars in Neighborhoods (PATH Research Report UCB-ITS-PRR-93-2, January, 1993.)

This report articulated three insights with significance for today:

- Replacing the dominant multi-purpose, multi-passenger vehicle with different kinds of specialized vehicles (such as the short range, low speed vehicle) could save gasoline and improve air quality;
- Roadways have been developed to accommodate the multi-purpose, multi-passenger vehicle and so success of specialized vehicles would probably require changes to the street infrastructure;
- There is a mutually reinforcing relationship between neighborhood vehicles and neighborhood design. Paraphrasing the report, the adoption and use of a neighborhood vehicle might improve mobility and also offer improvements in neighborhood designs. In other words, neighborhood vehicles could be space serving and as well space shaping. This is precisely the kind of transportation-land use linkage that is at the heart of SB 375 and the Sustainable Communities Strategy that it requires.

In 1993, Daniel Sperling, the Director of the Institute of Transportation Studies at UC Davis (ITS-Davis) began to research NEVs. In one paper, he states “the energy and environmental benefits are potentially so large, and the opportunity to create more human-scale communities so promising that it would be irresponsible not to pursue NEVs in a more deliberate fashion.” This paper coined the term neighborhood electric vehicle. (Today, Sperling continues to lead ITS-Davis and serves on the California Air Resources Board.)

Meanwhile, a grass roots movement toward the wider application of golf carts was gaining momentum, particularly in Sunbelt retirement communities. For example, a growing number of residents in Sun City, AZ, were using their golf carts to go to the grocery store and to visit neighbors in addition to driving them to and on the local golf course.

This same grass roots dynamic in Palm Desert, California led the City to introduce a formal Golf Cart Transportation Plan in 1993. This Plan resulted in street-legal golf carts and a network of designated streets and some class 2 lanes for golf carts. A new town, Peachtree City outside of Atlanta, Georgia, built paths specifically for golf carts, cyclists and pedestrians to link residents to shopping centers, schools and parks.



(McIntosh High, Peachtree City (left); Peachtree City Paths (right))

The vehicle market place took notice. The first true NEV distinct from a golf cart was designed in 1992 by a Michigan-based start-up company, Trans2 Corporation. This initial NEV concept was a fold-up so that the entire vehicle could be folded and parked vertically. However, the vehicle that trans2 actually produced had a conventional non-folding vehicle architecture.

A two-seat NEV with a modular rear cargo system was delivered to the market in late 1995 and sold through existing automotive dealers. Trans2 sold 700 of the NEVs before going out of business in 1997 after experiencing a costly recall of the first models produced.

Bombardier and Honda were established transportation firms that produced at least prototype NEVs. Honda never entered the NEV market. Bombardier was in the market between 1997 and 2000. That it lacked an effective dealer network for the product was one of the reasons for its withdrawal.

The early market was also artificially constrained. Certain golf course managers had begun to oppose NEVs as they feared unique looking higher speed vehicles on their fairways would prove to be a distraction. No golf cart manufacturers entered the NEV market.

Timing proved to be very important. A North Dakota businessman purchased the assets of trans2 and re-launched the company as Global Electric Motors (GEM) in 1998 just as some states began to offer incentives for EV purchases. Chrysler Corporation purchased GEM in late 1999 partly in order to help it comply with the California Zero Emission Vehicle program. Chrysler sold 10,000 GEMS in California between 2000 and

2004. GEM remains in business and the SBCCOG NEV demonstration used two of its vehicles.

Spurred by the California zero emission mandate, other manufacturers began designing and producing specialized vehicles for the neighborhood market. Ford Motor Company introduced the Think Neighbor in 2000 as well as an electric bike. Marketing and distribution proved difficult as it had earlier for Bombardier and the Think Neighbor was withdrawn in 2004 after 5,000 had been sold.

Beginning around 2003 another grass roots movement led by seniors and golf cart users was gaining momentum in Lincoln and adjacent Rockville, California, located approximately 30 miles northeast of Sacramento in Placer County. With a similar dynamic as Palm Desert in the 1990s, residents of the retirement communities pressured local government to take the necessary steps to make golf carts and NEVs legal on city streets. A formal NEV plan must first be authorized by the State of California, so the City introduced AB 2353 for that purpose and it became law on January 1, 2005.

A paper published by the American Society of Civil Engineers in 2008 and authored by MHM Engineers entitled Thriving with Neighborhood Electric Vehicles analyzed several dimensions of the use and driver satisfaction of approximately 5,000 NEVs regularly used in Lincoln in 2007. Some of the data from this report is used for comparison purposes in subsequent sections below.

China has recently emerged as a player in the NEV market. The country produces millions of electric bikes and motorcycles so the relatively simple NEV has been easily within their capacity to produce.

Another wave of NEVs entering the market in the late 2000s looked more like conventional cars than earlier NEVs. They included the Zenn (zero emission no noise) 2-door from Canada, the Miles 4-door using a body made in China, and the Wheego 2-door that looks similar to the Daimler Smart Car. None of the three remain in business. The Miles and Wheego became stepping stones for the entry of both companies into the full speed BEV market – resulting in the Coda and Wheego Life respectively.

The Miles and the Wheego were driven in the SBCCOG demonstration project along with the GEM e4, Columbia Summit and Vantage Crew Cab. Detailed assessments of the performance of each of those vehicles are discussed in the Appendix.

The enormous potential for NEVs to impact the environment, energy, economy and even neighborhood design has not yet been realized. In general, low production runs resulting in high cost and the lack of a robust distribution network are among the challenges the NEV industry faced so far and will continue to face into the future. Changes to the street infrastructure that would facilitate the growth of NEVs have occurred primarily in a smattering of new towns and in those few places anchored by golf oriented retirement communities where a grass roots movement provided the necessary political support. To date, the political support for the infrastructure has followed the vehicle usage.

1.3 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.

Since the South Bay will not attract large scale rail transit investments within the next 20 years, beginning in 2004 the SBCCOG initiated a research program that was designed to identify a land use and transportation strategy that would reduce GHG emissions, criteria pollutants and gasoline consumption without relying on transit investments, transit oriented development and increased residential density.

The Board of Directors of the South Bay Cities Council of Governments (SBCCOG) adopted the Sustainable South Bay Strategy (SSBS) in October, 2010 as the basis for the sub-region's contribution to the regional Sustainable Communities Strategy (SCS) and as a guide to land use planning and transportation policy in cities interested in becoming more sustainable.

The SSBS is essentially a *neighborhood strategy*. It proposes that cities begin to create compact destinations in the center of each neighborhood to facilitate a mode shift to walking with cycling and specialized neighborhood vehicle modes for circulation between the centers.

The mobility component focused on reducing the total number of motorized vehicles and shifting the residential fleet to some form of plug-in electric vehicle (PEV) – plug-in hybrid (PHEV), full speed battery electric (BEV) and specialized slow speed, short range electrics (NEVs but also Segways and other local-use vehicles coming to market – see Chapter 5 for a discussion of the emerging slow speed, short range market place).

Ten initiatives have been identified so far for implementing the SSBS; car sharing, compact commercial centers, smaller format commercial presence, complete streets, PEV readiness plans for cities and large employers, development oriented public transit, neighborhood van pools, a BEV demonstration and of course this NEV demonstration.

The following subsection provides a little more detail on the South Bay’s neighborhood strategy (SSBS):

1.3.1 Development Pattern

The existing development pattern features many horizontal mixed-use neighborhoods. Our surveys have shown that most trip destinations are within 3 radial miles of home because of the commercial strips in proximity to residential tracts. This existing pattern should work well for neighborhood vehicles but is not optimized for walking trips.

The land use component of the SSBS involves gradually re-organizing low density destinations -- especially commercial strips along major arterials -- into compact, higher density centers in the middle of every neighborhood (for example, at the intersections of major arterials).

The low-density commercial strips can be transitioned into new housing, built at densities compatible with the existing adjacent neighborhoods, rather than at the much higher densities needed to make public transit service more economically feasible. These land use changes should dramatically encourage walking, cycling and transit as mode choices since there will be compact commercial destinations within one-half mile of every home and a regular pattern of similar centers every mile in each direction. This strategy is referred to as “neighborhood oriented development” (NOD as distinguished from transit oriented development or TOD).

While NOD is a long-term strategy for improving proximity between residential origins and the variety of regular destinations, the mobility strategy can be implemented in the short term without changes in land use.

1.3.2 Mobility

The mobility component of the SSBS involves transforming the residential passenger vehicle fleet from predominantly gasoline-fueled to predominantly electric drive technology such as plug-in electric (PEV) or some future alternative such as hydrogen fuel cells.

Two significant strengths of this fleet-transition strategy are that household mobility will remain anchored in the door-to-door, on-demand service, which minimizes the need for significant changes in travel behavior; and that the primary source of investment will be by private households which minimizes the required level of public sector investment.

Although there are segments of the PEV market that eventually will be lower cost than today's gasoline fueled vehicles, a safety net will be required for those who cannot afford to purchase a vehicle. PEV purchase vouchers, lease-purchase programs, and neighborhood car sharing are among possible options. The safety net should also include neighborhood-based vanpools, jitneys, and ride sharing – all SSBS initiatives.

2. Neighborhood Electric Vehicle Research and Demonstration

2.1 Objectives

One of the objectives of the Sustainable South Bay Strategy is to reduce the number of petroleum fueled vehicles in the South Bay. Many homes own more than one vehicle and NEVs provide an option for replacing the second or third vehicle. A key finding of the SSBS research was that a high percentage of trips taken in the South Bay were a few miles or less -- trips which can be feasibly accommodated in an NEV.

This NEV Demonstration Project was planned to evaluate, through actual experience, the potential for slow speed, neighborhood vehicles to satisfy those short trips. The findings should also inform a discussion of whether or not there is a viable automotive market segment for slow speed, short range vehicles.

While NEVs were the vehicles used in this demonstration, the term *local use vehicle* (LUV) was adopted as a more attractive marketing term than NEV. LUV is a generic term that describes a class of zero-emission, slow-speed and short-range vehicles.

The Project was designed to answer these 3 questions:

1. Will South Bay residents drive NEVs to satisfy a significant portion of their travel needs?
2. Does the usage have the potential to produce significant environmental and economic benefits?
3. Can NEVs become a significant market segment?

2.2 Demonstration Methodology

The SBCCOG acquired a fleet of NEVs for the initial demonstration period of 18 months and loaned them to households that had submitted an application to participate. All costs other than for the electricity to charge the NEVs were paid for by the SBCCOG's grant from the AQMD. The point was to remove financial barriers in order to recruit a robust set of candidates willing to commit to driving an innovative vehicle.

Each primary driver in the selected household signed a "participation agreement" which identified the responsibilities of the SBCCOG and all the drivers in the household. For example, the driver would be responsible for the \$1,000 deductible required by the collision insurance in case of an accident.

The SBCCOG equipped each NEV with a GPS unit in order to track the movement of every vehicle. This generated a "ping" for every minute the vehicle was turned on. The GPS data included routes, longitude and latitude of destinations, speed, driving time and idle time. The vehicles were also striped with the project logo in order to distinguish them from normal autos and to establish the project's public profile.

The initial plan was to loan the vehicles to participants for a period of 3 to 4 months or more. This loan period was eventually shortened to 1-2 months per household as drive-patterns were rapidly established and the extended time was not producing unique data. Also, the list of applicants grew to a total of 250 on the waiting list. Shortening the loan periods accommodated more participants.

At the start of each “rotation,” drivers were trained to operate the vehicle and were given a “Driver’s Kit” that included rules, maps highlighted with streets posted over 40MPH, procedures in case of breakdown, instructions for maintaining driving logs, and so forth.

At the completion of each “rotation,” drivers were asked to attend a group debriefing that was video recorded.

The AQMD extended the active demonstration period by 12 months, due in part to the long list of applicants. In the end, the active demonstration period ran for 32 months and involved 51 households.

2.2.1 Vehicle fleet

A fleet of at least 5 NEVs was maintained over the life of the project. At the outset of the program the SBCCOG leased 5 vehicles through Enterprise Rent a Car (ERAC) including:

- Vantage Crewcab
- Columbia Summit
- Wheego Whip (2)
- GEM e4

ERAC was able to assist the SBCCOG expand this fleet to six vehicles with a loan from a GEM dealer three months after the launch of the program. A seventh vehicle, a Miles EV Sedan, was loaned to the SBCCOG by the City of Santa Monica 10 months into the program.

When the AQMD extended the project, the SBCCOG took the opportunity to replace 2 vehicles that were not popular with participants: the Columbia Summit and the Vantage Crewcab. They were replaced with an additional Miles EV Sedan and a Miles EV Pickup. The vehicles used are described in greater detail in the Appendix.

2.2.2 Participant Recruitment and Selection

The initial recruitment was conducted at a street fair in the Riviera Village commercial center in south Redondo Beach/west Torrance. One of the vehicles was parked adjacent to a booth where printed project information was available and those interested could submit an application form. The form requested a brief explanation as to the reasons for the interest. Over 100 applications were received although some were incomplete or simply asking for additional information. Nevertheless, this single event was so successful that additional formal outreach efforts were not required.

Past this point the vehicles themselves with their project logo served as a rolling recruitment advertisement – after one year there were over 200 interested households on a waiting list. By the end there were 250 on the list.

Households were selected based on several criteria.

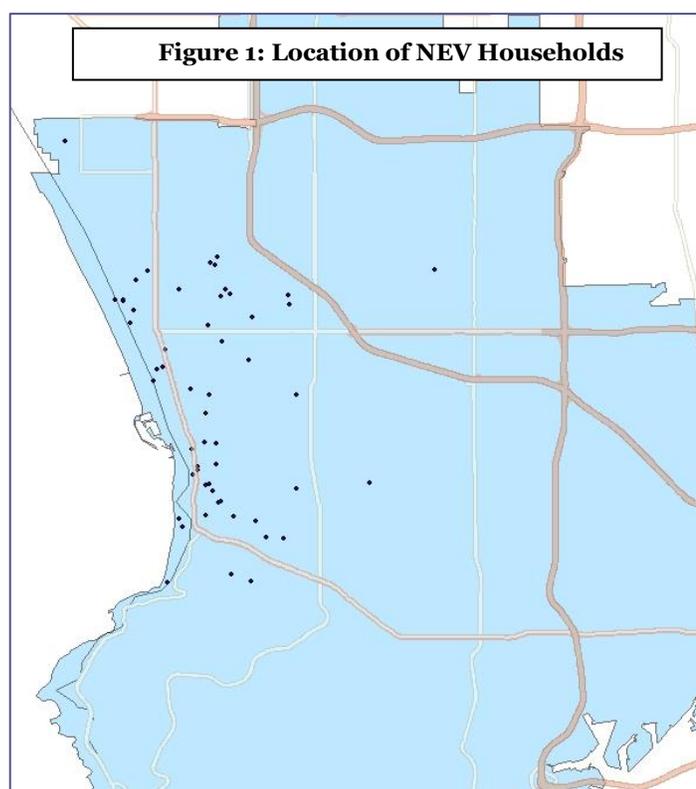
1. The applicant had routine travel patterns consistent with the capabilities of a NEV.
(The criterion was softened later in the program to test the limits of the NEV)
2. The applicant lived in a research area previously studied in SBCCOG projects.
3. The applicant was of an age underrepresented by previous participants. Seniors were a particular target.
4. The applicant had a clean driving record.

2.2.3 Geographic Area

Participants were not randomly selected from the entire South Bay. Initially the vehicles were placed in an area where previous SBCCOG research found a relatively high proportion of very local travel, the area surrounding the Riviera Village.

Subsequent rotations expanded out from Riviera Village to other South Bay Beach Cities. Beach cities provide a good fit for NEVs as their street networks generally consist of slow-speed streets. However, it was also important to understand how NEVs could be used and accommodated in neighborhoods faced with more high-speed streets. Therefore, approximately 10 households were recruited from South Bay inland cities such as Lawndale.

Attempts to expand inland were sometimes prohibited by the presence of “speed islands” (neighborhoods surrounded by 40 MPH streets). NEVs were not a particularly good fit on the Palos Verdes Peninsula (PVP) where the hills and speed limits severely constrained feasible locations. In the end applicants from the PVP were not selected.



2.2.4 Data collection

Data for this study come from multiple sources but generally fit into two categories 1) GPS based travel monitoring, and 2) participant reported data.

GPS Based Travel Data

Travel patterns were monitored with GPS units installed in each of the NEVs and on the gasoline fueled vehicles in some households. Individual GPS tracking units were initially carried by household members.

NEV emissions were calculated through Southern California Edison emission factors which include off-site emissions sources (e.g. emissions created from electricity produced by coal plants).

At first, travel monitoring was conducted for the NEV only using hardwired GPS devices that reported location once every minute.

The research team improved the data monitoring in an iterative fashion, initially by asking all household members to carry battery powered handheld GPS devices to document one week total household travel demand. These data did not prove to be 100% reliable because of occasional forgetfulness of the participant to carry the device, and because the batteries in the devices were not capable of holding a charge adequate for our application.

Direct vehicle monitoring with an onboard GPS unit similar to the device installed on the NEV replaced the handheld method. Units were placed in the household's gasoline fueled vehicles. Direct vehicle monitoring allowed for a reliable data collection of baseline vehicle use for all vehicles in the household.

Additionally, the research team attempted to monitor how much electricity the NEV vehicles consumed through the use of energy monitoring devices. The problem with currently available consumer products designed to monitor energy usage appears to be that they are designed to handle intermittent loads like refrigerators, but are not capable of monitoring loads that are uninterrupted for hours. As a result, the plastic face of the energy monitors melted repeatedly. This occurred for a variety of products.

Some data were collected from these devices, but the data were not substantial enough to use as a basis for the emission reduction modeling discussed in the environmental benefits chapter. NEV VMT emissions per mile of electrical consumption were estimated based on Southern California Edison's emission factors.¹

Participant Reported Data

Subjective data were collected from participants in three ways:

- Trip logs maintained by drivers to help interpret the GPS data especially in terms of trip destinations and purpose.
- Anecdotes collected when interacting with participants by phone, email and in-person.
- Post participation surveys and five focus groups. In all, feedback was received from 28 households.

¹ California Energy Commission's Demonstration of Neighborhood Electric Vehicles Consultant Report P600-02-020F

3. Research Findings

3.1 Question 1: Will South Bay residents drive NEVs to satisfy a significant portion of their travel needs?

YES

Participants used the vehicles to reach numerous destinations on a frequent basis.

Highlights include:

- **On average households drove 37 miles per week**
- **On average households made 10 round trips per week**
- **NEV travel per household was double the amount seen in Lincoln, CA in 2006**
- **Households drove 19% of their total vehicle travel in a NEV**
- **NEVs were used proportionately more by drivers aged 55 and over**
- **Most frequent trips were those for drop offs (e.g. chauffeuring children to school), work trips and grocery shopping**
- **Lower rates of driving can be explained through lack of appropriate street network, vehicle reliability and charging issues**

Three data sets are being used to address the question: The amount of NEV driving, destinations accessed when driving the NEV; and overall satisfaction expressed on a

post-driving survey. A few anecdotes and related case descriptions add qualitative insights to the numerical data.

3.1.1 NEV usage

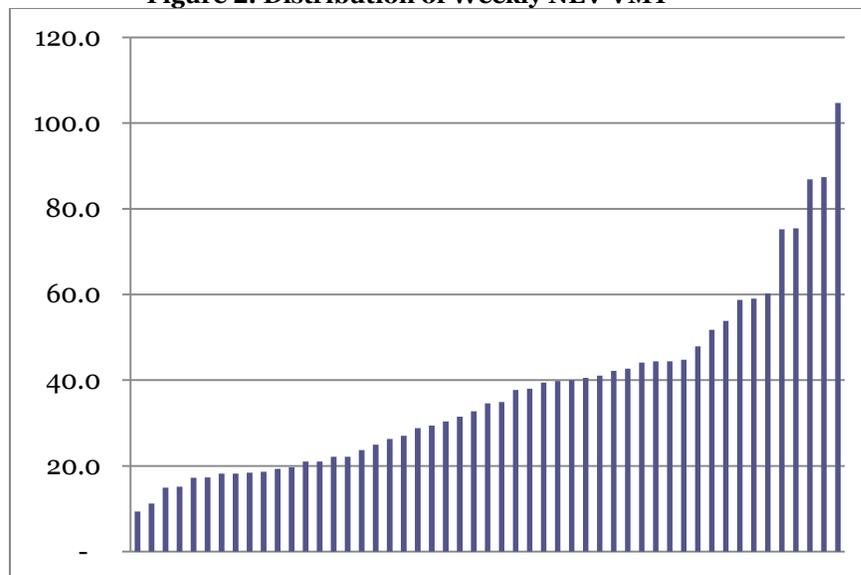
Fifty-one households participated in the program. Over the course of 32 months, 565 test weeks were logged driving neighborhood electric vehicles. A total of 6,100 round trip journeys from home totaled 21,837 vehicle miles traveled (VMT). The average weekly distance traveled per participating household was 37 miles from 10 round trips. The average round-trip travel distance typically ranged from 2 to 5 miles. Most trip legs or segments ranged from 1 to 3 miles and occasionally up to 6 miles. The upper limit recorded for a single trip leg was 16 miles. Average work-related round-trips ranged from 6 to 11 miles in an NEV. In these cases there were multiple worksites chained together throughout the day or households using the NEV for medium distance commuting.

Table 1 shows the total VMT and total weekly VMT for all 51 households. The range between the minimum and the maximum is over 2,000 miles. One household drove 2,123 miles, a surprisingly high amount. Each household drove about 5 miles per day or 1,900 miles per year. This exceeds the average of 1,260 total vehicle-miles reported in a survey of 160 GEM drivers statewide conducted in 2003 by the Green Car Institute. It is almost double the average annual VMT of about 1,000 NEVs and golf carts reported in a 2006 survey conducted in the city of Lincoln (Cosgrove T., 2008), and significantly more than the 1,300 reported in a CEC demonstration of mixed fleet and public NEVs (Little A.D., 2002).

Table 1: NEV VMT

	Total	Min	Max	Average
Total NEV VMT	21830.0	26.0	2123.0	428.0
Weekly NEV VMT		9.4	104.7	37.0
Weekly Complete Household VMT		101.6	659.7	240.5

Weekly VMT ranged from a minimum of 9.4 miles per week to a maximum of around 105 miles per week. The distribution in weekly NEV VMT per household can be seen in the figure below. Over $\frac{3}{4}$ of the households logged in over 20 miles per week in their NEV.

Figure 2: Distribution of Weekly NEV VMT

The following factors explain the variation in weekly NEV VMT:

- **Infrastructure**

The street network connections for low speed vehicles were better in some neighborhoods than others.

- **Technical difficulties**

Some vehicles were more reliable than others and reliability affected use. The range of the vehicles differed from each other and from the manufacturer's estimate. In practice the range varied between 14 and 30 miles. Of course, driver acceleration and hilly terrain also affected range.

- **Household characteristics**

Some households had more drivers than others; the amount and type of social activity varied; some households had family members living nearby and those visits generated trips; households with school age children made many "chauffeur" trips.

- **Work related driving**

The work and work related trips were a surprise. Some drivers made daily visits to multiple work sites (a realtor for example) while other households had minimal work travel because they worked from home, were retired or had a long commute in a gasoline-fueled vehicle.

3.1.2 NEV usage vs. total household travel

A key indicator of the value of an NEV is the proportion of the total driving in each household that was done in a NEV versus in a gas powered vehicle. This calculation requires an estimate of the VT (vehicle trips) and VMT driven in traditional vehicles.

The project's data set for fossil fueled vehicles is smaller than for the NEVs. 35 of the 51 households were equipped with either a handheld GPS unit that they carried with

them on all trips, or a GPS monitoring device plugged into the On Board Diagnostic (OBD) socket of their traditional vehicles.

As with NEV use, there is great variation in total gas-powered travel from participating households. The VMT for gas-powered vehicles range from a total of 101 to 660 miles and from 9 to 92 round trips. The average gas-powered weekly household travel was 240 miles from 25 round trips. To put this in context, the 2001 regional household average VMT was 283 per week.

On average, households used the NEV for 19% of their total Vehicle Miles Traveled (VMT). At the low end of the range, NEVs accounted for only 5%-6% of total household VMT. Low percentages reflected driving patterns with many trips that were longer than the NEV range and required a gas-powered vehicle. In other words, percentage NEV use was low because the gas-powered miles were unusually large.

Here are more detailed descriptions of the households at the low end of the range.

- They traveled to downtown Los Angeles for ‘entertainment’ once and ‘personal services’ once, along with two visits to Beverly Hills schools over the course of two weeks. They also have a worksite 11 miles away and made frequent medical visits 5 miles away. Their local travel consists of groceries, gyms, fast food, and restaurants.
- The next lowest NEV VMT share of 6% was generated by a driver who visits a pediatrician 30 miles away and whose husband’s worksite is 46 miles away. While NEV VMT was low, the round trip mode share was much higher.

- A second household at 6% NEV VMT share has a worksite 18 miles away. The household member who does not have a distant worksite travels 4 out of 7 days a week to a gym 5 miles away and made many of these trips in the NEV. The household's round trip mode share is lower than other households as they take fewer local trips than most participants.
- In the third 6% household, one spouse attends school about 18 miles away in east Long Beach and does not take many local trips. The other spouse has a worksite 16 miles away and performed only basic local travel (grocery pharmacy, hardware) in the NEV.

While the NEV VMT varied greatly by household, the average percentage of all household travel (VMT) taken in an NEV was 19%. In terms of vehicle trips, the NEV mode share averaged 46% of the round trips. This finding indicates a strong potential mode share for a wide variety of Local Use Vehicle types. The mode share would likely rise with a greater diversity in NEV vehicle body types which could accommodate varying cargo and passenger capacity.

3.1.3 Driving patterns of those over 55

Southern California Association of Governments (SCAG) forecasts that the 55 and over age group will have the highest growth rate in Southern California over the next 10 to 15 years. In addition, retirees have been historically the more avid drivers and political supporters of NEVs. Legislation has been recently introduced but not yet adopted in California for creating a driver's license for seniors that would be restricted to NEVs. This section will explore the utility that our drivers 55 and over found driving an NEV.

Seniors in the demonstration overall drove less than younger people. The left side of the bar chart below in figure 3 shows that the 55 and over participants drove their fossil fueled vehicles only about half as much as those younger than 55. The right side of the chart shows that the NEV VMT was slightly greater by seniors than by those younger.

Figure 3: Total Household Gas-powered Weekly VMT vs. NEV VMT by age groups 55 Older/Younger

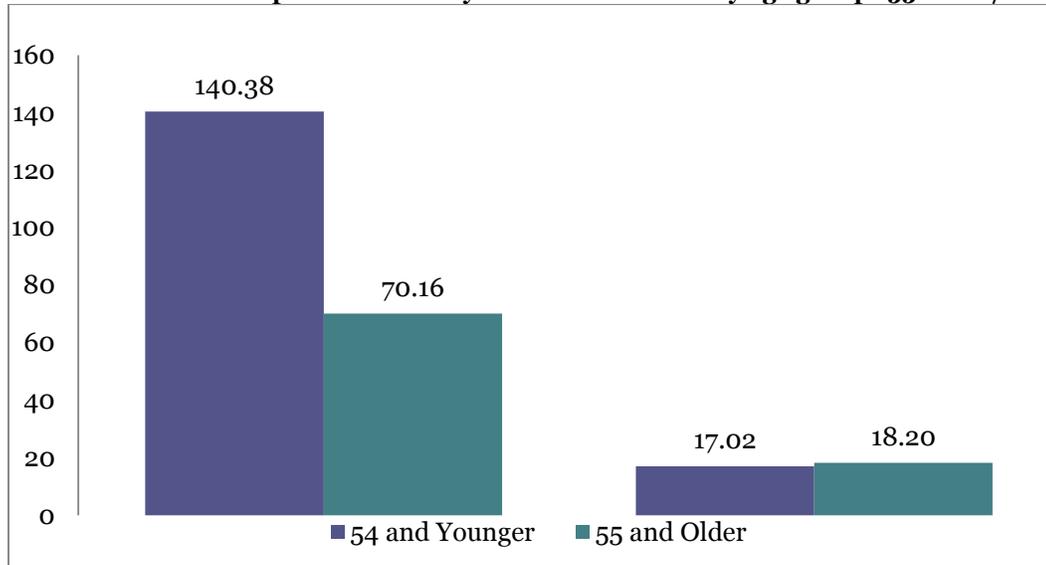
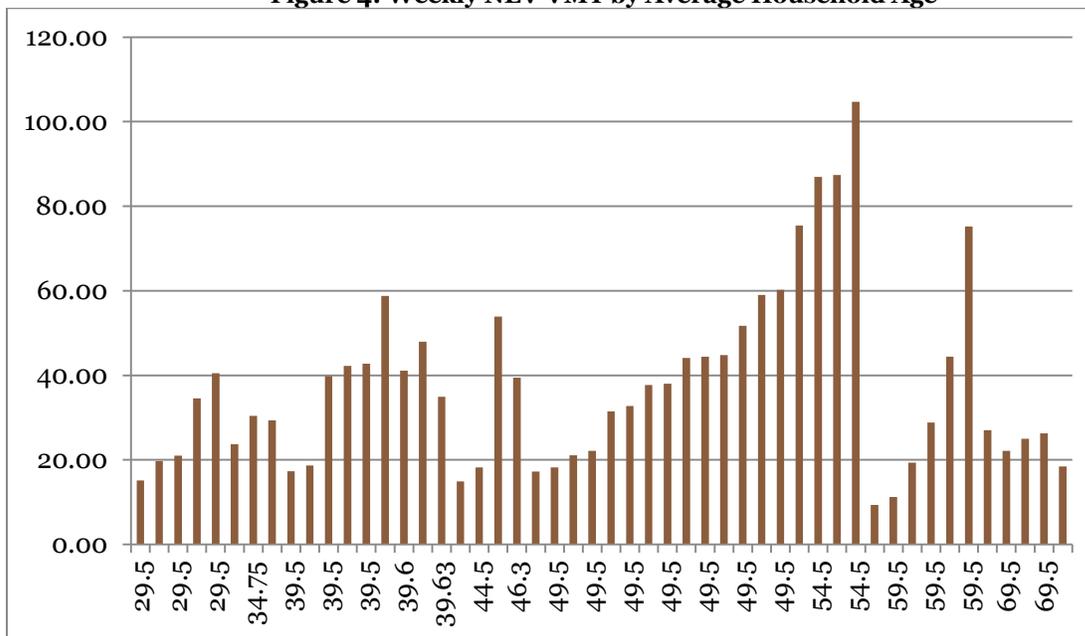


Figure 4 below shows the VMT driven by all participants arranged by the average age of the household. The most NEV driving was done by those 49.5 to 54.5, the group just younger than those 55 and over. A couple of households near 60 also had relatively large average weekly VMT in an NEV. Households with older members drove more VMT miles per week in the NEV than those with younger members. Even though this age group may have lower travel demand, their mobility needs as they age may be best addressed with some form of local use vehicle.

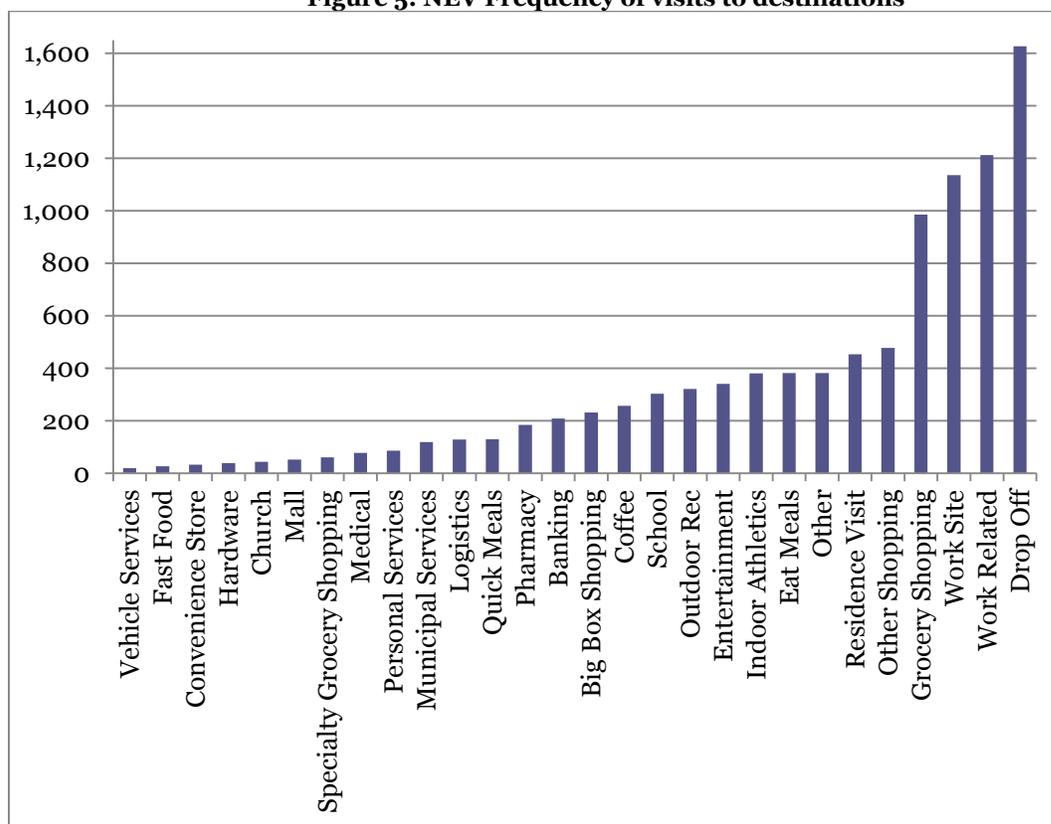
Figure 4: Weekly NEV VMT by Average Household Age

3.1.4 Destination frequencies

Another dimension of the NEV analysis is the destinations visited in the vehicles. A varied set of destinations indicates that an NEV is a viable travel mode for those households. Few destinations would indicate that the NEV was driven selectively rather than routinely.

Figure 5 below shows the total number of visits to each of 28 destination types while driving an NEV. The low of about 5 was for vehicle related service. This makes sense in that NEVs require very little maintenance. Malls are not easily accessed by NEVs as malls tend to be located on fast streets. Medical services may be difficult to access with NEVs because many medical specialties are only available at a distant location.

Figure 5: NEV Frequency of visits to destinations



At the high frequency end, the “drop off” category is associated with parents “chauffeuring” their children not old enough to drive to their various schools and after school activities. Schools were the most common drop off destination (around 60%); other drop off categories included residential houses (23%), sport activities such as dance and karate classes and for recreation destinations such as the beach.

Grocery shopping is also likely to be a short and frequent trip for most families. A neighborhood vehicle would seem ideal for those destinations.

The most surprising result is that “work site” and “work related” are the second and third most frequent NEV destination categories. The journey to work is known to be the longest regular trip taken by household members and thought to be incompatible with

local use vehicles. The best explanation of these results comes from a closer look at the characteristics of 9 of the NEV drivers most responsible for the work site and work related destinations.

NEV Driver Work Accounts

Driver 1 was a realtor that worked out of his home. His work related travel involved visiting the sites of his various listings.

Driver 2 was a contractor. He would have several projects going on at once and would make many trips to each of these sites every day.

Driver 3 was also a contractor. He made many trips to places such as Home Depot and other Hardware stores as well as many trips to his project sites using the NEV pickup.

Driver 4 was engaged in a major remodel of the family home. The entire family was intimately involved with the construction process and either stopped in on the construction or ran construction related errands multiple times per day in the NEV.

Driver 5 worked as a senior center programs coordinator for a city in the South Bay, and went back and forth between three senior centers multiple times every day.

Driver 6 was another real estate agent who made many trips to homes around his area.

Driver 7 was an administrator/pastor for a church and its associated elementary school. The nature of his job allowed him to start work before 7am before returning home in the late morning for an extended break after which he would return to work again in the afternoon – frequently resulting in two commute trips per day and time for charging in between.

Driver 8 was a local independent property owner/manager. A central part of his job was apartment renovations. He frequently dropped off building supplies at these sites and returned later to perform the associated work, resulting in multiple work related property visits each day.

Driver 9 was a physical education teacher who taught at many schools and other institutions. He typically visited between one and three different institutions per day for physical education instruction.

NEV Driver Accounts of Indoor Athletics and School Related Activities

Indoor athletics, the 9th most popular destination in an NEV, is a small surprise. Here are a few details:

Driver 10 worked part time at her synagogue and liked to spend much of her free time at the Gym.

Driver 11 was a home maker with high school age children. She exercised at the gym in her free time. One driver that accounted for a number of school visits has an especially interesting story:

Driver 12 used the NEV extensively to drop his three children off at a primary school, secondary school and a high school. He and his wife also engaged in many school related activities such as PTA and coaching soccer. Their gas powered vehicle had 7 seats. This meant that the use of a five seat vehicle occasionally required them to take the trip two times in a row with a divided passenger load. While this is not ideal, they reported that they didn't mind because they liked driving the NEV so much.

3.1.5 Driver Satisfaction

Another dimension when assessing the utility of NEVs to the participants is their subjective assessment of the experience. On a scale of 1 to 5, 5 being best, the responses averaged 3.65, with about 40% of all participants rating their driving experience the top score of 5. The lower response rates will be discussed later in the report but they generally respond to technology-related issues. The anecdotes and following tables highlight the positive experiences NEV users shared.

Anecdotes

“Surf’s Up!”

In a Manhattan Beach household, the father and his children were avid beach enthusiasts often finding creative ways to load up their paddleboards, kayaks and surfboards into or on top of the GEM for the short trip to their local beach outings

“Weekly Shower”

In one Torrance based household both participants were retired and used their Miles Wagon for “all kinds of trips...to the bank, the post office and shopping.” As part of their routine with the NEV they took it, every Friday, to the local carwash to “clean it up just like it was our regular car!”

Anecdotes

“Christmas Lights”

One very enthusiastic participant who drove the Columbia Summit became inspired to explore neighborhoods that he hadn’t travelled in recently. Of the many side trips he took one that stood out was when he re-discovered the Christmas Light Celebrations of Sleepy Hollow. He found that unlike his full-sized car he could easily negotiate the narrow and crowded streets for this popular annual attraction.

“Positive Design/Build Aspects – Wheego Whip”

A scuba instructor who lived in Redondo Beach and taught diving at a local dive shop used the Wheego Whip to “haul her bulky dive gear” down to the water. She was surprised that, although the Wheego seemed tiny it had a large cargo capacity and easily held all her diving equipment.

One participant in the hills of South Redondo with her husband and 2 grown children loved driving the Wheego Whip and was particularly thrilled that it “had a very large cargo area”. She was delighted that she could drive her NEV to the local OSH Hardware to purchase a large lawnmower and be able to bring it home in the back of the Wheego.

Figure 6: NEV Satisfaction 1-5 (1 is lowest)

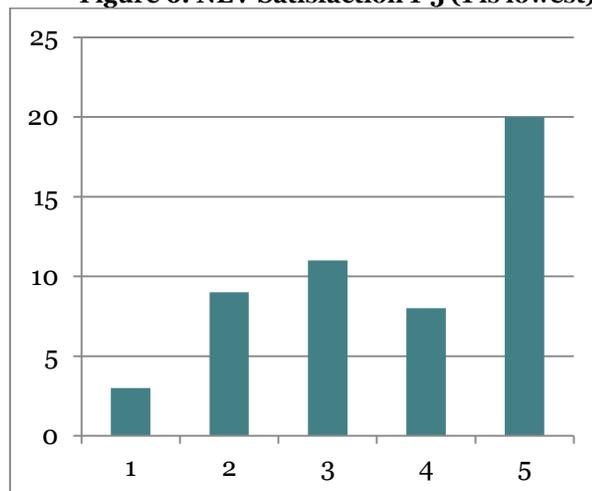
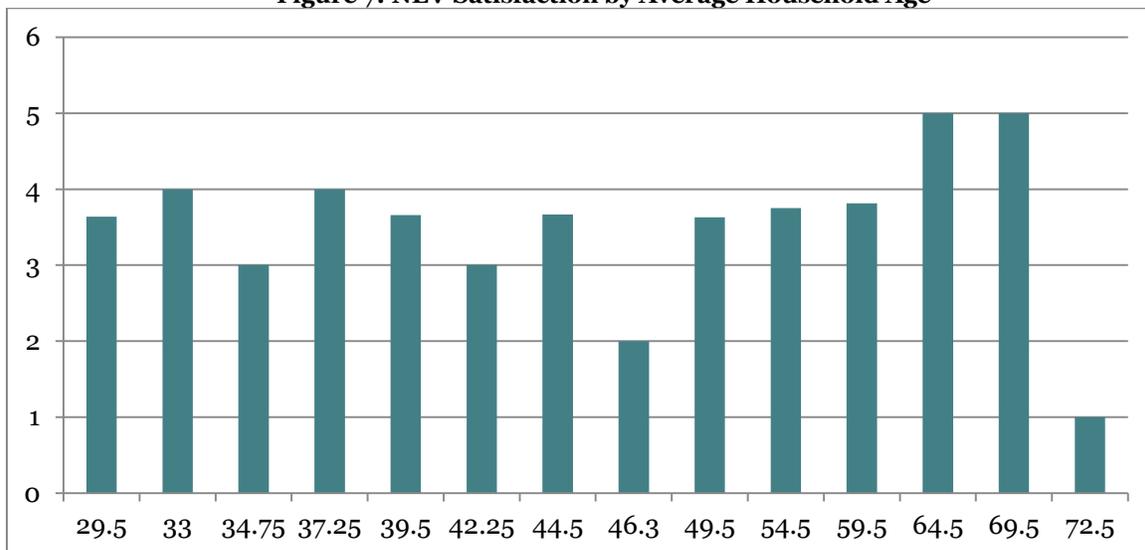


Figure 7: NEV Satisfaction by Average Household Age

Overall, the experiences of NEV drivers in this program were quite similar to those described in the CEC report (Little A.D., 2002):

“The vast majority of NEV participants, although some initially skeptical, came to understand and appreciate the utility, flexibility, and many advantages held by NEVs. Many became involved in the demonstration without recognizing that the slower speed were not meant to directly compete with the high speed gasoline fueled vehicles that they were used to. Many participants underestimated the number of short local trips that they make on a daily basis, and became intrigued by the NEV option.”

3.1.6 Factors that Affected NEV Driving Experience

A number of factors that affected the driving experience are discussed below.

Speed of the NEV vs. Speed of Traffic Flow

The most significant issue encountered was on main arterials where the posted speed limit may be 35 MPH but the traffic flows closer to 40 or 45 MPH during many periods. Drivers experienced discomfort holding up traffic. In response, we added a sticker to the back of each vehicle that said “Local Use Vehicle -- Speed 25 MPH MAX.” NEV drivers reported that other drivers became more courteous once the stickers were added.

While those stickers provided drivers with some peace of mind, the practical solution was to avoid arterials where fast traffic might be encountered. This required route planning and experimentation. The project equipped each vehicle with a map showing streets on which NEVs were legal to drive. In most cases, a parallel street could be found that carried much lower traffic volumes where a slow speed vehicle did not impede other drivers. Often these streets would be residential streets that are designed to handle through-traffic.

Speed can also affect travel time; however given the short distance of trips, participants generally reported that the only issue they had with the vehicle speed was due to limitations in the availability of low speed roads. All participants who experienced route related frustration with the low speed vehicles agreed that a vehicle capable of driving at 35 mph would solve the issue in almost all instances. However, bicycles, Segways, skateboards, and emerging local use vehicles in addition to NEVs also

lack appropriate low speed infrastructure to travel to their destinations in a reasonably direct fashion.

Travel Routes and Neighborhood Islands

Finding appropriate routes for low speed travel was not an issue for some participants, but was a major hurdle to others. The difference was determined by where participants lived and where they needed to go. Participants that lived near the water in the beach cities very rarely had difficulty finding reasonable low speed travel routes, while participants that lived farther inland often experienced such difficulty.

The underlying causes of this difficulty were often found to be a lack of low speed roadway connectivity at city and highway borders. Other causes included roads

with forced turns onto high speed roads, and the large footprints of single land use centers (malls, city airports, industrial districts, etc.) that block low speed roads from being built – functionally forcing all travelers onto higher speed arterial roadways.

“A Parking lot or Shortcut by Any Other Name”

Novel strategies came into play to create routes between and within neighborhoods to avoid high speed 35 mph streets or illegal options where the posted street speeds were 40 mph or higher. Participants would cross streets like Sepulveda Blvd. and enter the Manhattan Beach Village Mall as a way of “cutting through” to the other side so that they could travel to the local theatres and shopping further East on Rosecrans Blvd. Similarly, Del Amo Mall became a slow-speed short cut for those travelling across Hawthorne Blvd. heading toward Redondo or Hermosa Beach.

“40 mph – Looking the Other Way”

From time to time, many of the LUV participants found themselves on streets with posted speed limits of 40 mph; this would happen from inadvertently turning on to a major arterial (i.e. Hawthorne Blvd., Aviation, or Pacific Coast Highway), from forced turn lanes from low speed to high speed streets in south Torrance, or from making a conscious decision to travel – for brief periods of time – on these fast moving streets to connect their trips to locations that they could not otherwise reach (destinations in El Segundo being a good example of this type of trip). Usually, participants would feel very uncomfortable with such fast moving traffic around them. However, two participants who, from time to time, travelled on these 40 mph streets were curious as to what would happen if they got stopped by the police. They inquired with local policemen about whether or not they would be stopped and found out that, “unless they (NEVs) were holding up traffic they (police) would look the other way.” No LUV participant was ever stopped and ticketed for travelling in a 40 mph zone.

In addition to the route connectivity issue, drivers found that the low speed routes that were available to them were often quite a bit more circuitous than the streets they were used to. This is because residential streets are not optimized for through-traffic -- for good reason as

residents want safe streets that are not plagued with high speed cut through traffic. This finding does however point to a need to allow for low speed through-traffic while preventing high speed through-traffic. When examined closely there are many good opportunities to provide such low-speed street network optimizations.

In some extreme cases, the shortage of low speed routes resulted in what we referred to as “neighborhood islands.” These are neighborhoods that are bounded by streets with posted speed limits of 40MPH or faster.

Separate class 2 lanes with striping and signage would eliminate neighborhood islands. An example of class 2 lanes can be seen in Lincoln, CA where there is a fast lane, an NEV lane and a bicycle lane; and in some cases there is a full-speed lane and a “combination lane” that accommodates both bicycles and NEVs (width around 8 to 9 feet).

Charging and Range Anxiety

NEVs have small battery packs and are only capable of short, local trips. All of the demonstration participants charged on 110V, mostly but not exclusively at home.

The resistance to driving a battery electric vehicle (BEV) for fear of getting stranded with a dead battery is often mentioned as a potential barrier. This did not emerge as a factor in the demonstration. Part of the reason is that NEVs

“Opportunity Charging at Whole Foods”

One driver was very creative in terms of opportunity charging. She drove the Wheego Whip which, at the time of her rotation, had a very limited range. One evening, returning late from dinner she noticed that she was almost out of juice. Thinking quickly, she turned into the local Whole Foods store parking lot thinking, “there’s got to be a plug on the outside of the wall somewhere” where she could recharge the NEV with enough electricity to travel the short distance home. As the store was just closing she approached the evening staff to ask permission to use an outlet located on the outside wall of the store. The Whole Foods staff was unsure what to do with her request. Pointing to her LUV car she said, “Dude, help me out, I really need some power right now!” They agreed, and she left the Wheego Whip to charge overnight. She got a ride home and returned the next day to thank the manager for the opportunity charge.

are specifically for local use. With trips of 3 miles or less and a range of 20+ miles, home charging is more than adequate for most households.

“Opportunity Charging at Multiple Work Locations”

One participant worked multiple part-time jobs at local businesses near her home. Two of her jobs involved working at a restaurant and at a doctor’s office, respectively. She used her Wheego Whip to commute to those jobs and, at each location, took the opportunity to “plug in” and recharge for her trip home later that evening.

“Anecdote: Charging at School”

A teacher at a local high school 2 miles from her home would use the NEV for her commute and to drop off her kids at school. Typically, in the morning she dropped off her younger son at the nearby middle school while completing her commute to the high school with her daughter. At the school she would drive “straight up to her classroom, park the car and plug it in with her extension cord.”

Heavy-use households that drained their batteries with numerous local trips throughout the day ended up switching back to their gasoline fueled cars at the end of the day. This issue of needing to switch vehicles at the end of the day did not exist in NEVs with an effective range above 18 miles. The participants who drove their

NEVs so heavily as to drain the battery in less than a day were generally parents who dropped their children at school, extracurricular events, and friends’ houses multiple times during the day. In these cases, EV charging infrastructure installed at destinations would not have made a significant difference as the vehicle was rarely parked at the destination of these chauffeuring trips for more than a few minutes.

There have been three cases of drivers getting stranded. One involved a trip onto the Palos Verdes Peninsula where the batteries wore down from the demands of driving hills -- surprising the driver. The driver simply waited for the battery to recover (regain its equilibrium). Another occurred in the first week of the rotation before the driver had the experience of managing the charge levels. In this case, access to an 110v outlet was borrowed from a friendly resident. In the third instance, the ‘cut off’ switch (used only to prevent battery damage when parking the vehicle long term) was accidentally engaged by a car wash attendant.

Terrain

The South Bay has 3 distinct districts; beach, basin, and Palos Verdes Peninsula (Peninsula). While the first two are relatively flat, the Peninsula is quite hilly. The NEVs in our demonstration were occasionally driven on the Peninsula, but the hills slowed their speed and tended to drain their batteries. More powerful BEVs are better candidates for residents here. However, some small market segment for NEVs probably exists as a second vehicle for those living in close proximity to one of the Peninsula's commercial centers.

“Topography and Range”

One participant who tested both the GEM and the Wheego Whip learned that the steep hills she traversed for her daily commute to Redondo Beach City Hall noticeably drained her battery and, as a result, she would have to recharge at home after work before she could run errands with the NEV in the evening.

Safety

No injuries were sustained in our demonstration and no participant mentioned safety as an issue when driving on low speed roads. Safety was of concern when driving on higher speed roads where the typical flow of traffic is significantly above the posted speed limit. When asked if safety was a barrier to purchasing an NEV, a few participants said they would not buy a vehicle that did not have airbags. They generally did not care about any other safety equipment such as Anti-Lock-Brakes, or highway legal tail lights.

The flip side of driver safety is the potential threats that motorized vehicles pose to pedestrians, cyclists and other motorists. As the organization Safe Routes to Schools reminds us, 12% of all trips in the SCAG region are done via walking and/or bicycling, yet 25% of all roadway injuries and fatalities in the region are pedestrian and bicyclists. NEVs/LUVs are smaller and slower than typical motor vehicles and consequently are less likely to cause significant injury to pedestrians and cyclists.

3.1.7 Two Southern California Testimonials

NEV owners are everywhere throughout Southern California. Although not part of the demonstration project, the findings of the project can be enriched by testimonials from two NEV owners that were encountered along the way.

Paula Lantz, Pomona

Paula Lantz is a Council Member for the City of Pomona and the 2012-2013 Chair of SCAG's Community and Economic Development Policy Committee. She has been driving her GEM neighborhood electric vehicle daily since 2008. Between her duties for the Council as well as her work managing rental properties, Ms. Lantz found herself driving 10 miles a day – mostly all to local destinations. She felt these nearby trips were an inefficient use of her car, and sought an economic and fun alternative.

An owner of a Chrysler Sebring automobile, Ms. Lantz had seen the GEMs at her Chrysler dealer for years, but felt the \$13,000 price was too high, and thought that was the price of a “real car”. Ms. Lantz looked on Craigslist for a used GEM, and found a 2002 2-seater model. It was open-sided and had no doors. She bought it for \$4,500 and outfitted it to do both council work and property management. She has organized her trunk to accommodate both duties.

The first night Ms. Lantz had her GEM, she went out to do a quick errand but didn't return home for several hours. She had been stopped by local residents all along the way, who were interested in her GEM. Today she will mention her GEM takes her a “remarkable number of places”. She drives it to the gym and back daily, to see her daughter in nearby Claremont, and to Downtown La Verne as well. She knows all the NEV-friendly streets, and would like to have access to even more.

Ms. Lantz averages 10 miles on her NEV every day. She charges it every night and has found that there have been no significant changes to her electric bill for charging. Her insurance has been reduced by 50% and she only pays \$200 each year to insure her GEM through Allstate.

In August of 2013, in response to Ms. Lantz getting the “windblown look” in her open-sided GEM, she bought a second GEM through Craigslist, also used, but this one with hard doors. Ms. Lantz finds the GEM with doors is not as much fun to drive as open-door model and has decided to sell it, and stay with her original GEM.

The most common questions she gets from people are; “What is it?”; “Where can I get one?”; “How much did you pay for it?” and “Is it electric?” When asked about how safe she feels in her GEM she says that she's “not moving fast enough to cause much damage”.

Ms. Lantz has not had any mechanical problems with either of her GEMs. She had a problem with one turn signal light, and replaced it. She's also had to replace a set of batteries.

Ms. Lantz's family enjoys a ride in the GEM when they visit. Her daughter and son think it's the coolest vehicle. Her nephew always wants a ride when visiting. Ms. Lantz finds her GEM a very practical and fun vehicle to own.

Russell Fear, Santa Monica

Russell Fear and his family live in Santa Monica. In 2005, they bought a brand new 4-seat GEM. Russell works in the arts mainly from home. Wife Mimi, a self-admitted “bad driver”, worked just a half-mile from their home down a somewhat steep hill. At the time of their NEV purchase, the family owned a vintage VW convertible (that ran a bit rough), and a 1990 VW Vanagon (van). Since the hill between Mimi’s office and home resulted in a sweaty walk home, Russell would often give her a ride back from work in their big Vanagon. When Russell saw the GEM for sale at a city eco-fair, he thought it would be the perfect vehicle for their family’s needs. Today, Russell and Mimi have gotten rid of their two other cars and own only a GEM.

Russell uses his GEM every day as everything in Santa Monica is so close for them. They drive their NEV to the local grocery store, to stock-up at Costco, out for dinner, and Russell has even used it to haul lumber at times. They will also take their NEV over to nearby Culver City to one of their favorite restaurants. Their family also uses public transportation to augment their NEV travel and about once a month they rent an automobile when they need to travel out of the area.

When the family bought their GEM, they did not opt for the available side enclosures. They choose to ride around town in an open vehicle. On the occasional rainy days they wear rain gear. Russell likes the open sides and likes the ability it offers for him to talk with people when he’s out driving. More than once he has come across a pedestrian at a crosswalk that jumped in his NEV for a ride a few blocks up the street.

Russell paid \$10,000 for his GEM eight years ago at a Los Angeles Chrysler dealer. There has been little need for maintenance, and Russell found a mobile service company that comes by to service his NEV as needed. He’s had a wheel bearing wear out and has replaced his batteries once. They have their NEV insured by a standard auto insurance company. Mimi says the NEV costs them 3 cents per mile about 1/10 of the cost of owning and maintaining an automobile.

Russell’s son has spent most of his travel around Santa Monica in a seat in their GEM. Russell believes the NEV experience for his son has given him a more acute sense of his surroundings. For example on one school project, their son knew many landmarks intimately, knew routes around town, and was generally far more aware of his environment than his fellow classmates.

Russell wishes there was more available standard 110v charging around town for their GEM, for example at Metro park + ride locations. The family has found spots at their son’s school to charge and a few other places, but not as much as he would like.



Russell Fear showing off his 2005 GEM at the Santa Monica 4th July Parade (July 4th 2012)

3.2 Question 2: Does the usage have the potential to produce significant environmental and economic benefits?

YES

Over the course of two years, the 5 vehicles in the demonstration project saved around 200 gallons of gasoline per vehicle. In terms of emissions, use of one NEV vehicle was equivalent to planting 35 trees.

These data projected onto 100,000 vehicles would:

- **Save between 10 and 15 million gallons of gas per year**
- **\$45 million dollars saved in gasoline**
- **Emissions reduced equivalent to planting 3,5 million trees per year**

3.2.1 Environmental Benefits

Driving an electric vehicle in Southern California has significant environmental benefits. The reductions in greenhouse gas and criteria air pollutants emitted are achieved partly because power plant emissions are significantly cleaner than vehicle emissions for an equivalent amount of energy. On top of power plant combustion efficiency and pollutant controls, the fuels used by Southern

Emissions Saved through Program

- **12.6 Tons of CO_{2e}**
- **13 Kg of NO_x**
- **.6 Kg of PM 2.5 emissions**
- **Mean weekly emissions: 24 Kg of CO_{2e}, 25 g of NO_x and 1.5 g of PM 2,5**

California Edison (SCE) have significantly lower GHG emissions on the whole compared with gasoline.

In the Southern California Edison market area, driving an NEV reduces the Carbon dioxide emissions per mile by approximately 88%, NO_x by 99.9% and other criteria air pollutants by nearly 100%. The numbers are not as high when using electricity from LADWP because LADWP imports a fair amount of energy generated in out of state coal fired power plants. Even with coal the dominant power as is seen in the 'coal states' the reported mile per mile CO₂ reductions achieved by electric vehicles are reported to be in the vicinity of 50%. The 15 cities entirely within the South Bay sub-region are all served by SCE.

In the 34 households where total weekly travel demand data are available, there was a mean percentage reduction of these emissions equal to 18% of CO₂e, 22% of NO_x, and 21% of PM 2.5. Percentage emission reductions ranged from 5% - to 41% of CO₂e, 7% - to 50 % of NO_x, and 6% - to 48 % of PM 2.5. In other words, the most enthusiastic NEV drivers reduced their household's emissions by about half across the board. The large range is explained through the earlier discussion of how some households make large trips such as the commute in their fuel vehicle but many short, local trips in their NEV.

Of course, NEVs have a more pronounced impact on criteria pollutants than on GHG emissions. Criteria pollutants tend to be generated by cold starts and GHG emissions from driving miles. When a gasoline engine is first started (a "cold start") the fuel is less 'fully combusted' creating an exhaust with high levels of combustion byproducts. This is partially reduced with the advent of catalytic converters, but the catalytic converter does

not effectively burn these combustion byproducts until it warms up to a threshold temperature. In 2002 Arthur D. Little (Little A.D., 2002) summarized the internal combustion engine cold start emission problem by saying:

“Due to cold-start fuel enrichment, subsequent quenching of hydrocarbons in a cold engine, and the delayed attainment of proper operating temperatures of the catalytic converter, between 60 and 80% of the toxic air emissions from automobiles occur during the cold-start period.”

Electric vehicles eliminate 100% of those emissions. A survey of NEV users in Lincoln, California published in 2008 also found significant emissions reductions from eliminated cold starts.²

Unlike criteria air pollutants, GHG emissions are only slightly connected to the thermal state of the engine, and are directly correlated with vehicle miles traveled (VMT). VMT in a NEV reduce GHG emissions compared to an internal combustion engine (ICE) vehicle, but the local use nature of NEVs means that they simply don't generate that many VMT. When both vehicle types are available, NEVs are typically used for many short trips while ICE vehicles are used for less frequent, longer trips. It is clear that driving a NEV at least for the short trips reduces both criteria pollutants and GHG emissions over the same trips taken in an ICE vehicle.

Table 2 shows that the 5 NEV vehicles for 2 years saved 1,070 gallons of gasoline or approximately 200 gallons per vehicle. The 5 vehicles also saved 57 tons of CO₂

² Thriving With NEVs page 5

equivalent. In other words, driving a vehicle for one year is equivalent to 35 trees planted.

Table 2: Household NEV Emission Reduction

Emission Type	Mean % HH Reduction
Hydrocarbons	27%
Carbon Monoxide	23%
Nitrogen Oxides	22%
Particulate Matter 10	21%
Particulate Matter 2.5	21%
Sodium Oxides	17%
Carbon Dioxide	18%
Methane	24%
GHG (CO ₂ equivalent)	18%
Gasoline consumption –	19%

3.2.2 Hypothetical NEV market penetration

The previous Section quantified the gasoline consumption, criteria pollutants and GHG emissions reduced by the 51 households participating in the NEV demonstration. But, what are the potential aggregate benefits to the South Bay sub-region from large scale adoption of NEVs? What scale of adoption might be feasible?

Past NEV market performance is not a good guide to the future. State and local governments and vehicle manufacturers are among the players that can influence the future market. Multiple initiatives from both the public and private sectors will be necessary if the number of NEVs are to increase substantially (these initiatives are discussed below in the answer to Question 3).

A true market forecast depends on a set of factors discussed in Question 3. Rather than trying to estimate the market we conceptualize a certain percentage of vehicles replacing second household vehicles.

Consider 10,000 NEVs (or some sort of local use vehicle) by 2020 in the South Bay. To put this target into context, SCAG estimates that there were approximately 600,000 vehicles in the South Bay in 2011, about 275,000 of them “secondary” (not the first vehicle in multiple vehicle households). An additional 30,000 vehicles are forecast by 2020.

UCLA’s Luskin Center for Innovation estimates there were 750 battery electric vehicles in the South Bay in 2012 with a conservative projection of 47,000 by 2020. The most optimistic forecast is 70,600 by 2020. In other words, between 11% and 13% of all vehicles in the South Bay are expected to be some form electric by 2020.

The 10,000 vehicle level is less than 4% of secondary vehicles in the South Bay today. Following the Luskin report, 13% of all secondary vehicles equates to 76,000 electric vehicles. A very ambitious scenario would be transitioning to 100,000 NEVs. The estimated benefits of such a large number, outlined below, should help determine whether the efforts to accelerate the NEV marketplace are worth it.

3.2.3 Projected Environmental benefits

The overall environmental impact from such a simple technology is potentially substantial. If significant market acceleration techniques were employed, a NEV passenger vehicle fleet would be capable of achieving the following annual emission reductions.

Table 3: Annual Projected Emissions

	From 10,000 NEVs	From 100,000 NEVs
Hydrocarbons – Tons	9 Tons	90.5 Tons
Carbon Monoxide – Tons	128 Tons	1,279 Tons
Nitrogen Oxides – Tons	12 Tons	121.5 Tons
Particulate Mater 10 – Kg	598 Kg	5,981 Kg
Particulate Mater 2.5 – Kg	557 Kg	5,565 Kg
Sodium Oxides – Kg	95 Kg	948 Kg
Carbon Dioxide – Tons	11,100 Tons	110,997 Tons
Methane – Tons	1.6 Tons	15.9 Tons
GHG (CO ₂ equivalent) – Tons	11,848 Tons	139,431 Tons ³
Gasoline consumption – Gallons	1,018,267 Gallons	10,188,671 Gallons

The 139,431 Tons of GHG reductions projected to be achieved with 100,000 NEVs would be a significant public benefit. *Putting 100,000 NEVs on the road would save between 10 and 15 million gallons of gas per year⁴. The carbon emission offsets would be the equivalent of planting over 3.5 million trees each year.⁵*

Another approach to evaluating the potential of NEVs is to project the benefits from South Bay residents ‘range matching’ or matching the range of the vehicle to the distance of daily trips. Assuming all trip segments taken by South Bay residents that are less than 5 miles long are taken in some sort of electric vehicle, approximately 1.7 billion or 43% of the VMT driven by South Bay residents could be shifted from gasoline to EV propulsion technology. That is approximately 1 billion annual trip segments or 82% of all trip segments. That equates to a 59% reduction in private vehicle

³ GHG emissions are calculated using CO, NO_x, CO₂, CH₄ via <http://www.epa.gov/cleanenergy/energy-resources/calculator.html>

⁴ Low end is calculated based on modeled LA County passenger fleet vehicle average mpg

Upper end calculated as a GHG equivalency via <http://www.epa.gov/cleanenergy/energy-resources/calculator.html>

⁵ Equivalents are based on the average of LUV test users and EPA GHG Equivalencies Calculator <http://www.epa.gov/cleanenergy/energy-resources/calculator.html>

Hydrocarbons, 52% reduction in Carbon Monoxide, 51% reduction in Nitrogen Dioxide, 48% reduction in all particulate matter, 47% reduction in Sodium Oxides, and a 56% reduction in Methane emissions. See Table 4 below.

Table 4: South Bay Emissions Reductions through shifting all Under-5 Mile Trips

	TOG	CO	NOX	PM10	PM2.5	SOX	CO2	CH4
Tons 2011 Households	714	10,666	1,042	51	48	10	1,000,471	135
Tons 2020 Households	746	11,149	1,089	53	50	11	1,045,810	142
Tons 2011 Vehicles	653	9,755	952	47	43	9	814,914	124
Tons 2020 Vehicles	685	10,241	1,000	49	46	10	855,450	130
% Reductions	59%	52%	51%	48%	48%	47%	43%	56%

The EPA calculated GHG reduction equivalency from shifting all 2011 trip segments under 5 miles in length to electric propulsion vehicles would be 1.2 Million Metric Tons – the equivalent of 13.6 million gallons of gasoline per year – 32 Million trees planted – carbon sequestered annually from 1,586 square miles of forest (that is the size of Massachusetts and Connecticut combined).⁶

Current South Bay data show that NEVs can account for 83% of the vehicle trips under 5 miles and 43% VMT under 5 miles demonstrating that NEVs are the best solution for vehicle travel under 5 miles. These projections illustrate that the potential value of the SBCCOG’s ‘range matching’ initiative.

⁶ The calculated impact is derived from baseline travel demand of participating households that does not represent a random sampling. A random sample would likely show the same volume of short distance trips but a higher volume of long distance commute trips.

3.2.4 Projected Economic benefits

Transitioning 100,000 ICE vehicles to some form of electric-drive vehicle would save South Bay residents \$45 million per year⁷ on gasoline, with the amount increasing as prices increase. This would be approximately \$448 of savings per year for each of the NEV-households. Shifting \$45 million annually from gasoline purchases to the disposable income of South Bay residents would stimulate an array of non-automotive sectors such as retail, housing, food and beverage, health care and others.

Local businesses would benefit from NEVs (local use vehicles in general) not just due to an increase in consumers' disposable income, but also because lower speed and range limited vehicles have been shown anecdotally in this study to increase residents' awareness of local businesses and their likelihood to shop locally due to this increased awareness.

If the SBCCOG's "range-matching" was successful so that all trip segments under 5 miles in length were driven in an electric vehicle, the annual fuel cost savings to the South Bay would be approximately \$390 million in 2011 figures (approximately \$1,000 annually per household) and almost \$500 million by 2020. The assumptions are noted in the footnote below.

Table 5: Projected Fuel Savings from shifting all Short Distance Trips to NEVs

	Gasoline Consumed	Gas Cost Savings	Fuel Cost Savings ⁸
2011 Households (352,620)	87,915,844	\$439,579,219	\$360,975,278
2020 Households (368,600)	91,900,006	\$599,543,316	\$492,335,182
2011 Vehicles (600,900)	80,580,519	\$402,902,593	\$330,857,031
2020 Vehicles (630,790)	84,588,759	\$551,845,722	\$453,166,697

⁷ Assuming \$5/gallon gas, and \$0.13/KWh where NEVs use 0.233KWh/Mile as calculated by the California Energy Commission in the 2002 report titled Demonstration of Neighborhood Electric Vehicles

⁸ Cost savings are calculated assuming 2011 electricity prices of \$0.13/KWh and \$5/gallon gas both with a 3% escalation rate. KWh/mile is assumed to be 0.337 as monitored by the SBCCOG on two Nissan Leaf's for a 2 month period.

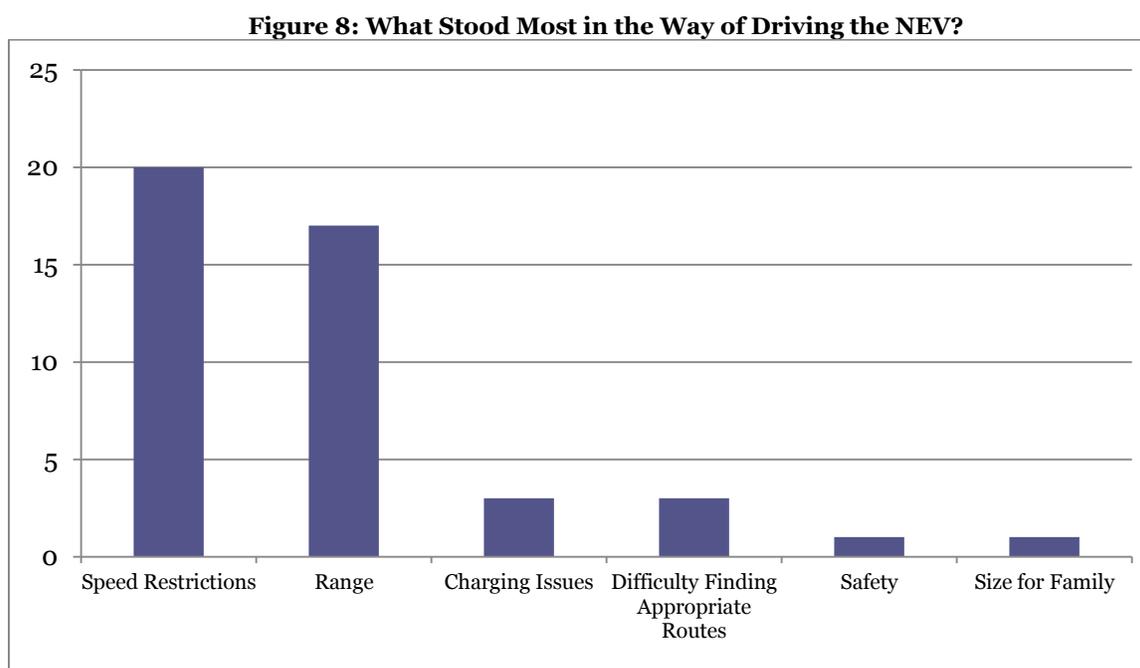
3.3 Question 3: Can NEVs (LUVs) become a significant market segment?

Maybe

More widespread use of the vehicles was constrained by infrastructure issues such as legal speed requirements and route options. Some drivers experienced speed anxiety (low speed vehicle holding-up faster traffic flow). Discontinuous slow-speed routes also proved a barrier. Most importantly, the price and quality of the vehicles were the largest factor. 83% of respondents indicated they would be willing to pay \$6000, 69% were willing to pay at least \$8000.

There is no clear cut answer to the potential size of the NEV/LUV market segment because it depends on what a variety of institutions do to overcome the constraints. Market solutions include: complete streets that specifically accommodate slow speed electric drive vehicles; manufacturers that produce vehicles with higher quality and lower price than today; federal and state subsidies more generous to small battery, short range vehicles; state emissions credits more generous to small battery, short range vehicles; more effective retailing models; and more self-aware consumers capable of matching the range of their vehicle to the length of their trips can all contribute to a more robust market segment.

The attitudes and opinions about their experience with NEVs were collected from 45 participants by surveys, focus groups, and informal interactions with project staff. The following chart identifies those issues that respondents believed most affected the use of the NEV. Speed restrictions and range were mentioned by 20 and 15 of the drivers, respectively. Of the concerns that were mentioned by less than 5 of the drivers, route issues are related to speed restrictions and charging issues are related to range.



3.3.1 Speed and Route Issues

Speed

The 25 MPH speed limitation and restrictions to arterials with speed limits of 35 MPH or less were the biggest barriers to additional use by our participants. The low maximum speed was not a problem in terms of time on the road since all the trips taken

were of short duration anyway. The issue was low speed in relation to the flow of faster traffic. This might be termed “speed anxiety.”

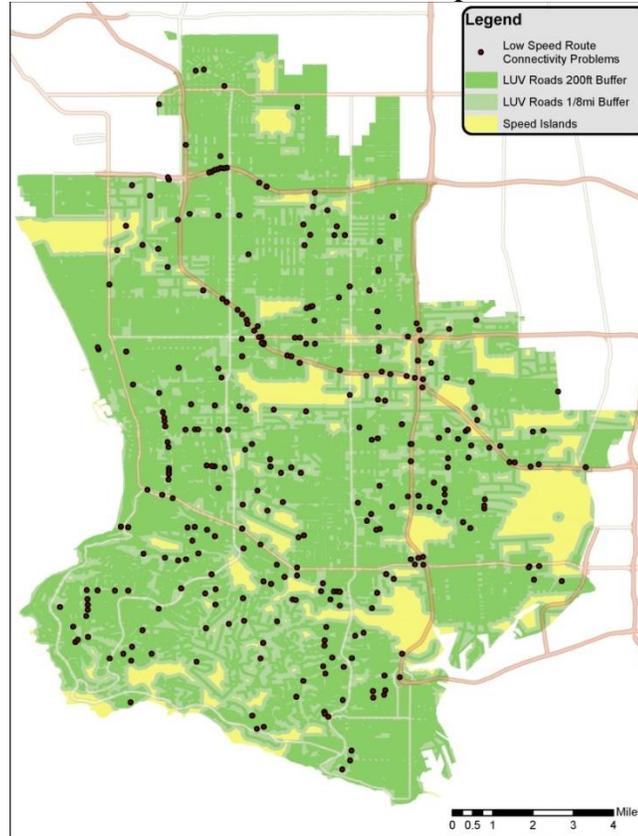
The problem was more pronounced with the Wheego and Miles, the NEVs that looked most like a normal car, and least in the GEM since its unusual appearance naturally communicated its limitation to other drivers. In response, we added a prominent sign to the back of each vehicle announcing that it was speed limited. This helped relieve our drivers’ anxiety.

Route problems are related because most direct arterials typically have 35MPH or faster speed limit. Driving NEVs on 35MPH arterials often caused speed anxiety. Arterials with a posted speed limit of 40 MPH or faster required the search for alternate routes which were inevitably less direct and often discontinuous.

Routes

The figure below highlights areas in the South Bay that are at least 100 feet from a 40mile per-hour street making it difficult for a slow speed vehicle to leave the area. As can be seen, these neighborhoods make up a significant portion of the South Bay and are more prevalent in the inland cities as well as the peninsula. The image also shows points where low speed routes are not connected and where it is impossible for a NEV to traverse. As can be seen, these points are clustered around highways and high-speed arterials.

Figure 9: Speed Islands and Discontinuous Low-speed Routes in the South Bay



The pictures below illustrate a low speed route that is interrupted by a barrier.

Elimination of barriers can provide more route options for slow speed vehicles.



Solutions

South Bay cities can begin managing street rights of way (ROW) to accommodate and even encourage slow speed vehicles, including bicycles, as well as full speed

vehicles. This would also apply to Caltrans (owner of state highways such as Pacific Coast Highway and Hawthorne Blvd.).

California's Complete Streets Act of 2008 (AB 1358) mandates exactly that kind of approach to retrofitting faster streets. The objective is for the major arterials to eventually accommodate all users – full speed autos, cyclists, transit services, pedestrians and motorized slow speed vehicles. This has typically been interpreted as creating Class I or Class II bicycle lanes, however that narrow definition opens the streets to only one additional mode.

Lincoln, California has fashioned complete streets by creating separate side-by-side lanes for NEVs/golf carts and for bicycles. When the ROW is not sufficiently wide to accommodate three dedicated lanes (full speed, NEV and bike), Lincoln deployed “combination” lanes for both bikes and NEVs to share that are 8 to 10 feet wide instead of the typical 6 to 8 feet for bike lanes.



Separate class 2 lanes in Lincoln, CA



Combination class 2 lanes in Lincoln, CA

Some of our participants, while they would gladly use combination lanes, said they did not want to ‘interfere’ with bicycle infrastructure. Another reservation was the use public funds on vehicles not widely used -a classic chicken and egg situation.

The City of Hermosa Beach recently designated a full speed lane on a street segment in its downtown area as a “sharrow” (“sharrows” alert drivers of potential bicyclists). Such lanes would also accommodate motorized slow speed vehicles. Managing the road infrastructure has proven to be politically volatile in many communities who have tried it, particularly where parking would be affected.

Adding traffic calming devices or lowering the speed limit are roadway management options that slow traffic without reallocating lanes. Speed limits, based by law on the speed of traffic flow, are difficult to change. The risk of traffic calming of any sort is more congestion and political opposition by drivers of full speed vehicles, particularly in areas like the South Bay where arterial roadways often function as major throughways.

ROW management can also occur by optimizing the street network. This involves targeted alterations to streets that currently make certain neighborhoods into “speed islands,” by removing connectivity barriers in order to create a continuous network of slow speed routes. Our focus groups generally supported this approach.



Grade Separated Lane in Torrance, CA

Another way to address the speed/route issue is for the State or federal Department of Transportation to authorize a class of vehicles that are allowed to operate at 35 MPH. This class is referred to as a medium speed vehicle (MSV).

MSVs tested very well with focus group participants. One participant even sought to start a lobby to create an MSV classification with the National Highway Traffic Safety Administration (NHTSA) of the USDOT. The creation of an MSV classification might result in higher safety standards for equipment including airbags and could require crash testing which is expensive and could make producing the vehicles uneconomic.

NHTSA was approached by the Medium Speed Electric Vehicle (MSEV) Coalition (an advocacy group) in the late 2000s to create such a classification and declined to do so on safety grounds. Nine states including Washington, Hawaii, Indiana, Maine, and Texas have created their own MSV classification in violation of NHTSA regulations.⁹ This approach may result in more Local Use Vehicles on the road, but it comes with the risk of the state losing federal transportation funds and of being exposed to litigation from the NHTSA if a severe accident occurs.

A final strategy for addressing the speed/route issue is to do nothing and let the market take over. There is a chicken-egg situation where the driving culture can change to accommodate NEVs through road management techniques, or more NEVs on the road will help change the driving culture. With a sufficient number of NEVs, lanes closest to the curb or to the parking lane could evolve organically into de facto “sharrows.” The experience in senior communities followed a similar path as a

⁹ <http://www.iihs.org/laws/low-speed-vehicles.aspx>

concentration of NEV drivers developed in sufficient numbers to effectively pressure the local government to accommodate their needs.

3.3.2 Range and Charging Issues

Issues

Range and charging are related because the need for periodic charging increases as range declines. Based on focus group discussions, it appears that the issue is not the relatively short range between charges but the variation in the actual compared to the manufacturers' listed range. The fairly low quality control in the vehicles used (discussed below and in the Appendix) is at the heart of the problem.

Assessing the cause of variations in range is complicated since effective range has many variables. As was discussed earlier, actual range is directly affected by the terrain, driving habits, amount of night driving (use of head lamps), and use of radio or air conditioning when included. Age of the batteries is a factor. Range is also limited when the driver forgets to plug in the vehicle overnight, an error that is common in the first few weeks of driving an electric vehicle.

Realistically, the 25 mile range, if it is reliable, is sufficient for all but a few drivers. There was one case where the household use was so extensive that NEV had to be exchanged for the family car mid-day. The 25 mile limit had been reached in a few hours through continuous driving. This was unusual.

Solutions

Every participating household charged at home on a normal 110V outlet. One option for extending range would be for many local retailers to offer an 110V outlet for NEVs to be opportunistically charged even during brief stops. It takes about 15 minutes to charge an NEV for a ½ mile drive. A full charge takes 10 hours.

The range problem, like the speed problem, could self-correct once more reliable vehicles on the road reach a critical mass of numbers. Once that threshold has been passed, most destinations will be offering some sort of charging opportunity for visitors.

The focus of public EVSE deployment planning to date has been on the location of level 2 chargers, especially at work sites. One of the benefits of a substantial fleet of NEVs is that the far less expensive level 1 charging is sufficient for their small battery packs. This makes affordable the prospect of near ubiquitous charging opportunities currently associated with gas stations. It is also less taxing on the electric infrastructure.

3.3.3 Range Matching Vehicle Purchases

Demand for specialized, slow speed, local use vehicles depends on consumers coming to understand their actual mobility needs. The multi-purpose, full speed, gasoline fueled vehicle has been embedded in the culture for nearly a century. Consumers are just beginning to accept vehicles defined in terms of range.

Solutions

There are at least two consumer education initiatives that might lead to wide-scale deployment of NEVs.

The first is an online tool that invites interested parties to input their travel patterns in order to obtain a zero emission vehicle scenario that addresses their household mobility needs. A variation is a community-based transportation planning “charrette” that would develop a neighborhood-based methodology for teaching residents to self-assess their mobility needs. The SBCCOG proposed this to Caltrans in 2011 but that project was not funded.

A second education initiative would be to explain the charging requirement and options at the PEV point of purchase and on local government web sites. The electric charging infrastructure and practices are radically different from liquid fueling through its ubiquitous gas station networks. Topics from whether a panel upgrade is needed at home to driving patterns to cope with range limits are suddenly important factors. Though the NEVs required no electrical upgrades, participants in the NEV demonstration experienced a learning curve of between two weeks and a month just to master the range-charging interaction.

Education about how to assess the value proposition of NEVs, including the environmental benefits as well as the household fuel savings will also be valuable. Traditionally this has been the domain of the vehicle sales force. However, some special effort will be required in order to include the full range of LUVs and the potential environmental and economic benefits about which some households are more sensitive than others.

3.3.4 Price and Quality

Supply is as much an issue as demand. The primary barriers to ownership of a NEV are the price and the quality of the vehicle. The question of whether a significant market segment can be developed depends on whether or not vehicles can be produced at a quality and in a quantity that meets the price point that consumers will pay for such specialized vehicles. If not, consumers will continue to use multi-purpose vehicles that are larger and more powered than necessary for those trips. Government incentives may be necessary for manufacturers to build low cost vehicles with limited profit potential.

This section reviews the challenges to the NEV. The following chapter describes LUVs in production or prototype elsewhere that might address this specialized market segment in the future.

NEV Components

When asked about purchase barriers for NEVs, participants universally agreed that poor design and construction practices would be unacceptable even at significantly reduced prices. While there was some interest in purchasing an NEV, around 40% of the participants stated that price was an issue. This issue of build quality is particularly interesting, as many drivers want more car-like amenities but struggle to accept the NEVs that most closely resemble traditional automobiles. It appears that the closer the vehicle is to looking like a normal car, the more the driver expects the quality and creature comforts that come with mass produced automobiles sold in the American market. Thus many drivers of higher end NEVs expressed a desire to have a more stripped down version of the NEV that would reduce the cost and make it feel like a

different type of vehicle all together; while the drivers of lower end NEVs appreciated the simplicity, but wanted improvements in seat quality.

The NEV drivers experienced extensive and varied problems with part durability. The majority of these problems are a result of low quality plastic components that easily break such as key fobs, glove box handles, door handles, gear selection box, and rear view mirrors. Additional component problems included:

- Poor calibration of the parking brake cut off switch which caused accidental motor cut off on numerous occasions.
- Electrical components that would 'go haywire'
- Batteries that needed replacement due to poor quality control by the manufacturer
- Un-diagnosable power failures
- Malfunctioning onboard charging units
- Parking brakes that could not properly hold the vehicle in place while parked on mild hills
- Seatbelts that would not allow participants to buckle while parked on steep hills
- Peeling coatings on headlights and tail lights
- Knocking sounds during acceleration
- Loose control wiring causing power failure

NEV Design and Configuration

The most common design failure reported by NEV drivers was poor placement and design of the battery disconnect or cut off switch. Placement of the switch behind the

passenger seat or at the foot of the passenger seat caused numerous accidental engagements of the battery disconnect switch in the course of normal use. In all such cases, drivers were unaware that the switch had been accidentally engaged and could not figure out why the car stopped working all together, necessitating assistance in solving the mystery of why the NEV no longer powered up. Poor placement was compounded by poor switch design in some vehicles where the 'default' position of a switch was off, effectively facilitating accidental switch engagement.

Participants generally agreed that, to be successful, NEVs should have radios, power steering, and comfortable seats, but every other feature should be bare bones to reduce cost. For example, our participants believed that doors were not necessary, particularly as that would lower the price (however, all demonstration vehicles had doors).

NEV Price

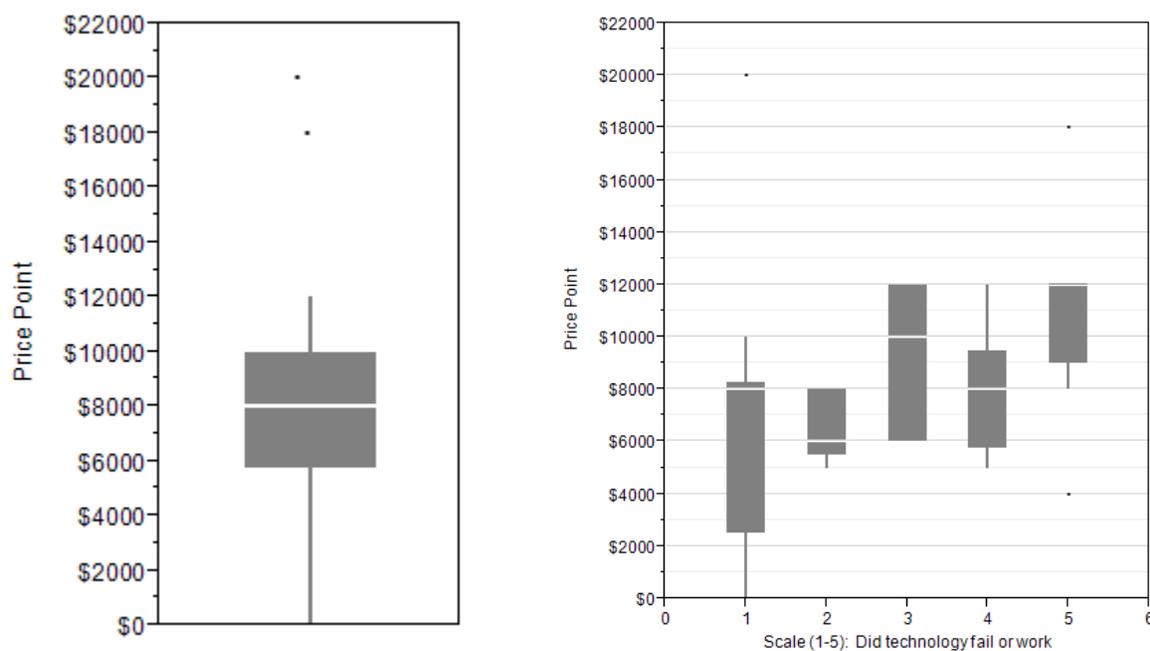
Our participants universally agreed that the price must be reduced significantly before they would consider purchasing an NEV. The NEV's used in the demonstration program cost between \$14,000 and \$21,000 new. 69% of the respondents indicated that they would be willing to pay \$8,000 or more for an NEV while 83% of the respondents indicated that they would be willing to pay \$6,000 or more (see Figure 10 below).

These price points are based on the assumptions that certain improvements are made to the vehicles which was validated at the end of the program when the SBCCOG made a couple of the vehicles available to participants for purchase and manufacturers' vehicle liquidation offers were forwarded to participants for their consideration. With

no changes to the vehicles no participant was willing to spend \$7,500 for a new Miles EV that was priced \$12,000 below MSRP to liquidate in preparation for the arrival of the next model year; nor was any participant willing to spend \$5,000 for a used Miles EV Sedan, Miles EV Pickup, or Wheego Whip.

Figure 11 below illustrates the interplay between price and quality among our participants. Those who experienced breakdowns or frustrations with design features indicated a willingness to pay \$6,000 to \$10,000 for an NEV. Those not experiencing those difficulties were willing to pay \$8,000 to \$12,000. Overall, 69% of respondents agreed that the reasonable price for quality NEVs should be between \$8,000 and \$12,000.

Figure 10 and Figure 11: NEV Price Range for Test Drivers and Relationship between Technology Failure and Willingness to Pay



Three vehicles from the pilot study were sold. Two vehicles were sold to the county and one to an individual from the study itself. Two other individuals from the study purchased a new GEM and a new Miles.

Solutions

The vehicle supply issue may be the hardest to address. The SBCCOG intends to inform manufacturers about the existence of a market segment defined in terms of slow speed, local vehicles. Electric vehicle manufacturers can benefit from the zero emissions credit market. More credits are given to vehicles with larger ranges. Tesla has benefited greatly from these credits helping to explain why they have experienced immediate profits. Currently NEV manufacturers receive smaller credits due to the low range of the vehicles. In order to stimulate the NEV market, credits should be enhanced. This would in turn reduce the pressure on market prices and attract more suppliers.

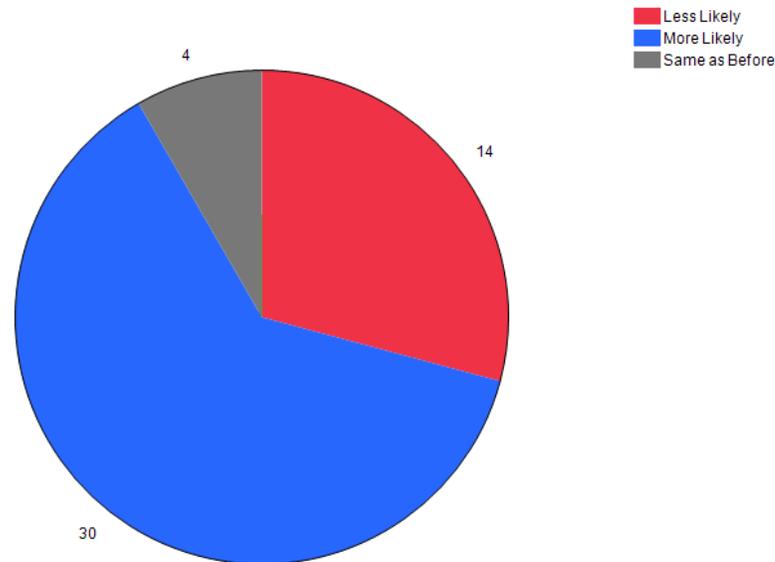
There is a bottom line to increasing supply. Manufacturers need to make a reasonable profit producing a sturdy, low amenity vehicle specialized for local use and slow speeds. The options on the horizon are discussed in the next chapter. Assuming the manufacturing challenge can be met, the need for retail distribution channels is the final issue.

3.3.5 Retailing Issues

NEV sales and distribution issues have been a barrier to success in the past, and they remain barriers today. There are no NEV dealers in the South Bay. Absence of dealerships selling NEVs means there are no opportunities for prospective buyers to test drive the vehicles. As with any vehicle, consumers are used to driving it before

purchase. Having hands-on experience with NEVs is important in promoting the vehicles. Our survey shows that 60% of our participants are more likely to purchase an NEV due to their experience in the demonstration program (see Figure 12 below).

Figure 12: Likelihood to Purchase an NEV after Program Experience



For much of the NEV history, conventional automobile and golf cart dealers have been the distributors of the low-speed vehicles. There are problems with both of these types of dealerships when it comes to NEV sales. While there are challenges with these existing models, there are also opportunities to consider such as new, Internet-age sales and distribution models that could quickly satisfy substantial NEV adoption across the South Bay.

In the past, several NEV manufacturers have sold their vehicles through automobile dealers. There were poor results from this approach for several reasons. Dealer motivation was low because they make considerably more profit selling more expensive vehicles. NEV inventory takes space that could be used to store the more profitable

units. Many dealerships were located on high-speed arterials or next to freeways making test drives difficult or impossible.

Golf cart dealers, located in warm areas of the country, have had some success in selling NEVs. They are accustomed to the scale of technology and the need to transport NEVs to and from a service appointment at times. But most golf carts are sold in fleets to golf courses. The independent dealers are usually under-capitalized and have facilities that are lacking in appearance. They tend to locate on less expensive land on the metropolitan fringe, far from the suburban or urban areas where NEV demand could potentially be found.

Bicycle dealers are located in better locations for NEV sales. They are also more connected with other potential mobility options in the area. But they do not have experience with motorized vehicles and lack the space required to showcase even just a few NEVs, let alone accommodate any NEV service operations.

Solutions

There is an opportunity to “reinvent the dealership” in our new Internet-age, and see a more meaningful sales channel become established for NEV sales. Some electric automobile makers have begun innovating in these areas on their own. New channels have the potential to offer a richer, more informed sales process to a prospective customer, and allow the NEVs to be test driven in the consumer’s own neighborhood, while keeping the NEV price as low as possible.

Consumers today can learn quite a lot about a particular vehicle online. It may be possible to reinvent vehicle retailing by creating a network of “NEV Sales Ambassadors”

that assist the sales process in the community they live in, supported by a regional centralized support operation. It is feasible today for a prospective NEV buyer to go to a website, type in their zip code and have their request for a “test drive” forwarded to a NEV Sales Ambassador located in their community.

The local ambassador could arrange a test drive at the prospective buyer’s home or nearby the home using their own NEV. The ambassador could inform the prospective buyer about local driving routes and other relevant information, along with assisting them with an online purchase. Using this model, the NEV company would set-up a central fulfillment center in the larger metropolitan region to provide mobile delivery and service directly or through a second-party contract service provider. Lastly, it’s not hard to imagine that the delivery of a new NEV into a neighborhood could become a sales event as well, almost like a Tupperware Party, where neighbors would come and learn about their neighbors new NEV.

3.3.6 Government Role

There must be a compelling reason for governments to facilitate a private vehicle market. The impacts on air quality and GHG emissions described in the answer to Question 2 provide a strong argument for public support of NEVs. Here are a few additional considerations:

- In general, society benefits when consumers use the smallest unit of energy needed to meet their needs. Although both are electric, driving ½ mile to the local grocery store in a 5 hp GEM rather than a 400 hp Tesla is better for society. Of course, either would be preferred to a gas powered vehicle.

- Small battery packs offer a number of significant advantages. They can fully charge at home with the ubiquitous 110 V (level 1) electric outlet. This reduces the barriers to occupants of multi-unit dwellings and does not challenge a dwelling's or building's electrical infrastructure. They also require less electricity to fully charge which means less energy is required from the utility company. Small battery packs weigh less, take up less room, and cost less than larger packs to purchase and eventually replace. Battery cost is one of the reasons why PEVs are more expensive today than their gasoline fueled vehicle counterparts.
- NEVs are also physically small which means they take up less space on the road and require less space to park. They offer the potential to reduce parking lots and road surfaces around residential and commercial areas of neighborhoods. This in turn reduces the urban "heat island" effect allowing communities to realize more green space.
- Less space required for parking (and less investment in public charging infrastructure) also changes the economics of building, which can make the redevelopment of the existing built environment into new neighborhood designs more feasible.
- Life cycle costs – the costs of vehicles from production to demolition – will be lower with NEVs. Using fewer batteries means fewer batteries to recycle. In general, fewer parts require fewer raw materials and less energy in the manufacturing process.
- Advances in telecommunications are offering individuals new options to work, shop, and socialize with little or no travel. Enhanced public transit along with new car share and rideshare options diminish the need for one-size-for-all-trips

transportation. These trends make local use vehicles a feasible and potentially valuable element in upcoming metropolitan mobility systems.

- Small, lightweight, slow speed vehicles pose less of a threat to cyclists and pedestrians on residential streets. NEVs serve as “active traffic calming” agents.

Several examples of local government policies and infrastructure investments have been identified in the previous sections on issues key to large scale deployment of local use vehicles. The following recaps the preceding options and adds a few more.

Class I and II lanes

The possible infrastructure investments that would stimulate large scale deployment of NEV/LUVs can be addressed through a “complete streets” plan. According to AB 1358 passed in 2008, starting January 2011, all cities and counties, upon the next update of their circulation element, must plan for the development of multimodal transportation networks. Cities are required to craft a network of travel options that are reflective of a community’s individual context.

In order to support NEV/LUVs, Class I and Class II multimodal lanes should be considered. Class I lanes are completely separate from traffic while Class II lanes are on-street but marked as a separate lane. Class I lanes are often developed as back doors from residential areas to adjacent commercial centers.

Bike-only lanes are normally 6 to 8 feet wide, In order to accommodate both bicycles and slow speed vehicles (such as NEVs, Segways, and electric bikes), the lanes should be 7 to 9 feet wide. Multi-modal Class 1 and Class 2 lanes, plus separate NEV and

bike Class II lanes can be seen in Lincoln, CA Full lane sharrows might be the best way to introduce multi-modal streets.

Street Discontinuity

The complete streets plan could also address discontinuities and impediments on 25 MPH streets that could be removed in order to facilitate slow speed through-traffic. Signage will be especially important for identifying routes for slow speed vehicles. Removing some of the barriers would also facilitate cycling.

Charging

Public charging Infrastructure (also known as electric vehicle service equipment or EVSE) can play a significant support role but it will be of the 110V variety rather than the more expensive 220V. It will not be nearly as essential as the 220V charging infrastructure that is preferred for BEVs and PHEVs. And demand will be focused in different places – work sites are the top priority for BEVs while local schools, retail centers, big box store and gyms will be more appropriate for NEV opportunistic charging.

Policy

Parking restrictions could be adapted to support NEV/LUVs. Free parking, preferential parking, and parking adjacent to 110V outlets are options.

Sometimes accommodating NEVs into the household's lifestyle requires adding a 110 outlet to the outside of a house or apartment building which can be better accessed by

the vehicle. Such additions require permits. Municipalities can assist by streamlining the permit process.

In general, local jurisdictions should promote opportunities to shorten the trip lengths of their employees, residents and visitors. Land use, telecommuting and e-government are some of the tools available. Five miles or less should be the target.

Neighborhood Design

Developing more neighborhood centers which incentivize local trips will involve possible changes in general plan land use designations, zoning ordinance or specific plans. Chapter 6 discusses this in more detail.

State and Federal Governments

Currently, the California Air Resources Board (CARB) offers a cash rebate on electric vehicles purchased by residents. The AB 118 program establishes a fund that new PEV purchasers can apply to for cash rebates until the fund has been expended. One unfortunate aspect of the CARB subsidy program is that the amount of cash awarded is a function of battery size of the vehicle – the bigger the battery pack, the larger subsidy received. One way to stimulate demand for LUVs would be by increasing the subsidy for small battery packs.

Other options can be considered. The demonstration project has shown that a price range from \$6,000 to \$10,000 would attract buyers. GEM is the current market leader and offers basic NEVs with no doors for about \$8,500. Reducing that base price to \$6,000, or with doors and other amenities increasing the cost to perhaps \$10,000,

could be expected to significantly stimulate sales. A \$2,000 per vehicle subsidy would help meet the price target.

A section specifically on NEVs/LUVs in the Complete Streets guidelines for implementing AB 1358 would likely have a significant impact on ROW management. A funding program for public EVSE installation and for multiple unit dwelling units without adequate 110V access in the parking area would be useful. State standards for slow speed vehicle signage could contribute.

Finally, as was mentioned previously, restructuring the zero-emissions credit market would make it possible for NEV manufacturers to lower prices. Currently, zero-emission vehicles with a range of 50 miles receive 2 credits in the market that can be sold to manufacturers who need credits. Zero-emission vehicles with a 30-mile range receive 1 credit and those with a 15-mile range receive $\frac{1}{2}$ a credit. As was noted, Tesla, makers of large-range electric vehicles, has become profitable from the credits. However, NEV manufacturers cannot benefit as much since they only receive a $\frac{1}{2}$ credit per vehicle. Increasing the number of credits NEV manufacturers receive can help to reduce base price of the vehicles and stimulate the market

4. Emerging Local Use Vehicle (LUV) Technologies

The current NEV is but one example of a family of specialized slow speed, short range, zero emission vehicles that can be referred to as local use vehicles (LUVs).

The SBCCOG defines a Local Use Vehicle (LUV) as *any slow-speed, zero-emission vehicle used primarily to access destinations in close proximity to one's home or place of work*. This broad definition encompasses numerous existing and emerging technologies.

LUVs can be simple, like basic bicycle technology, and could be made locally. On the other end of the spectrum, a LUV may be one of the most advanced products in the world. The Segway self-balancing scooter is one example of a high technology LUV.

Quadricycles; Renault Twizy; Toyota COMS; and Honda Micro-Commuter Prototype

A number of high quality Local Use Vehicles (LUVs) are being developed and produced in Europe and Asia. These vehicles have a unique, more “open” look and are capable of travelling at higher speeds than a NEV. They are built to meet the European standard for “Quadricycles” (4-wheel vehicles that are like “motorcycles” but do not have to meet conventional vehicle safety standards). These vehicles are not designed for use on a freeway.

The Renault Twizy is an interesting experiment to address a new market for basic local mobility in Europe. The Twizy offers 1+1 seating, the driver sits in the center, the passenger sits behind the driver – tandem style. The vehicle is now in full commercial production. It has a design with open sides and a mini pivoting half-door is an available

option. While the quadricycle safety standards are less demanding than for automobiles, the Twizy comes standard with a driver's airbag.

Top speed for the Twizy is 50 mph. The local car is electric powered and costs roughly \$9,000 to purchase. The batteries however are not sold with the car and only available for a monthly lease from Renault. The batteries from Renault cost roughly \$60 / month. In many ways the Twizy has been a large experiment for Renault. The open sided vehicle is selling well near the beaches of Portugal and South of France. Some countries such as Germany have strongly embraced the Twizy, yet some European cities lack convenient urban charging infrastructure and sales have been less than hoped. It should be recognized that Renault has made a sizable investment in the Twizy and appears very committed to it. However, from May 2012 to May 2013, only 10,000 Twizy's have been sold.¹⁰

The Twizy was originally designed to be offered with a smaller motor in a 25 mph top speed "NEV" version. There has been no news about this NEV Twizy becoming available. The (quadricycle) Twizy is also being studied in Japan as a Nissan offering, branded as a Nissan "New Mobility Concept". A small fleet (less than 100) is being tested in a shared vehicle application there.

Toyota has a new minimal vehicle called "COMS" that is a one-seater and offers an open NEV-style side. These vehicles are being studied exclusively in Toyota's "Ha:Mo" mobility system concept together with the involvement of Japanese universities. The top speed of the COMS and performance are very similar to the Renault Twizy, meaning

¹⁰ <http://insideevs.com/sales-of-renault-electric-vehicles-on-the-decline-in-2013-only-zoe-shows-promise/>

matching the (EU) quadricycle's performance. The COMS does not offer a door or even a half door. It only has one seat (driver), no seat for a passenger.

Honda's "Micro Commuter Prototype" is very close to the size and matches the performance of the Twizy and Toyota COMS. The Honda offers a more substantial door than either the Twizy or COMS. Honda has not said where their demonstration(s) will be in 2013 with this new minimal vehicle. NEVs and quadricycles have the potential to cost far less than a conventional



(Renault Twizy top left and right. Toyota COMS bottom left, Honda Micro-Commuter bottom right)

Hiriko (MIT) Folding Urban Car

One all-new concept of urban vehicle (LUV) introduced in Europe recently is the “Hiriko” folding car. The idea came from researchers at MIT as they sought to invent more space-efficient forms of personal mobility for inner-urban areas. MIT envisioned that European cities would begin to restrict larger cars from their center, and consumers would switch to micro-sized on demand personal mobility vehicles / services.

There are three unique aspects to the Hiroko. First, the car folds for storage, a useful feature in European cities tight on parking space. Second, the door to enter is at the front, meaning the windshield is in the front door. By parking the nose of the car to the curb, the driver never has to get out in the (dangerous) street. Third, the electric motors are in each wheel allowing the car to turn around in a very small space, almost acting like a crab.

Several years ago a Spanish-based company, interested in commercializing the vehicle concept, funded the next phase of development. At the end of 2012, German railway operator, Deutsche Bahn became interested in the Hiriko and promised to launch a demonstration with the cars in Germany in 2013-1014. While the ability of the car to fold for condensed parking is a compelling idea, it adds weight and cost to the minimal vehicle concept, and may not be a feature that adds as much to the offering as one might think. But for the South Bay, the Hiroko offers proof that minimal vehicles can fold or be condensed for storage needs. Perhaps NEV-type vehicles could fold down into a very condensed form for storage at Metro Transit Hubs, future Park + Ride lots, or for future beach parking needs.



(Hiriko folding car shown in Europe - 2012).

Wheelchair-Operated NEV

The fact NEVs can be developed and manufactured for a small fraction of the cost of building a conventional automobile enables many meaningful custom NEVs to reach the market. One innovative variant is the all-accessible NEV called the “Kenguru”, now in production by a new Texan mobility company. The Kenguru does not offer a driver’s seat, rather the back of the NEV becomes a wheelchair ramp so the driver can roll in and operate the vehicle.

Currently, someone confined to a wheelchair has less mobility options for short distance trips. Driving a converted minivan or waiting for a ride service can be a lot of effort for someone in a wheelchair. While production has only recently begun for the Kenguru, there are indications that similar vehicles will be coming to market from a China based (NEV) manufacturer as well.



(Kenguru all-access NEV is in production in Texas).

Self-driving Low Speed Vehicles

GM's EN-V system concept was introduced in 2010 in China. The initial system was co-developed with Segway and is built off a 2-seat self-balancing new vehicle platform. GM is currently developing the EN-V system for pilot testing in a China Eco City in the upcoming years. They have moved away from the self-balancing technology and will build their system around a 4-wheel self-driving micro-vehicle platform - essentially a smart NEV. The EN-V is more likely to be offered as a service than a product which consumers can own.

Toyota's i-Real is a 3-wheel electronic self-driving vehicle. The vehicle has a top speed of 20 mph. While the i-Real does not use the more expensive gyroscopic technology, the vehicle can operate autonomously and do all of the tasks done by unmanned Segways. Toyota has not released pricing, although it may be more likely to find i-Reals in a shared service rather than available for consumer purchase. The company has been interested in the growing population of senior citizens in Japan, and how to best assist their personal mobility in the years ahead.



(General Motors / Segway EN-V in development along with rendering of upcoming 4-wheel version).

Cargo Trikes & Local Delivery Vehicles

While lacking the advanced technology of the Segway, i-Real and EN-V, there are a growing number of 3-wheel trike cargo vehicles becoming available around the world. The trike layout allows for a considerable amount of cargo to be carried for local deliveries. One wheel in front, and two in the back is the most common layout. This is the lowest cost layout, although travel must be kept to a very low speed due to handling challenges of this vehicle configuration. This is the layout of the common pedicab as well.

Currently these cargo trikes do not classify as NEVs and may only gain road access as “bicycles”. If the aim is to not require the driver to pedal (and propel the entire load themselves) then an electric motor and battery can be added. The vehicle can remain a “bicycle” even with electric power added. In California the speed would need to be kept at 20 mph or less. Any South Bay city that adds bike lanes to the local street network could be enabling the use of these cargo trikes, which could be a benefit and serve as a low-cost low-emission goods delivery solution.



(Delivery trikes shown in Europe along with rudimentary available trike - bottom left).

Hybrid Electric Trikes and Bikes

Getting smaller, there are innovative electric trike concepts springing up in Europe, Asia, and in the United States. Some of these new designs are clearly larger, more utility-oriented bicycles. By offering electric drive, they are easy to operate and widen the potential appeal of these vehicles. These new 3-wheel e-trikes are “LUVs”. Since the definition of NEV in the United States clearly limits NEVs to being 4-wheeled vehicles, they will be classified as electric bikes or electric scooters. Prices for these types of vehicles can range from \$1,000 up to \$5,000.

An e-trike travelling on South Bay residential streets at 20 mph, and staying on the right side of the road, would likely be an adequate LUV. The more minimal body construction allows e- trikes to have a considerably lower price than current NEVs.



(Stromer on the left and Pedago)

Bigger Cargo Bikes

There are many bicycle-based vehicle innovations coming to market that offer to be valuable LUVs. The cargo bike, invented in Europe, offers to carry goods or children for short trips. It requires effort to ride these heavier bike vehicles, and may only be of interest to younger residents of the South Bay. Adding a third wheel, thus creating a “trike” and attaching an electric motor and battery may make these types of LUVs attractive to a larger percentage of the population. The price for a cargo bike can range anywhere from \$1000 - \$6,000. Bicycle trailers are another option, often a less expensive one than the cargo bike. There are other innovative child-carrying bicycle designs that convert to strollers when needed for that purpose available on the market today as well.



E-Scooters

There is also a growing market for electric scooters, and electric motorcycles. Since motorcycles are able to travel at higher speeds and for longer distances, they are not considered to be a LUV. Electric scooters that look similar to the Italian Vespa motor-scooter are commonly available in the United States and many are manufactured and imported from China. Using an electric scooter of this type to reach local stores and link to other transportation options is similar to the value of the NEV, but the scooter is considerably less expensive to purchase than the NEV. Many of these scooters can travel up to 40 mph, they can travel 30 miles on a charge, and cost roughly \$2,000-\$3,500 to purchase. Another option for the scooter rider is to attach a small trailer, which makes picking up goods from the local commercial area more convenient.



(Volkswagen e-bike shown left. Generic e-scooter right)

Gyroscopic Personal Mobility Devices; Segway; Toyota Winglets

The Segway is a gyroscope-balanced micro-sized personal mobility device. It is the most technically advanced LUV commercially available in the world. The Segway has not achieved market success at the level anticipated by some. Like many LUVs, neither the city sidewalk nor the streets are an appropriate place for Segway travel. The expensive highly advanced technology allows the vehicle to have a very tiny footprint, but that may be more of value in land restricted Tokyo. Japan more than Southern California. A new Segway weighs roughly 100 lbs, travels at 12.5 mph (top speed), will travel over 30 miles on a charge, and costs \$5,000.

Toyota has experimented with Segway-like self-balancing technology and developed the Winglet vehicle concept. The Winglet is like a Segway but much smaller. Toyota has explored the potential of the Winglet for a number of years. Commercialization plans are unknown. The Ryno is self-balancing, one-wheel, electric scooter with a top speed of 12.5 MPH. The Arcimoto is a 3 wheeled, electric, freeway speed vehicle that seats two in tandem.



(Segway to the left; Rynomoto in the middle; Arcimoto to the right)

5. The Land Use Connection: Neighborhood Vehicles and Neighborhood Design

California's SB 375 mandated that Regional Transportation Plans include a Sustainable Communities Strategy (SCS) beginning in 2012. The SCS is required to meet carbon emissions targets established by the California Air Resources Board by coordinating transportation investments with municipal land development policies. Essentially, a mobility strategy that will reduce fossil fuel consumption is needed to address the spatial distribution of destinations established by the development pattern in every region and, perhaps eventually, in every sub-region.

The strategy of coordinating land use with transportation is not new.

Beginning about 20 years ago, Peter Calthorpe, Robert Cervero and others began articulating and advocating a strategy consisting of dense transit oriented developments (TOD/transit villages) that complement rail transit investments. This has grown in popularity over the years, at least inside the planning profession. SCAG's 2012 SCS relies on some form of that strategy for coordinating land use and transportation in order to demonstrate that the plan meets its SB 375 carbon reduction goals.

The problem is that there are relatively few areas to which the rail transit – TOD strategy is realistic. While rail transit and TODs may work well for sub-regions expecting large public sector rail investments and private sector land development, the South Bay cities (and most of region) are not and probably will not be among them, at least for decades. Additionally, substituting transit in the South Bay for personal mobility is

problematic since the bus service in general is limited on weekdays and even sparser on weekends.

Also about twenty years ago William Garrison and Daniel Sperling independently introduced a different land use – transportation strategy based on the idea that neighborhood vehicles (transportation) could lead to new neighborhood designs (land use) and that new neighborhood designs could advance the use of neighborhood vehicles. Unlike rail transit and TOD, this neighborhood strategy failed to gain traction.

There are many possible reasons why the neighborhood strategy has not become more popular. It may be that the strategy involved too much innovation at the time – both battery electric propulsion and specialized neighborhood vehicles pushed the cultural envelope oriented to multi-passenger, multi-purpose gasoline fueled vehicles. The established suburban development pattern has been hard to change on a large scale, especially without a compelling vision or the stimulus of very large public sector rail infrastructure improvements. The automobile industry pushed hard for the repeal of the public sector zero emission requirements which cooled the electric vehicle market. There was no clear economic beneficiary equivalent to the rail construction industry. And so forth.

Perhaps some of that is changing. Increasing gasoline prices and an emerging plug-in electric vehicle market place, supported by federal and state subsidies, have begun to attract consumer interest in alternative fuel vehicles. While it is true that the interest is currently focused on hybrids and has not yet fully embraced pure battery vehicles,

economic and environmental considerations are converging making a major transition possible.

Pure battery power is range limited. The level of onboard kWh determines the distance the vehicle can travel before stopping to re-charge. But larger capacity also increases the need for both the level of electric service and the time to fully charge the batteries.

The range-charging tradeoff opens the conversation about household trip distances and vehicles specialized by range to address those distances. In other words, planners increasingly need to coordinate the spatial distribution of destinations with the range limits of the vehicle fleet. Mobility options and development patterns can evolve together.

The need to coordinate land use and transportation in a Sustainable Communities Strategy could lead to re-evaluating the neighborhood vehicle – neighborhood design strategy as an option to TOD in transit-poor sub-regions. The data collected in this NEV Demonstration Project can contribute to the renewed conversation

This chapter on the land use connection addresses three themes using LUV driver data:

- The current compactness of the South Bay expressed through trip lengths to frequent destinations.
- Implications of driving times and travel patterns for public transit service.

- Insights into neighborhood design drawn from “hot spot” data and analyses of the spatial distribution of functionality.

5.1 Trip Lengths and Compactness of the South Bay Development Pattern

The National Household Travel Survey (2009) found that 23% of reported trips in Los Angeles County were less than one mile and 12% were between one and two miles in length. This means that about 65% of all trips were longer than 2 miles.

Residents of 8 South Bay neighborhoods were surveyed between 2004 and 2008 (South Bay Transportation Performance Study funded by SCAG under its Compass Program). All 8 were *horizontal mixed-use neighborhoods* – 4 that were centers (circular commercial surrounded by residential) and 4 that were linear in the form of strip commercial with residential behind the commercial.

A surprising result was that the nearby commercial concentrations regardless of form captured a lot of the trips taken by adjacent residents and, as a result, the average trip length was relatively short. For example, no more than 35% of the trips taken to access personal services were longer than 2 miles. In the best performing neighborhood only 13% were longer than 2 miles. Trips to grocery stores longer than 2 miles ranged from a low of 8% to a high of 32%. There were similar results for a number of different trip purposes.

The trips taken by the 51 households participating in the NEV Demonstration as tracked by GPS were even shorter, regardless of the type of vehicle driven. When driving the gas-powered vehicle, 90% of the participating households’ destinations were less than five miles from home, 82% less than three miles from home, and 46% less than one mile from home as the crow flies. That compares with 99% of LUV trip destinations within five miles from home, 96% within three miles, and 58% within one mile from home.

In other words, the built-out traditional suburban development pattern in the South Bay is compact enough that somewhere between 2/3 and 9/10 of non-work trips are under a couple of miles. Parts of the South Bay are apparently more compact than Los Angeles County on average.

While the existing development pattern in the South Bay (and probably other compact sub-regions) is optimized for auto travel, trip distances are well within the range of cycles and small battery local use vehicles. *This means that the existing sub-regional development pattern can support the reduction of criteria pollutants and GHG emissions through a strategy of converting the gasoline fueled fleet to electric while also working to reduce the size of the passenger fleet. It is not essential to change land uses or to make very large, capital intensive infrastructure investments in order to become sustainable.*

The following charts illustrate compactness in the South Bay in terms of different trip destinations. They show how often per week the NEV was used to visit the study's 28 destination types by their distance from home. For example, participants did not drive their NEV often to a hardware store but when they did the trips were usually around 1 mile. Drivers averaged 1 trip every two weeks (1/2 trip per week on the chart) to a bank that was within a mile of home. Drivers averaged one trip per week to a grocery store that was within one mile from home.

Note: These trips would otherwise be taken in a gas-powered vehicle. None of our participants indicated that they took these trips by walking or cycling.

Figure 13: Destinations by Distance Increments

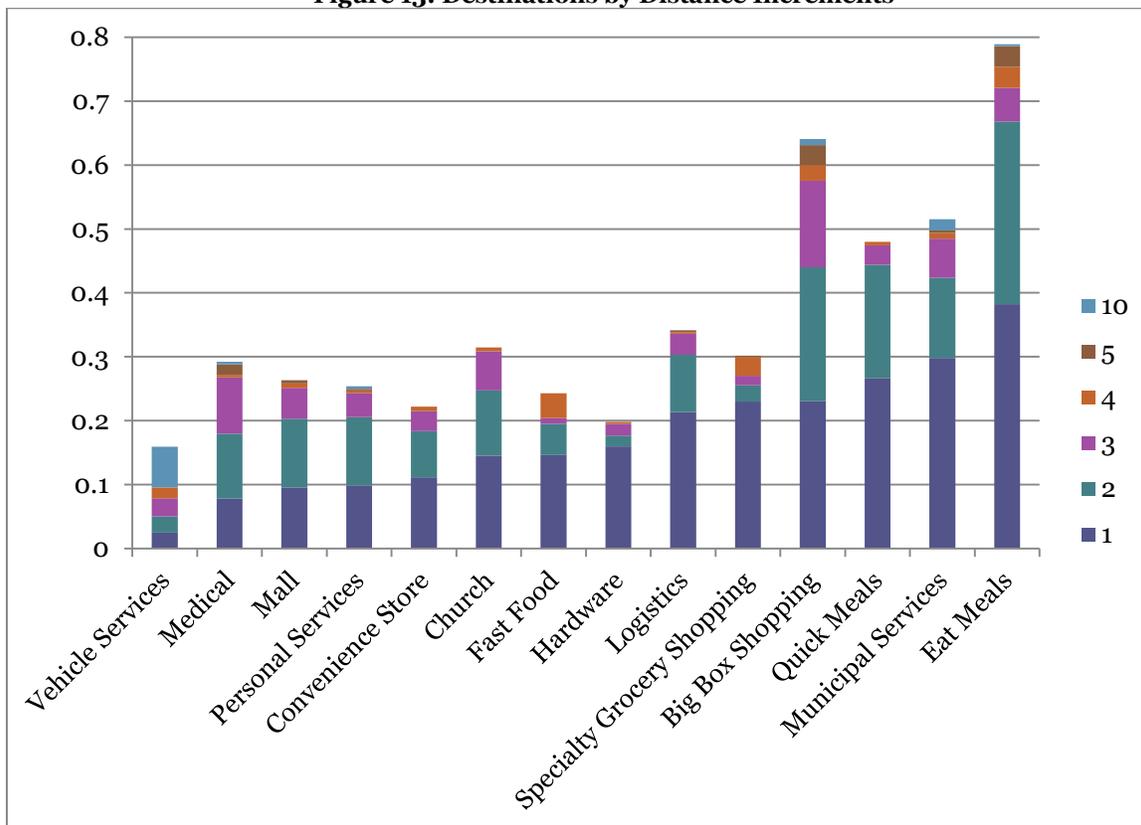
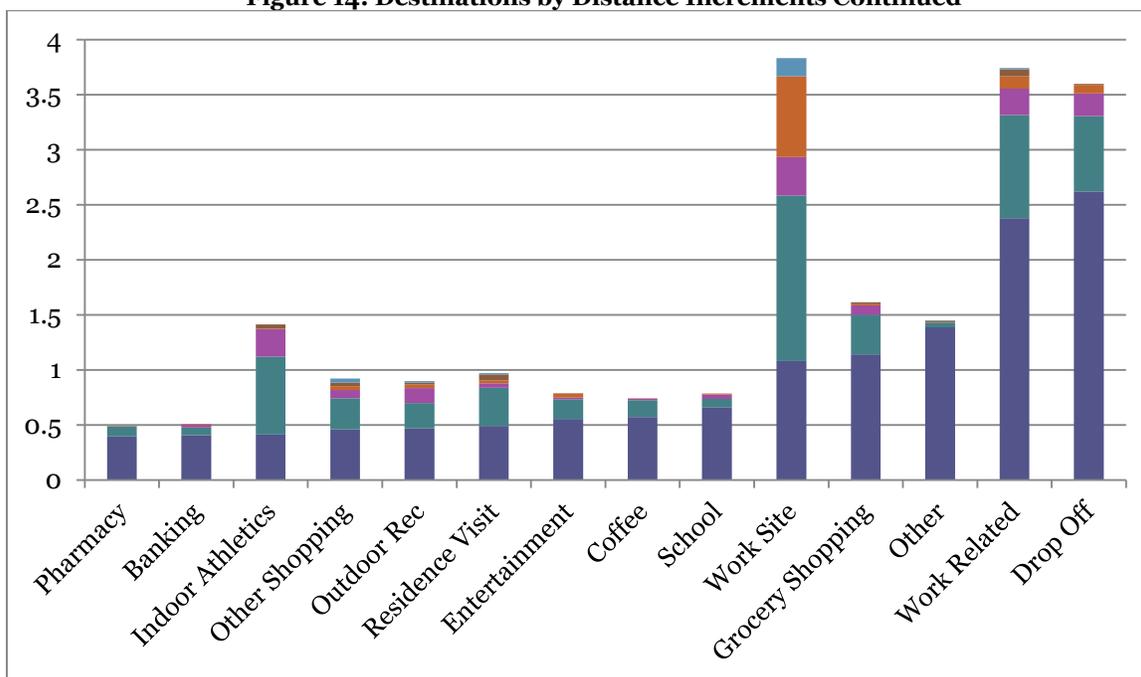


Figure 14: Destinations by Distance Increments Continued



In general most NEV drivers accessed most of these categories below on a regular weekly basis at distances around 1 or 2 miles. Visits to work sites were the only trips with lengths that regularly reached as many as 5 and 10 miles.

Grocery Shopping: 1.2 average weekly trips are made within a mile. An additional .32 trips are made with 1 to 2 miles. Frequency declines thereafter.

Coffee: .59 average weekly trips are made within a mile. An additional .13 trips are made with 1 to 2 miles. Frequency declines thereafter.

Eat Meals (sit down dining): .47 Average weekly trips are made within a mile. An additional .2 trips are made with 1 to 2 miles. Frequency declines thereafter.

Banking: .42 average weekly trips are made within a mile. An additional .07 trips are made with 1 to 2 miles. Frequency declines thereafter.

Pharmacy: .40 average weekly trips are made within a mile. An additional .06 trips are made with 1 to 2 miles. Frequency declines thereafter.

Quick Meals (not sit down, not fast food): .32 average weekly trips are made within a mile. An additional .09 trips are made with 1 to 2 miles. Frequency declines thereafter.

Specialty Grocery Shopping: .22 average weekly trips are made within a mile. An additional .04 trips are made with 1 to 2 miles. Frequency declines thereafter.

Fast Food: .17 average weekly trips are made within a mile. An additional .04 trips are made with 1 to 2 miles. Frequency declines thereafter.

Personal Services: .15 average weekly trips are made within a mile. An additional .05 trips are made with 1 to 2 miles. Frequency declines off thereafter.

Convenience Store: .14 average weekly trips are made within a mile. An additional .04 trips are made with 1 to 2 miles. Frequency declines thereafter.

Medical: .1 average weekly trips are made within a mile. An additional .1 trips are made with 1 to 2 miles. Frequency declines thereafter.

Dropping off a family member is a frequent activity, averaging 3.5 trips per week. It also occurs mostly within a mile of home. Taking children to school makes up about 60% of those trips; dropping a family member to a friend's or other family member's house makes up about 23% of them. Taking a child to a dance or music class makes up about 9% of the drop-off trips. Only .6% involved a drop-off at a transit stop which means that the NEVs were rarely used as the first/last mile to transit. This is likely related to the small transit mode share in the South Bay.

5.2 Trip Legs, Routes and Transit

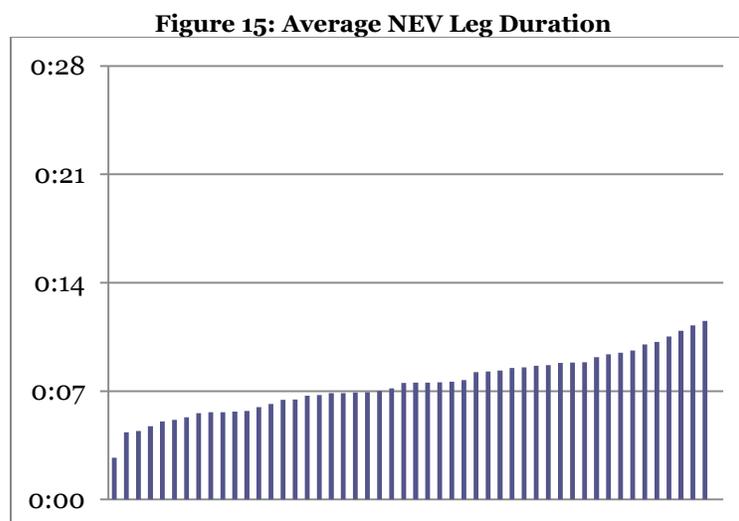
The number and length of trip legs can inform which mobility options are viable in the current development pattern. A trip leg is created when a driver visits more than one destination on a round trip beginning and ending at home. This is also referred to as trip chaining.

The following table shows the distribution of legs driven in an NEV. About half of the trips were roundtrips from home with just one destination. Almost one quarter included a second destination; the frequencies decline from there to a total of 12 stops which accounted for only .06% of the total.

Table 6: NEV Leg Distribution

Total Associated Legs	Percent of Total	Total Trips
2	49.32%	9,990
3	22.90%	4,638
4	12.49%	2,531
5	6.41%	1,299
6	3.82%	774
7	2.16%	438
8	1.41%	285
9	1.23%	249
10	0.14%	29
11	0.05%	11
13	0.06%	13
Total	100.00%	20,257

The following graph shows the average driving time of each leg. The average duration of these trips range from a low of about 2 1/2 minutes to a high of about 11 1/2. Over 20,000 legs were recorded.

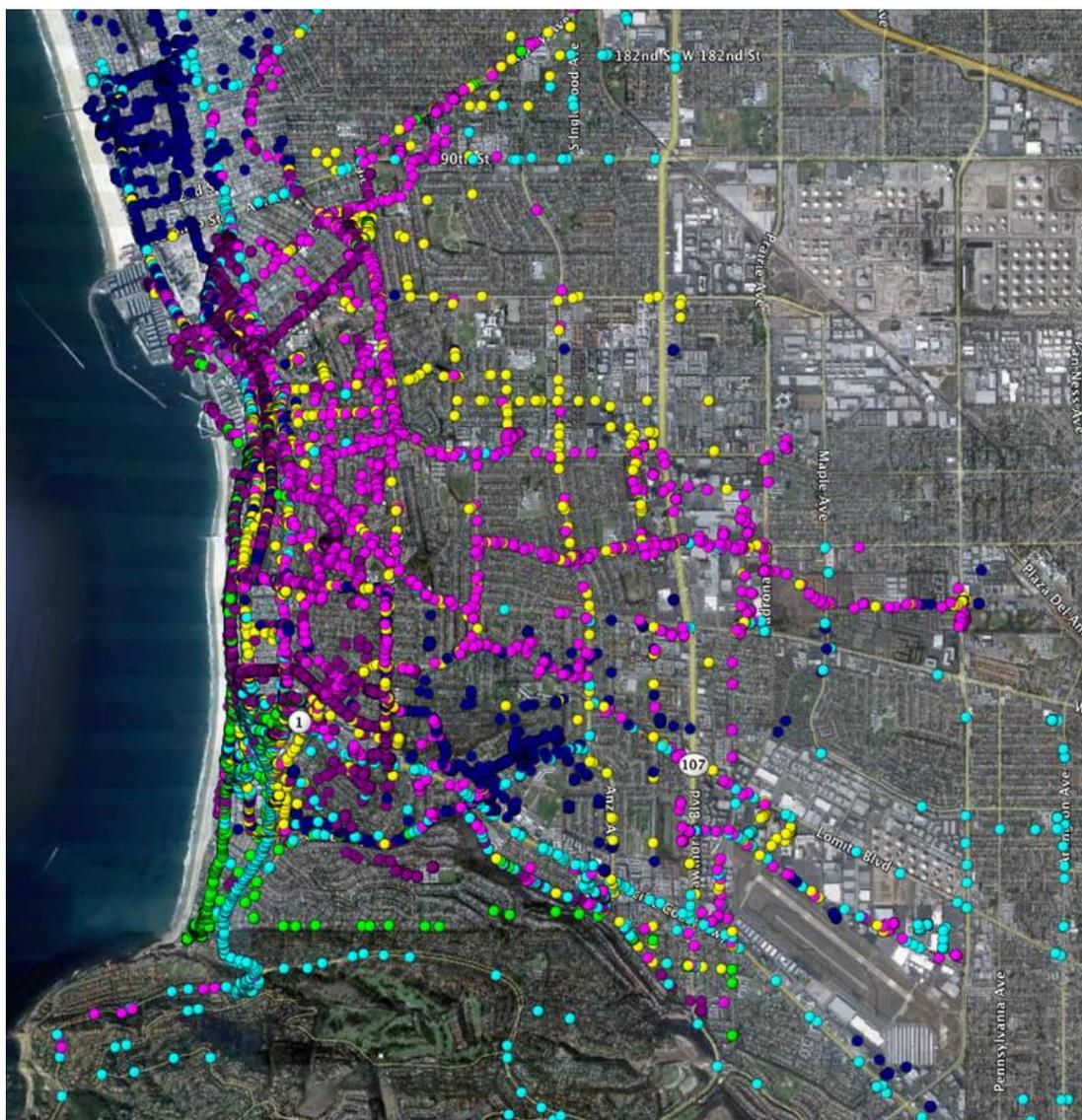


The average driving time for each leg and the number of legs combined with the radial distances to different destinations provide one explanation as to why the mode share of public transit in the South Bay is so low – approximately 2.8% of all trips. Most trips are simply too short in distance and duration for traditional transit service to address.

The following map shows the routes taken by 8 NEV drivers, each shown in a different color. Beyond the clustering around a core of destinations, the routes are not linear. Most trip legs zigzag. Transit service along corridors is not compatible with actual travel patterns.

This evidence suggests that a mobility strategy based on neighborhood vehicles within the existing development pattern will be more effective than a transit-based mobility strategy. It will also avoid the need for large public investments and will overall be more affordable while preserving the on-demand, door to door service to which most residents are accustomed.

Figure 16: NEV Routes



5.3 Destinations and Neighborhood Design

One promise of extensive deployment of specialized local use neighborhood vehicles is the design of new neighborhoods. Essentially, this means taking compactness to a scale below the sub-region – by creating compact neighborhoods. The challenge is to design new neighborhood centers, inspired by the capabilities of a neighborhood mobility strategy that can get built in the context of strip commercial developments and regional malls

The Sustainable South Bay Strategy included a vision of a development pattern based on a system of compact neighborhood centers at the intersection of the major arterials in the suburban grid, regardless of the level of transit service on those arterials. Strip commercial, mostly underperforming today, would be migrated into the centers and physically replaced by housing at densities compatible with the adjacent residential tracts. That vision was summarized in the Introduction Chapter of this Report.

Beyond that broad vision, previous studies have provided a few clues about the design of the centers.

One known design parameter is a large number of businesses per acre which will increase the propensity of adjacent residents to walk to the nearby commercial center. This information is derived from the regression analysis in the South Bay Transportation Performance Study (SBTPS). This means that the commercial spaces will need to be relatively small compared to today's standards; and retailers will need to become relatively compact, like the 5,000 square foot grocery. See also "Retrofitting the Suburbs to Increase Walking," *Access*, Number 39, Fall 2011; Boarnet, Joh, Siembab, et.

al., and “Retrofitting the Suburbs to Increase Walking: Evidence from a Land Use-Travel Study,” *Urban Studies*, 48(1), 2011, Boarnet, Joh, Siembab, et. al.

The ideal land use in the new neighborhood center is office in a second story over retail. This is because each center will attract more of the trips from the adjacent residences if it contains a maximum number of destinations. Second story residential would add little to the demand necessary to support the commercial space and will dilute the magnetism of the center. Office space is occupied by a work force that will also function as customers for the ground floor retail.

Technology can play a role in creating compactness. For example, Amazon lockers can simulate the presence of the thousands of retailers available at amazon.com by providing a distribution point in the neighborhood center.

5.3.1 NEV “Hot Spots”

An analysis of NEV “hot spots” can contribute insights into both the scale and content of neighborhood centers. Scale includes the building envelope and the number of businesses that it should optimally contain. Content involves the business mix a neighborhood center should offer in order to attract a high percentage of local trips – it is a much more granular planning issue than describing the building envelope and extends past zoning, architecture, and engineering into economic geography.

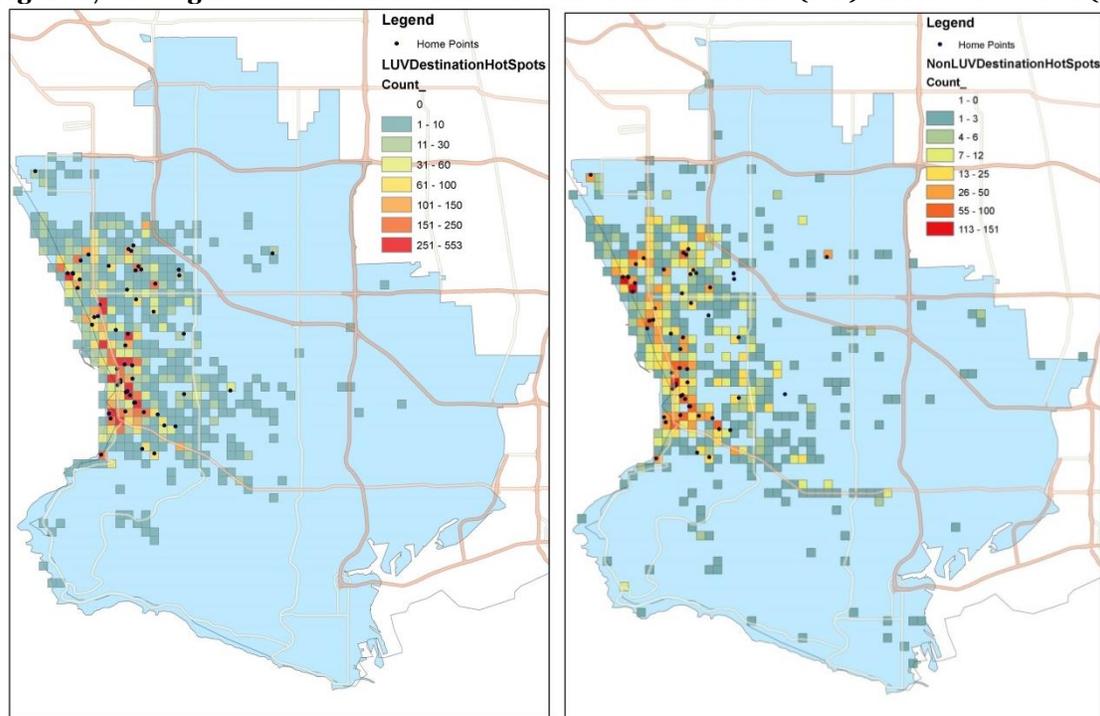
NEV “hot spots” are those clusters of destinations that attracted a large number of trips by a number of different drivers. What did we learn from them? How big are they and what’s in them?

Distribution of Hot Spots

The following maps show the home locations of participating drivers as black dots with the destinations driven in a NEV (left) and gas-powered vehicle (right). The cells are 1/4 mile squares.

There are more NEV hot spots and in general NEV destinations are more tightly clustered, gas-powered vehicle destinations are fewer and more dispersed. This is a step toward verifying that local use vehicles can lead to a greater compaction of destinations and that compact destinations can be well served by LUVs.

Figure 17 and Figure 18: Concentration of Destinations in an NEV (left) and Gas-Powered (right)



Location of Hot Spots

The following table lists the top 15 hot spots labeled by the closest intersection to the cluster and ranked by total trips arriving there and the number of NEV households

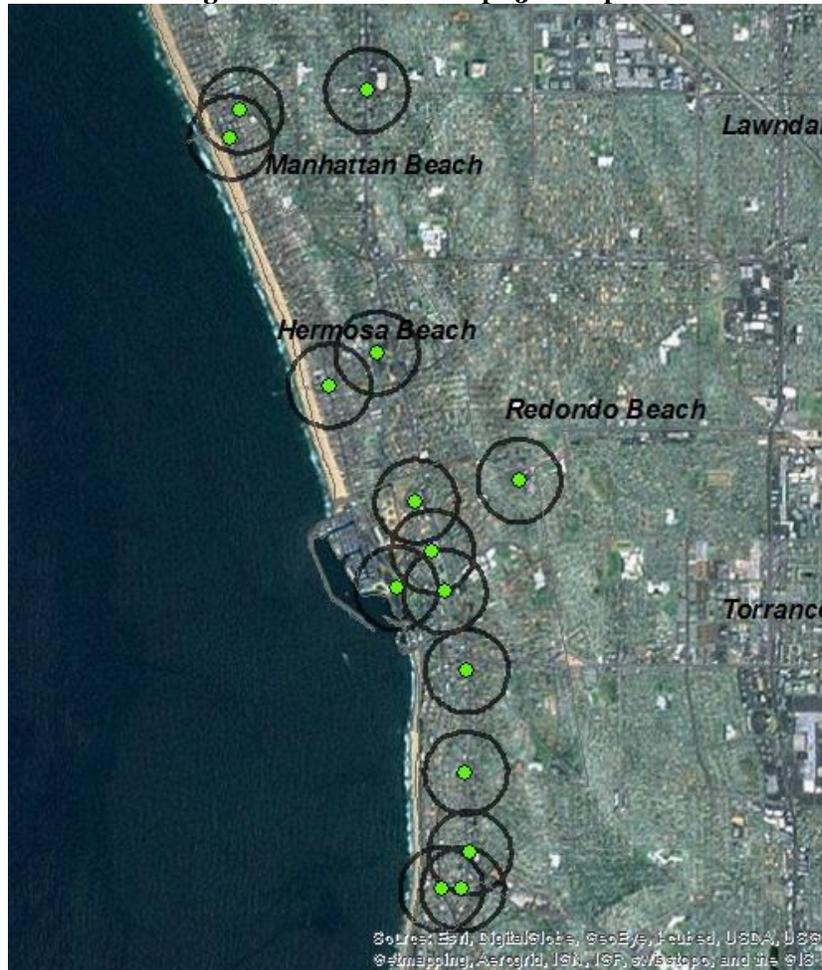
generating those trips. Both are important because a spot can be made hot by frequent visits from just a few drivers. Francisca and Beryl Streets may have attracted only the third most total trips, but it attracted visits by 29 households, the most of any hot spot. The number of businesses and employees within ¼ mile walking radius are also shown.

Figure 19: Top 15 Hot Spots

Closest Intersection	Total Trips	Total Households	Total Businesses	Total Employment
PCH and Avenue I	305	22	251	2,236
PCH & Avenue G	210	16	319	2,026
Francisca & Beryl	178	29	521	3,030
Broadway & Diamond	173	20	201	1,778
PCH & Torrance	159	20	162	1,058
Catalina & Del Norte	123	17	485	2,609
Ardmore & 14th	117	19	456	2,751
Catalina & PCH	110	16	163	860
Ocean & 9th	103	16	344	3,281
MBB & Morningside	94	17	367	3,459
Beryl & Prospect	92	17	108	699
Hermosa & Pier	89	21	485	3,296
MBB & Sepulveda	73	15	247	1,815
Harbor & Portofino	62	15	96	1,688
PCH & Knob Hill	57	16	439	1,741

The hot spots break nicely into three categories -- the top five, the middle four and the bottom 6. Essentially the top 5 have the total visits and the number of households to justify further examination. With the exception of Hermosa and Pier (the base of the Hermosa Beach downtown and entertainment district) the bottom 6 have relatively few visits and fewer total households visiting.

Figure 20: Location of top 15 Hot Spots



The map shows the location of the top 15 hot spots and a one quarter mile study area around each. They are tightly clustered in the coastal zone and sometimes the study areas even overlap.

In general, destinations in the South Bay can be spatially organized in three ways:

- In commercial strips that run along arterials
- In large single purpose developments such as retail malls or office parks
- In commercially mixed-use centers

Arterial commercial strips lack what urban designers refer to as “sense of place.” A decision to locate on an arterial is usually related to capturing customer traffic passing by, or at least in becoming visible to that passing traffic. High volume arterials are more attractive than low volume for that purpose. Several NEV hot spots were located along commercial strips.

Single purpose developments have a sense of place but their typically large scale generates a good deal of the congestion on South Bay streets as a significant number of employees and customers all converge on and exit from the same place, often at the same time. There were no NEV hot spots in single purpose developments.

Commercial mixed use centers have character and a sense of place. However, there are not many of them in the South Bay – primarily Old Torrance, Riviera Village, and downtown El Segundo. Riviera Village was a significant NEV hot spot.

Riviera Village as a Hot Spot

The quarter mile radius around the top 2 hot spots (PCH and Ave I, PCH and Ave G) and the 6th (Catalina and Del Norte) overlap; they essentially cover Riviera Village and the streets that lead into it.

The dominance of the Riviera Village (RV) as a LUV destination is significant because RV was the best performing commercial area of the 8 that were studied in the SBTPS. It had the highest capture rate of total trips taken by households located within 1/2 mile of the center of the area, and the highest rate of walking trips. Still, about half of the trips into the Village from that maximum half mile distance were driven in gas-powered

vehicles. This suggested that NEVs could replace gas-powered vehicles for those short trips into Riviera Village. And that's what happened in the Demonstration.

Because of its success in both the SBTPS and the NEV Demonstration, RV should be considered as a model for the design of neighborhood centers elsewhere in the South Bay. The RV is a compact, mixed-use (retail and office) center completely surrounded horizontally by a variety of single family and multi-family residential neighborhoods. Of course, it has other characteristics impossible to replicate elsewhere such as proximity to the beach.

It is also too large to serve as a center for a single neighborhood. Re-developable land the size of RV is not available – that is one reason that intersection corners have been envisioned as the location of new neighborhood centers.

Many intersections are currently occupied by gas stations, Jiffy Lubes, drive through fast food, mini-malls, or parking lots. Finding one or two corners ready for redevelopment appears feasible.

LUV destinations – what makes each cluster hot?

The following bar charts show for the top 5 hot spots the percent of the total trips made to the destination categories used in the Demonstration. Grocery shopping was by a large margin the most common destination in 4 of the 5. For the fifth it was coffee shops.

In general, popular destinations across all hot spots included grocery, coffee and restaurants, banks, post offices (or Fed Ex/UPS stores), work sites or work related.

Surprisingly, personal services and shopping, although present, were not all that an important destination in making a hot spot hot.

Figure 21: PCH & Avenue I: LUV Destinations

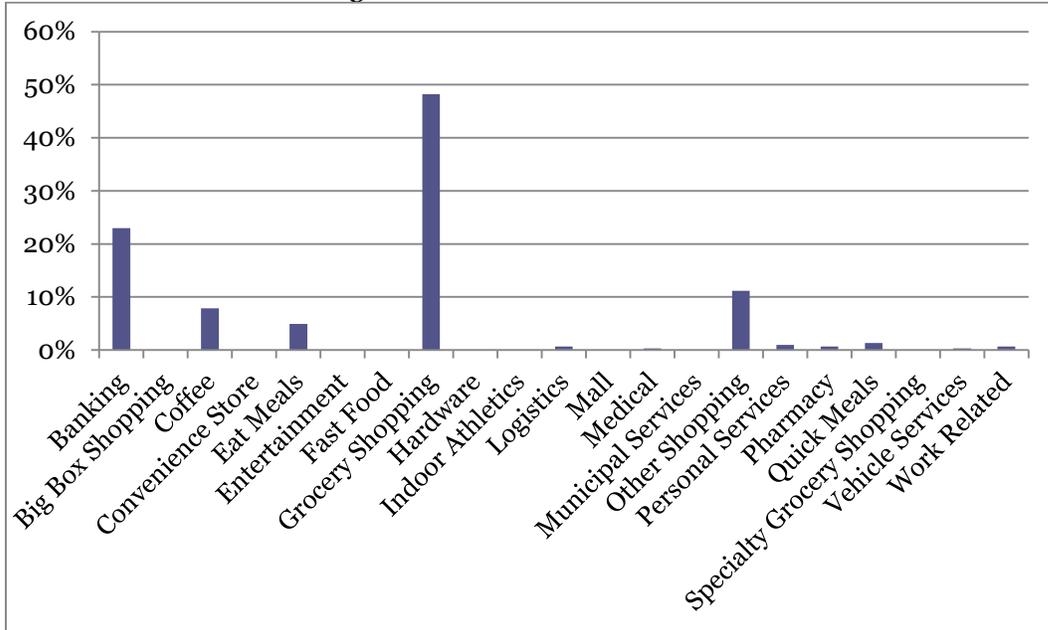


Figure 22: PCH & Avenue G: LUV destinations

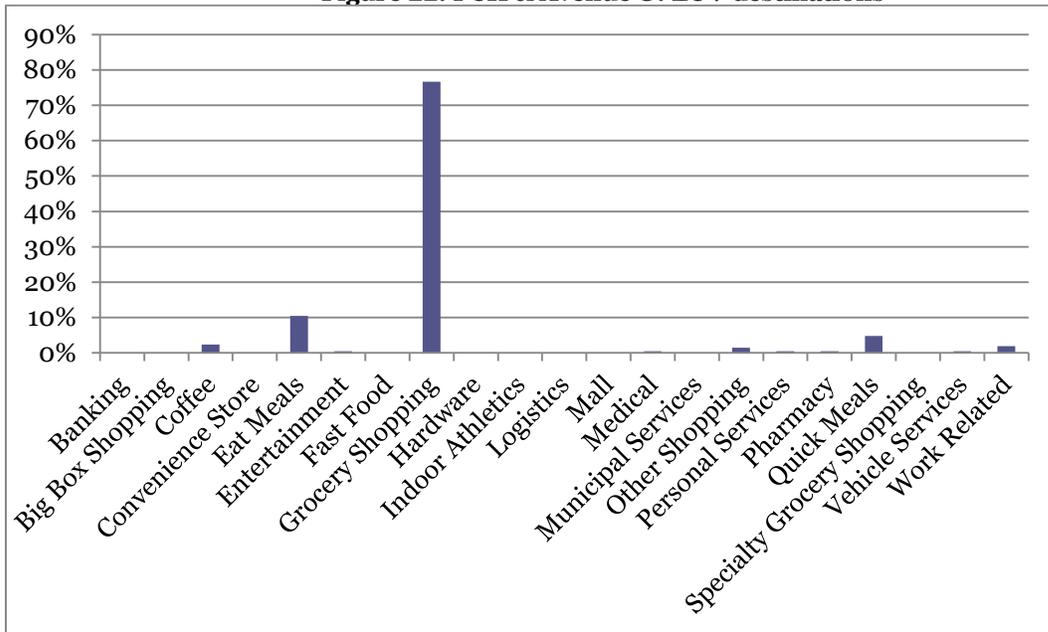


Figure 23: Francisca & Beryl: LUV Destinations

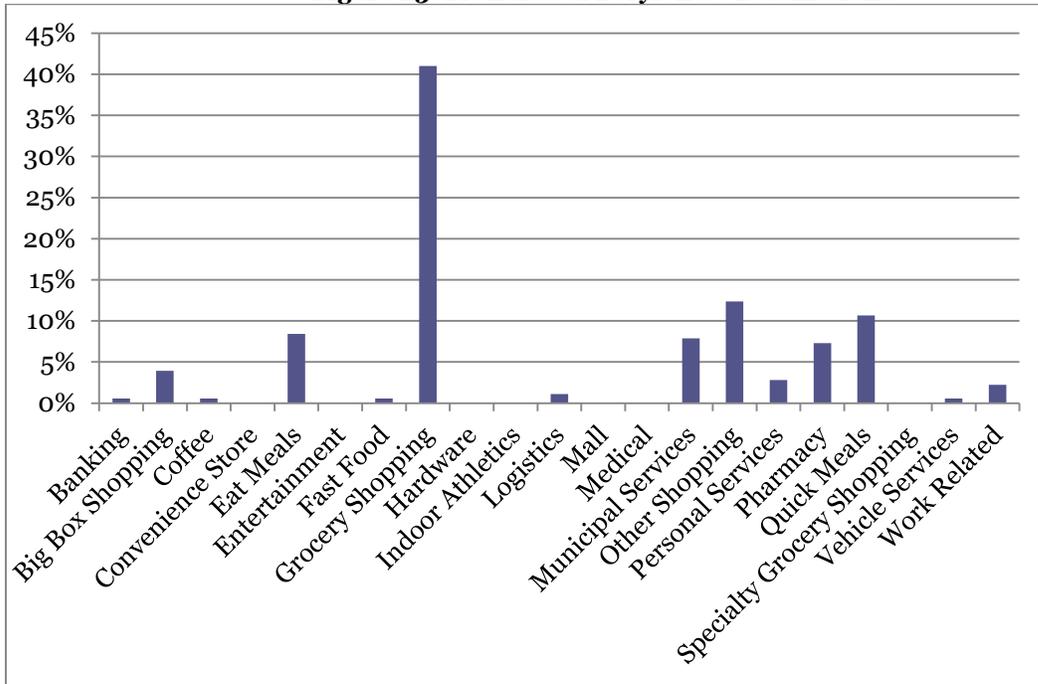


Figure 24: Broadway & Diamond: LUV Destinations

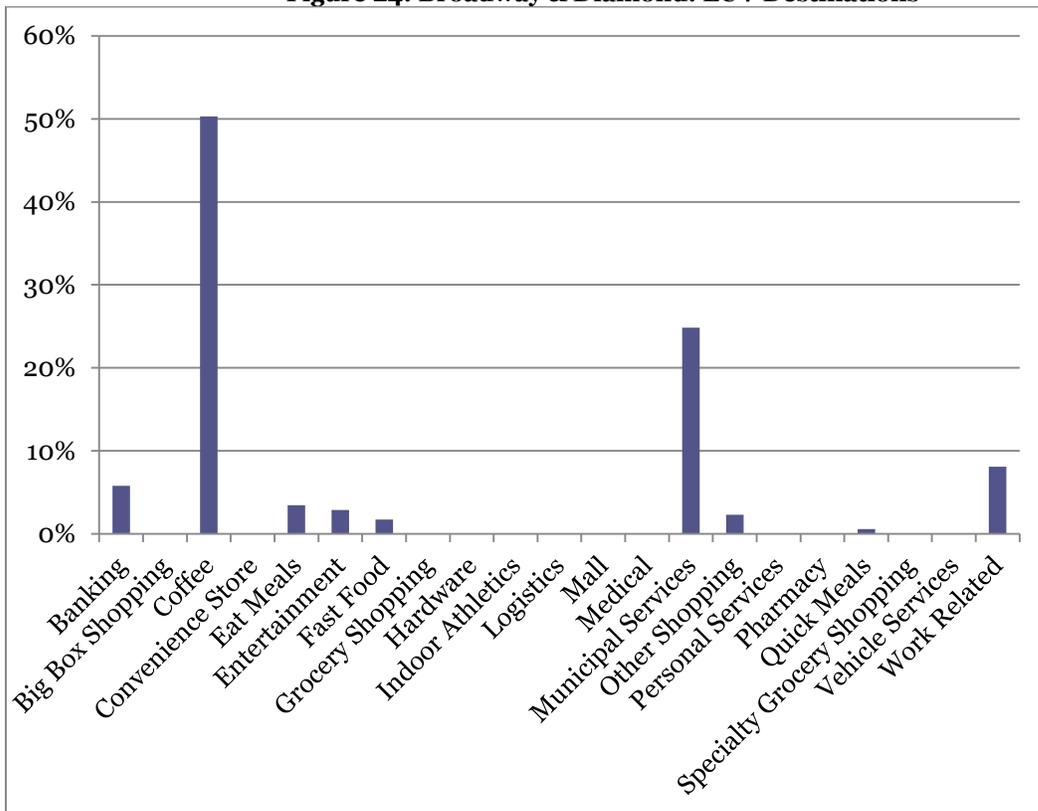
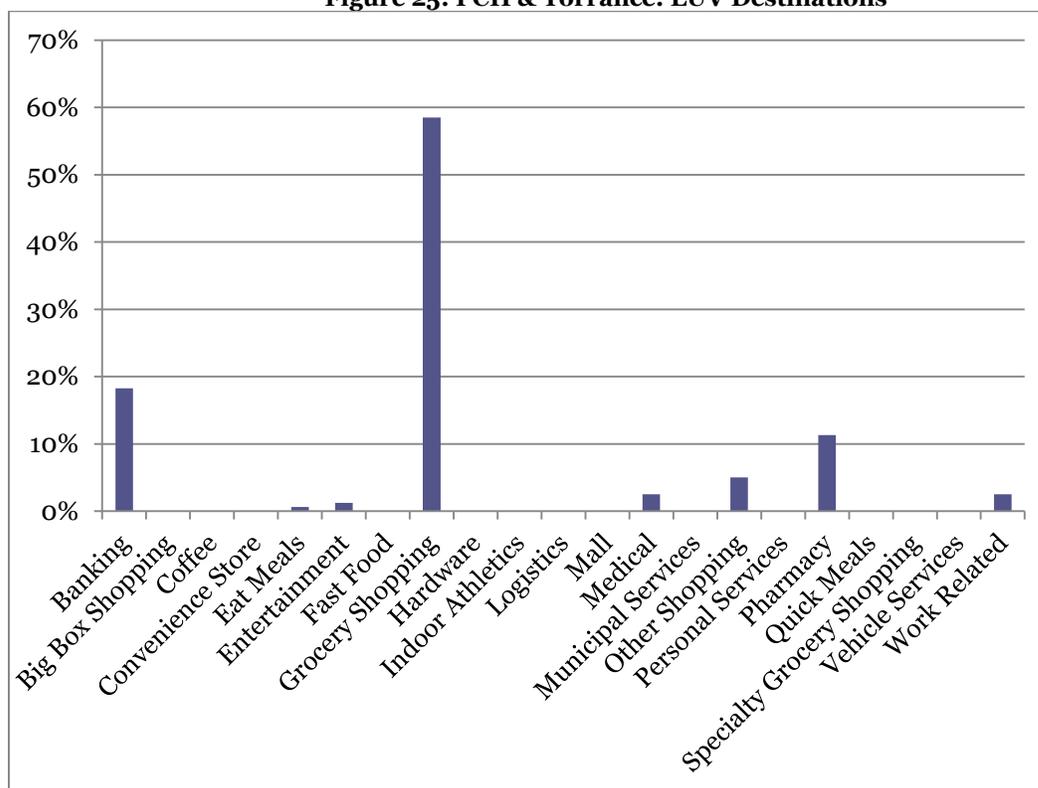


Figure 25: PCH & Torrance: LUV Destinations



Hot Spots– what is there VS what is hot?

While hot spots are made hot by numerous visits by multiple NEV households, each hot spot is a cluster with hundreds of business in dozens of different categories. The question is the extent to which the cluster itself plays a role even though trips were attracted by some very specific business types. The provisional answer pending further analysis is that the NEV drivers appear to be attracted to specific destinations.

And those popular business types serve as destinations way out of proportion to their actual presence. At the top LUV destination, PCH and Avenue I, grocery shopping attracted 48% of all trips to that hot spot, but only 1% of the businesses in the quarter mile hot zone were grocery stores. Or the inverse, banks made up 22% of the businesses in the quarter mile hot zone but they attracted only 2% of the total LUV trips.

At the second hottest LUV destination, PCH and Ave. G, grocery shopping attracted 77% of trips while only 1.8% of the businesses in the quarter mile hot zone were grocery stores. Similarly, Francisca and Beryl grocery stores were also the main attraction accounting for 41% of the visits with only 1.8% of the businesses.

Coffee and meals of some sort attracted 55% of the trips at Broadway and Diamond zone with only 10% of the business inventory. At PCH and Torrance, grocery shopping dominated again with 58% of the trips attracted by 4% of the businesses.

The implication is that the mix along most corridors and even in centers does not work together to facilitate trip chaining. Visitors are drawn by a specific destination rather than a related cluster.

The resulting mix is more or less determined by external market forces in contrast to the mix in a retail mall. Malls are typically owned by a single entity which manages the mix so as to include certain brands and an ensemble of complementary businesses. They are designed to accommodate a park once, shop often strategy. Malls specialize in a narrow range of retail stores plus food and entertainment. The retail options are many, such as men's or women's clothing.

While malls provide a single destination for many trip purposes, they have several transportation downsides. The business density is relatively low compared to centers or even to arterials, largely due to the extensive parking lots that surround the main buildings containing the stores. Those parking lots, often surface lots, cut off access to the malls from the adjacent neighborhood and can add as much as a quarter mile distance just to reach the stores. Customers and employees typically drive to get there.

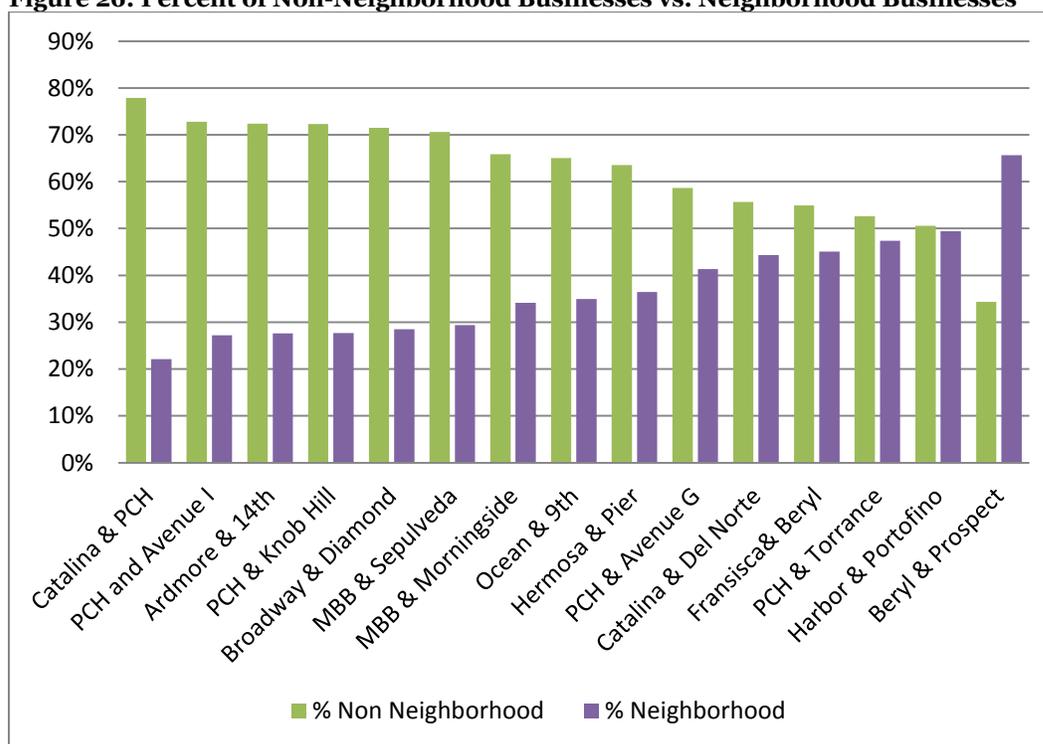
Malls lack most of the destinations that generate trips to corridors and centers, from neighborhood services to schools, medical services, and non-retail employment opportunities. Centers and corridors lack the rational plan that facilitates trip chaining for a narrow band of destinations.

In the end, both corridors and regional malls face challenges being transformed into neighborhoods and centers. Malls have a single owner while ownership on corridors is fragmented. Each condition has both opportunities and challenges.

Hot Spots- Neighborhood Destinations

Since these clusters become hot on the basis of driving as there are no walking data, it would seem reasonable that non-neighborhood functions/destinations would dominate.

Figure 26: Percent of Non-Neighborhood Businesses vs. Neighborhood Businesses



Neighborhood businesses are those that draw most of their support from residents of the immediate walking area of .5 mile (and from employees of the other businesses in the center). Given the sheer number of businesses in these clusters -- 11 of the 15 have between 200 and 520 businesses -- a reasonable assumption is that a relatively low percentage would be neighborhood serving. That is the case, at least at the .25 mile radius distance. A different pattern might be found at a 1/8th mile radius. Beryl and Prospect is the lone exception with about 65% neighborhood serving businesses and it is near the top of third tier of hot spots. Harbor and Portofino is close to a 50-50 split and it is in the middle of the third tier of hot spots. Still, three of the top five hot spots (#2,3, and 5) have between 42% and 48% neighborhood businesses.

A significance of a large percentage of non-neighborhood businesses is that the area may be dependent on an effective system of mobility. Those businesses rely on attracting customers from outside the area. Ease of access, cost of mobility, and availability of parking are key considerations.

Summary

In summary, the following findings are potentially useful to designing new neighborhood centers:

- Scale of a neighborhood center could be around 1.2 million square feet.
- This could be accommodated on two 1/8 mile square corners at an intersection in two story buildings.
- The buildings would house a mix of around 400 retail and commercial office businesses occupying 3,000 square foot each on average.

- Up to a couple of thousand people could be employed there.
- Each center should contain some of the following popular retail destinations: grocery, coffee and restaurants, banks, post offices (or Fed Ex/UPS stores), and some personal services and personal shopping. Work spaces are also essential.
- Single ownership of neighborhood commercial centers could produce the kind of mix design that makes regional malls so internally effective, replacing the spatial “chaos” of the real estate market.

Developing a new neighborhood design compatible with innovative neighborhood mobility is a work in progress. More detail will be added once the NEV data are analyzed further (looking at business density and residential density for example) and combined with the results of related studies including the NOD Feasibility Study (funded by SCAG) and the BEV Demonstration Project (funded by AQMD). All of this will be combined with the data from the SBTPS. The next synthesis should be prepared sometime in 2015.

6. Conclusions

The built-out development pattern of the South Bay consists of many horizontal mixed-use neighborhoods where most trips are between 1 and 3 miles. They are typically too long to walk and too short for transit but ideally suited for short range vehicles like NEVs/LUVs and cycles. Consequently, it is not essential to change land uses or to make very large capital intensive rail infrastructure investments in order for the South Bay to become sustainable – so long as progress at converting the gasoline-fueled automobile fleet to some form of zero emission vehicle is proceeding at a swift pace. Consumers “range matching” their vehicle choice to trip length is one key to that transition. Local use vehicles and cycles as substitutes for a household’s “second car” are essential to the pace of transition. If signs of the transition fail to materialize in the next two or three years, then changes to the development pattern in the form of neighborhood oriented development need to proceed at the most promising locations. NOD will create opportunities for more walking and transit usage in addition to LUVs and cycles.

This project has demonstrated that there are substantial economic, environmental, and societal benefits to be captured by wide spread adoption of specialized local use vehicles, in most cases as the second car in a household. In an ambitious vision, it is even possible for LUVs to become a catalyst to improvements to the built environment in neighborhoods everywhere, not just in high quality transit service areas.

Emerging options in the LUV market segment are in prototype or being marketed elsewhere in the world. Consumers may soon have a number of zero emission LUV options.

Scientists recently reported that carbon dioxide in the Earth's atmosphere had surpassed 400 parts per million, thought to be the threshold beyond which there will be profound changes in nearly every aspect of life. Days with temperatures over 95 degrees, 100-year storms, intense droughts and wildfires will be the norm not the exception. Transportation produces the largest percentage of GHG emissions and is the prime target for reducing them.

At the same time, economists predicted that the price of gasoline would increase over the summer. This reflects the higher cost of the special summer blend required in California for air quality reasons, but also the gradual increase in gasoline prices expected as supply remains relatively fixed while global demand continues to grow.

Monetary cost of air pollution in Southern California is at least \$14.6 billion per year. In 2030, pollution from just 3 sources – ships, trains, and aircraft – will lead to ozone levels near the federal standard. Reaching the 2032 federal ozone air quality standard and the 2050 state climate goal will require nearly complete transformation of the passenger vehicles to zero-emission technologies.

These economic and environmental imperatives mean that how South Bay (and California) residents shop, work, and conduct family business must change dramatically in a relatively short period of time. Local use vehicles can make a significant contribution. The stakes are high. Change is urgently needed.

However, the LUV is caught in a classic chicken-egg situation. According to Wikipedia, the “chicken-egg problem” refers to a situation in which it is impossible to

reach a desired outcome because a necessary precondition is not satisfied, while to meet that condition in turn requires that the desired outcome has already been realized. The core challenge is to break into this circular dependency.



Wide scale LUV deployment has several circular dependencies:

- Multi-modal Class II lanes depend on a threshold level of LUVs on the road; getting more LUVs on the road depends on having class2 lanes.
- Manufacturers producing more LUVs depend on consumers making range matching decisions; consumers range matching depend on there being more LUV options in the market place.
- New neighborhood centers designed to accommodate LUVs depend on a threshold level of LUVs; more LUVs will be purchased as new neighborhood centers are developed.

Addressing the Challenge

The challenge is to identify which of the many policies and initiatives discussed in previous chapters would be the most useful for breaking into the chicken-egg syndrome. Here are some candidate initiatives to begin with.

- A vehicle manufacturer produces a sturdy, no frills vehicle at a price point of \$8,000 or above. GEM's prototyped but never marketed Peapod may be that vehicle.
- Sharrows are more widely used on streets posted at 35 MPH. Sharrows may be a way to introduce mixed-mode streets that could evolve into an extensive system of mixed mode Class II lanes.
- Aggressive public education campaigns about "range matching" are funded. The SBCCOG would like to develop an online "needs assessment tool" that will allow residents to input their travel pattern and receive vehicle options.
- Level 1 charging becomes widely available at work places, hot spots and other retail centers. With multi-head 110 V chargers available, the cost of making level 1 charging ubiquitously available would be relatively modest.
- State subsidies for small battery vehicles are substantially increased. As it stands, state incentives for purchasing a PEV are going to relatively wealthy consumers. Making them available at comparable amounts for small battery, less expensive vehicles would help get more local use vehicles on the road and provide the subsidies to lower income households. Initiatives that will reduce average trip length are adopted by a range of institutions.

For example:

- An aggressive telecommuting program is developed in the SCAG region.
- SCAG and Caltrans include trip distance reduction as a key metric to be used in the 2016 SCS and in applications of the Smart Mobility Framework.
- Many retailers adopt small format stores.

Other options relate more to advancing the “vision.”

The SBCCOG integrates the findings from its various land use and transportation studies and demonstrations into a vision of the *Corridor of the Future* where a suburban arterial can be imagined as a series of sustainable neighborhoods. The SBCCOG, with regional partners, sponsors a competition to design the *Neighborhood Center of the Future* on a real site with re-development potential.

Beyond those initiatives that would be advanced by individual local governments, individual auto makers, CARB, SCAG or other single agencies, the possibility of an integrated strategy that would cut across agencies and break down silos would have the best possibility of success but also would be the least likely because it would be difficult and expensive. The following description is illustrative rather than practical. Nevertheless, a vision can advance the conversation.

The integrated initiative would encourage vehicle production, consumer interest, municipal infrastructure development, and EVSE deployment simultaneously by focusing incentives on a defined area like a sub-region or a district. For example, in

2009 representatives of the City of Santa Monica and the SBCCOG discussed the feasibility of creating a “coastal LUV zone” that would run from Santa Monica to the South Bay in which subsidies would be focused in an attempt to encourage deployment of over 1,000 local use vehicles in a short period of time. With success, the target would be increased to 10,000 vehicles.

To make the ‘coastal LUV zone’ work, the following steps would be desirable:

- CARB would expand its AB 118 vehicle subsidy program to a level that would lower the price of certified LUVs to \$6,000 or so; and make the subsidy available solely to residents of a designated zone chosen competitively with the requirement that all jurisdictions in the zone commit to cooperatively create and implement a comprehensive route plan consisting of mixed mode Class II lanes (or sharrows) and public or private charging opportunities at appropriate locations.
- Car manufacturers would have to agree to establish a production line for this market niche that meets specified minimum reliability and performance standards necessary for a vehicle to qualify for the CARB subsidy. The creation of a “coastal LUV zone,” the guaranteed vehicle market and related publicity should provide a carrot to a range of LUV manufacturers with qualified vehicles in production or prototype
- Complementary funds would need to be provided to participating cities in order to pay for the infrastructure improvements, signage, EVSE installations, and marketing/public education campaigns.

From this bold demonstration, an expanded version could easily follow on. This simultaneous attack on both the chicken and the egg would involve a substantial public investment in modes other than rail and infrastructure other than freeways. The LUV proposition would accommodate multiple modes (cycles, NEVs, Segways, and other LUVs) in a single zone 25 miles long for a relatively small cost to the public sector.

The economic and environmental threats are real and immediate. Off the shelf technology is available. Whether an incremental fragmented approach or a bold integrated approach, the time is now for an innovative strategy that addresses our economic, environmental and mobility challenges with the costs minimized for the public sector and with a prominent role for the private sector offering consumer choices.

Appendix A: Vehicle Profiles

Wheego

Vehicle: Wheego Whip

Make: Whip

VIN 485223 (Whip-223)

VIN 485183 (Whip-183)

Year: 2010



Description: The Wheego Whip is a compact 3 door all electric vehicle. It seats two people with a rear cargo area. The Whip features regenerative braking as well as standard “traditional” car-like features which include: am/fm radio; usb portal for an MP3 hook-up; cd player; air conditioning and heating; rear defroster; and, power locks.

Range (Factory Spec): A Wheego Whip has an estimated range of 40 miles.

Cost: \$21,990

Deployment: Two Wheego Whips were used as part of the Neighborhood Electric Vehicle Study fleet. The Whips were placed into service in April and June 2010, respectively. Except for a brief 2 week repair period at a local service center (for Whip-223) as well as the occasional (lesser) mechanical challenges, the Wheego Whips were used continuously by study participants for over 2 years. Both vehicles were rotated out of the project in August, 2012. Over the course of the study, the Whips were driven by a total of 18 households for an average of approximately 2 months. The Wheego Whips totaled 3,353 and 2,613 miles, respectively over the duration of the study.

Participant Overview: Study participants experienced the Wheego Whip as “cute” and a “fun to drive” and, in some instances, the Wheego Whips were a “good match” for participants’ local trips. On the whole, however, participants noted that the performance of the Wheego Whip did not match their expectations. Given their experiences and challenges, participants placed the relative price of purchasing a Wheego Whip between \$8,000 and \$10,000 - substantially less than the manufacturer’s suggested retail price of \$18,000. Influencing this understanding were issues concerning the “Range” as well as the “Design-Build” – that is, a multiplicity of mechanical problems diminished the participants’ driving experience and/or were prohibitive to participants’ fully utilizing the vehicle for local trips.

Participant Feedback

Range: Critical to participants’ perceived utility and effectiveness of the Wheego Whip was the issue of the car’s “lack of range.” Before participating as drivers, each participant was advised that the Whip might have a total range (based on 100% battery charge) of between 20-30 miles. This was a conservative estimate (against the factory range specifications of 40 miles) to account for possible terrain (hills), driving behavior and use of on-board systems like the car radio, heater and air conditioning which were expected to diminish total driving range for the participants. Given this conservative estimate, all participants reported being dissatisfied with “how far they could actually travel.” No participant reported experiencing a total range that more than 25 miles and many reported (estimated) ranges of between 12 and 15 total miles. As a result, many trips “were not taken” or there were instances where participants were forced – due to lack of battery charge - to find or use charging opportunities outside of their own home – often, this would mean having to leave the Whip somewhere overnight for charging.

Design/Build Issues: Based on their experience in the NEV study, participants had both praise and criticism concerning the “design/build” quality of the Wheego Whip. Several of the

participants noted that there was “surprising (passenger) room” given the cars “smallish” external size. Additionally, the fold-down back seats provided ample cargo space – one participant noted that she was able to “pack 300 books into the back” for a library sale while another participant, was able to “haul all of her scuba gear” she needed for a class that she taught at the beach.

In terms of criticism, in comparison to their “regular” family car, several drivers noted that it was “not very well built” causing one participant to suggest that driving the Whip left him “feeling a lack of safety.” Of note, almost all drivers experienced some sort of mechanical issue while driving the Whip. Issues, both minor and major occurred leading several participants to note that they would not “have expected” this type of problem from a relatively new car.

The range of minor issues were numerous and included instances where plastic components like (glove box) handles within the car failed or broke, rust formed on exterior metal parts, wiper blades needed replacing (after limited use), plastic film linings on exterior lights began to peel, the automatic windows did not function properly and, in one instance, a seatbelt component broke.

More serious challenges to the driving experience required either Wheego Servicing and/or LUV Staff assistance to diagnose trouble-shoot and fix. Issues of this nature included both electrical and drive-train problems. Over the course of the study one or the other Whip experienced specific problems like an “unresponsive throttle”; a failed charging unit; a damaged (factory approved) extension cord; a “loose control box mounting bracket”; a “charge controller pin problem”; and, at least one instance of the engine shutting down due to overheating from climbing local hills. Each of these problems affected the actual drivability of the Whip – forcing the car to be taken off line for brief periods of time or, in the case of one of the Whips, the problem required the car to be taken out of service (for repair) for about 2 weeks.

Additionally, there were instances where design issues proved to be challenging to the successful use of the Whip. In particular, it was discovered that the “cut-off” switch (located behind the passenger side seat) could be inadvertently engaged thereby cutting off the electrical system; trouble-shooting this issue was not recognized immediately and, as such, resulted in two days where the Whip could not be used. Similarly, the key/FOB proved problematic when it was “pressed” in the wrong sequence thus resulting in hazard lights turning on (and not being able to be turned off) and locks malfunctioning. Additionally, it was reported that the “charging plug” was poorly designed thus, for at least one participant, proving problematic to efficient charging.

GEM

Vehicle: GEM

Make: e4

VIN 051128 (GEM-128)

VIN 051331 (GEM-331)

Year: 2010



Description: The GEM e4 is a compact 2-door (butterfly style) all electric vehicle. It seats four people with a rear external trunk box. Aside from windshield wipers and seatbelts the GEM e4 does not feature any other amenities.

Range (Factory Spec): A GEM e4 has an estimated maximum range of 30 miles.

Price : **\$15,380** (one NEV was loaned to the project from the GEM dealership)

Deployment: Two GEMs were used as part of the Neighborhood Electric Vehicle Study fleet. The GEM NEVs were placed into service in May (GEM-128) and July (GEM-331), 2010, respectively. GEM (128) used in the study for a period of 1 ½ years completing its final rotation in October, 2011. During this time was used continuously during this period of time without any mechanical or battery issues. The second GEM (132) was used in the study for 2 ¼ years and was rotated out of the program in October, 2012. It was used continuously with the exception of 8 days where the vehicle required servicing or was in-operable. Together, the two GEM NEVs were used by 16 households for an average rotation of 2 ¾ months per household; the first two drivers of each GEM drove their respective NEVs for substantially longer periods of 7 and 5 ½ months, respectively. The GEM e4 NEVs were driven a total of 2,978 and 4,693 miles,

Participant Overview: Study participants were extraordinarily enthusiastic about their experiences driving the GEM e4. Participants were universal in their comments that the “golf cart” like NEV was “fantastic” and the “perfect” for local trips around their respective communities. Participants often characterized their experience as it’s “a fun car to drive.” All participants with children noted that “even their kids loved driving in the GEM.” The lack of amenities and noticeable design/build issues were, for the most part, forgiven by participants. Participants embraced the NEV as a vehicle that was perceived safer than other small “car-like” NEVs for the very reason that it “doesn’t look like a car” but more like a golf cart; participants felt that because of this, while driving in traffic or on faster-moving streets, they would be better seen and/or other drivers would not be “impatient” with their slow speed of travel. Enthusiasm for their LUV experience with GEM translated into two families (based on their positive experience of driving the GEM) purchasing new models for their households; additionally, several other participants stated that they were “seriously” considering the purchase of a GEM for their households.

Participant Feedback:

Range: Study participants indicated that the range for both GEM e4s was less than 20 miles – about 33% less than the factory specifications estimated. Approximately 1/3 of the GEM drivers noted that they would have desired a better range during their participation. For several participants, traversing the local hills in the GEM resulted in fewer trips that they could take on a full charge. For these individuals opportunity charging would be necessary for additional trips to be taken during the day. That being said, most participants, even with a less than ideal range, found that they could get where they needed for most of their local trips.

Design/Build Issues: Participants in the study liked the GEM e4's "very basic golf cart" like design. It was often referred to as "cute" or "fun-looking". Certainly, when participants received their GEM e4 at the beginning of their rotation it was what they expected in terms of their perceptions of what neighborhood electric vehicle would look like. Interestingly, the lack of amenities, like a radio, was seen by participants as disappointing however, it did not deter their enjoyment of driving the NEV.

On the other hand, in terms of the build quality of the GEM, participants were very clear that it was cheaply made pointing to such features like the plastic pull-up windows which were described as "schlocky" and the door handles that rattled. Importantly, GEM participants noted – after days when it rained - that the car leaked with water getting inside the vehicle; the car was really a "fair weather" vehicle and not designed for bad weather. Additional issues were discovered when, in colder weather (with the windows pulled up) the plastic would fog up. This became a problem since there was no on-board defroster to mitigate this issue; participants reported that they would "just open the windows to clear up the windshield. While no major battery or mechanical issues occurred one driver was forced to "abandon" the GEM for several hours after it over-heated during a series of trips "up and down" his neighborhood hills. Like

the issues concerning the rain, his experience was viewed as a minor inconvenience. He remained extraordinarily enthusiastic about driving the GEM even if it he had to “walk back to his house” for a little while before being able to restart the vehicle.

Miles Wagon

Vehicle: Miles EV

Make: Wagon/Sedan ZX40S

VIN 000085 (Miles-085)

VIN 000132 (Miles-132)

Year: 2010



Description: The Miles Wagon is a compact 5 door all electric vehicle. It seats four people with a rear cargo area.

Range (Factory Spec): A Miles Wagon has an estimated range of 40-50 miles.

Price (MSRP): \$19,500

Discount Price for Study: \$7,500 (one NEV was loaned to the project from the City of Santa Monica)

Deployment: Two Miles Wagons were used as part of the Neighborhood Electric Vehicle Study fleet. The Miles EVs were placed into service in February, 2011 and April 2012, respectively. Miles (Vin 085) was used in the study for a period of 2 1/2 years completing its rotation in August, 2013. During this time period it had two major repair and servicing issues which resulted in a total of 3 1/2 months where the vehicle was not available to the study. The

second Miles Wagon (Vin 132) had an 8 month rotation in the study that ended in December, 2013. Two weeks of study time were lost due to a broken key in the driver's side door. Together, the two Miles NEVs were used by 16 households for an average rotation of 1 ¾ weeks of use per household. The Miles Wagons were driven a total of 5,190 miles over their use in the study.

Participant Overview: Study participants experienced the Miles Wagons as very simplistic car-like electric vehicles. Essentially, they were viewed as being very utilitarian “glorified golf carts” with “no bells or whistles.” The quality of the NEVs was perceived as poorly made, participants observed that it was “not a car built in Detroit” and that it was more like “a car that’s like a tin can.” That being said, it was driven by many of the participants with great enthusiasm and high frequency, essentially being used for “all local trips” that would otherwise have been made using their regular family cars. Common issues for the Miles NEVs concerned the lack of range as well as the quality of the design/build of the car.

Participant Feedback:

Range: Study participants indicated that the range for both Miles Wagons was approximately 20 miles – about 50% less than the factory specifications estimated. The poor battery quality was noticed by all participants over the course of the study. This was especially so during the early period of the study where the resulting lack of range ultimately led to the batteries being replaced twice during the first 4 months of the study. While participants throughout the course of the study desired longer range the Miles Wagons they were still able to use the NEVs for most of their desired trips. Participants used strategies of opportunity charging at other locations or re-charging during periods of time when the vehicle was at home to maximize the number of trips that could be taken during the course of a day. Examples of this type of range extending charging strategy occurred with one a family that drove many daily trips to take their children to school and various afterschool activities. The family would “recharge” at every opportunity

“between picking up and dropping the kids off.” Other participants would recharge at work locations or “charge-up while (they) were having dinner at a friend’s house.”

Design/Build Issues: On the whole though, the Miles Wagons were seen as very utilitarian and not having much by way of amenities. Many of the participants suggested that they thought it might have a few “car-like” bells and whistles like a radio. Several of the participants noted that the Miles Wagon had ample cargo space for carrying groceries and other items; often participants would take the spare tire out of the back area of the car to afford a bit more room. Ironically, larger families of more than 4 people could not all safely fit in the NEV. In some instances, the lack of an extra seat for a 5th passenger proved a challenge to planning family trips or would, in some instances, necessitate 2 trips to shuttle everyone to one location.

In terms of the build quality, all participants were in agreement that the Miles Wagons were built poorly. In some instances this was observed through experiences of broken door handle; a rear view mirror that snapped off; a window handle that broke, and a key that snapped off in the driver’s side door lock. Moreover, as one participant noted, “the car seemed to be made of tin;” from the inside it seemed to rattle while driving leaving participants and passengers with the sense that it wasn’t “put together very well.”

Miles Pickup

Vehicle: Miles Pick-up

Make: Miles ZX40ST EV

VIN 000329

Year: 2009



Description: This Miles (ZX40ST) Pick-up is a 2 door utility electric vehicle that has bench seating for 2 passengers. The model came equipped with on-board climate control (heater/air conditioner). The flat bed is approximately 6 ft. long by 4 ft. wide with “easy-hinge” side collapsible panels that fold down. This EV did not have a radio or other amenities

Range (Factory Spec): A new Miles Pick-up EV has an estimated range of 30-40 miles.

Price (MSRP): \$19,500

Discounted Price for Study: \$7,500

Deployment: As part of the Neighborhood Electric Vehicle Study fleet the Miles Pick-up EV was placed into service April, 2012 until it was rotated out of the project in December, 2013. The Miles Pick-up was driven continuously during this period by four different households for approximately 2 months per family. Over the course of the study, the Miles Pick-up EV was driven a total of 3,720 miles.

Participant Overview: Study participants experienced the Miles Pick-up EV as a utilitarian “working” vehicle. The lack of any design features including bench seating for only two people limited the type of use that participants had with the vehicle. Those individuals that had work that necessitated carrying of loads or equipment found more value and use for the vehicle while other families had a harder time incorporating the Pick-up into their life-style and driving patterns. The NEV was fairly durable however it had range limitations as well as other mechanical issues that deterred participants from positive experiences during their participation in the study.

Participant Feedback

Range: Study participants indicated that the Miles Pick-up range was about 20 miles – approximately 50% less than the factory specifications. In almost all instances the limited range was not a problem because of the relatively short trips (from home) that participants took. However, in one case a participant who lived in North-East Manhattan Beach ran out of power on a return business trip to South Redondo Beach. Ultimately, this was uneventful as the participant had a power cord on-hand and stopped to charge for “a couple of hours” before heading home.

Design/Build Issues: Of note for all participants was their feeling that the Miles Pick-up was lacking in certain design features and that it was poor build qualities. While all participants understood that it was a utility vehicle, they expressed regret that the design of the NEV did not include such amenities as a radio and bucket seats. Bench seating was seen as a negative experience and limited the amount of cargo that could be carried within the cab – behind the front seat. The tight and narrow cab also mitigated taking more than 1 passenger; travelling with the family dog became a challenge for one participant and impossible for another who had two dogs to travel with.

In terms of the build issues, the NEV “handled like a truck” and performed like one; all participants expected and had this experience. One participant, familiar with pick-up vehicles, used a 50 pound bag of sand to “stabilize the ride.” However, in two instances where the Miles Pick-up required servicing for mechanical issues – a dirty speed sensor and a loose connector between the battery and the engine – were experienced by the participants as indicating poor build quality. Of note, one participant dropped out of the program after experiencing an “engine cut-off” while in traffic, furthering his perception that the NEV was not reliable nor well built.

Vantage Crewcab**Vehicle:** Vantage**Make:** CrewCab**VIN** 113575**Year:** 2010

Description: The Vantage CrewCab is a 4 door all electric vehicle. It seats four people with front bucket seats and a back-seat bench. Additional cargo space is provided with a small cargo trunk mounted on a small rear platform. The features standard car-like features which include:

Range (Factory Spec): A new Vantage CrewCab has an estimated range of 40 miles.

Price: \$21,633

Deployment: As part of the Neighborhood Electric Vehicle Study fleet the Vantage CrewCab was placed into service May, 2010 until it was rotated out of the project in August, 2011. The Columbia Summit was driven by four different households. Over the course of the study, the Vantage CrewCab was driven a total of 4,897 miles. On average each participant drove the NEV 4 ¾ months. The vehicle was pulled from the study 3 times for servicing and repair issues concerning the battery. The total time that the NEV was out of service during its time in the study was 6 weeks.

Participant Overview: Study participants experienced the Vantage CrewCab as a utilitarian work vehicle. The back-seat was handy for taking extra passengers or storing cargo within the cab of the NEV. Three out of four participants felt that the Vantage CrewCab was “perfect for their driving needs” – each respectively using the vehicle for their businesses that involved property management or construction. One participant who owned a design/build firm had

anticipated that the NEV would be well used by her project managers to go from “job site to job site.” However, the reality was that they felt the maximum speed of 25 mph was too slow for them to get to their meetings and appointments and so “would opt to use their big trucks instead.” On the other hand, she discovered that her office workers would “use the CrewCab all the time to run errands in town.” While the NEV was well used, participants also recognized the NEV as having design/build issues; as one participant put it, the “CrewCab seemed a little cheap.” All of the participants experienced mechanical or battery difficulties during their participation in the program.

Participant Feedback

Range: Study participants indicated that the Vantage CrewCab’s range was, at best, 20 -25 miles per full charge. This was approximately 50% less than what was anticipated given the factory specifications. In some instances this was not an issue as the NEV was used for very short trips during the course of the day and was recharged frequently during the day. However, for others in the study, the range was an on-going issue. Several of the participants in the study noticed, over time, a continual down-turn in how far they could drive the NEV on a full charge. The decline in range was symptomatic of on-going systemic battery problems and required multiple service calls and repairs over the time that the Vantage CrewCab was in the LUV fleet. After the Vantage CrewCab was rotated out of the study it was learned that the recurrent problems were likely caused by improperly programed battery control software that consistently overestimated the charge status of the vehicle – thus causing repeated battery damage and the lack of range that was experienced by the participants.

Design/Build Issues: The Vantage CrewCab was perceived as a utility vehicle and, as such, participants had low expectations about the design and amenities for the NEV. The primary feature that participants liked was the design allowed for both a flat-bed as well as back seat

with an external cargo trunk for the vehicle. While looking like a “glorified golf cart” it easily allowed extra passengers as well as carrying extra goods inside and outside the cab.

One participant did not experience any real challenges with the NEV and was “ready to buy one right away” but all participants, at one time or another, had problems with design/build of the NEV. The issues ranged from “poorly designed seatbelts” that didn’t fit to a key FOB that broke to an ongoing battery issues which would require servicing or the NEV having to be pulled from the study for weeks at a time. All of these issues led one participant to sum up that the Vantage CrewCab “had a lack of quality given considering their expense.”

Columbia ParCar-Summit

Vehicle: Columbia

Make: Summit SM4 NEV

VIN 01722

Year: 2010



Description: The Columbia Summit is a 4 door all electric vehicle. It seats four people with front bucket seats and a back-seat bench. Additional cargo space is provided with a small cargo trunk mounted on a small rear platform. The Summit features standard car-like features which include: 4 doors, headlights, taillights, back-up lamps. It also included a front attached dashboard heater that could (when the heater was turned off) function as a fan. The Columbia Summit did not have any other amenities like radio, cd player, air conditioning, power windows or rear defroster.

Range (Factory Spec): A new Columbia Summit has an estimated range of 35 miles.

Price: \$15,780

Deployment: As part of the Neighborhood Electric Vehicle Study fleet the Columbia Summit was placed into service June 2010 until it was rotated out of the project in August, 2011. Two different versions were tested during the course of the study. The first version was a DC battery system which was placed into service in June 2010 and rotated out shortly thereafter in favor of a similarly appointed vehicle with an AC battery system. The Columbia Summit was driven continuously during this period by two different households. Over the course of the study, the Columbia Summit was driven a total of 2,483 miles.

Participant Overview: Study participants experienced the Columbia Summit as very “utilitarian” and, though it was a “harsh ride,” one participant indicated that it “goes and goes.” Participants were divided about the quality of the vehicle with one person indicating that it had a “lack of build quality” while another suggesting that its “golf cart-like frame” was sturdy enough. Participants were more approving of the AC powered version than that of the version with the DC battery system. No issues of any import reported during the deployment of the Columbia Summit during the course of the study. When asked “at what price would you consider purchasing” this NEV participants indicated an average of \$15,000.

Participant Feedback

Range: Study participants indicated that the Columbia Summit’s range was about 30 miles – about 15% less than the factory specifications estimated. In terms of driver feedback, this seemed fine. As one participant noted that it “just goes and goes and goes.” Another participant was able to maximize his range through a strategy of using the “Tortoise” switch which economized the battery use. The use of this feature was particularly noticeable for one participant when he observed that his range held steady (in this mode) while travelling “uphill”

when returning home from local trips. Participants did not seem to notice any difference in the range between the DC and the AC battery versions of the vehicle - albeit the DC version was not tested over a long period of time.

Design/Build Issues: All three participants that tested the Columbia Summit indicated that the car was very “utilitarian.” While the lack of design features and amenities like a radio, cd player, power windows and even air conditioning were understandable for a “golf cart” like vehicle it was also noted that “compared to other NEVs (like the Wheego or Vantage Crewcab) the Columbia Summit’s design/build was “a little cheap.” One participant was critical of the lack of a horn as well as the lack of an automated shutoff for the turn signal. On the other hand, another participant noted that the design of the NEV – with its utility bed and four doors was “useful” and a “plus” for his needs as a caterer. All three participants indicated that the AC battery system allowed for better “acceleration and power” than the DC battery version of the NEV.

Appendix B Participating Household Profiles

Household 1 (KA): KA lived in a single-family rental home in South Torrance. She worked for a local non-profit and drove the Miles Wagon during a 2 1/2 month period beginning in July 2012. The sole vehicle for the household was a 2002 Mazda Wagon. KA worked for a non-profit and used the NEV for local trips for local trips that involved transporting her 3 children to various local destinations. Her challenge was both the speed restrictions posed by 40 mph posted streets in the area as well as the fact that the NEV could not travel faster than 25 mph. Interestingly, after participating in the NEV study and her own research KA purchased a Chevy Volt to replace the family car.

Household 2 (NA): NA lived in a single-family home in Hermosa Beach. NA was a stay at home Mom with 2 children. The family owned 2 cars including a “gas guzzling” SUV which, at one point, was replaced entirely by the use of the LUV for a period of 3 months. The family participated in the study for 6 months from July through December, 2010. Their primary NEV was the GEMe4; however, for a brief period while the GEM was being fixed NA drove the Summit. While both vehicles had issues, NA favored the GEM and used it primarily for local shopping trips as well as transporting children to various local activities.

Household 3 (TA): TA lived in a relatively small single-family home in Hermosa Beach. TA worked in the entertainment industry and commuted, as needed to different set locations throughout the region. The family owned two cars. For one month, beginning in August, 2012, TA and her family participated in the study. During that time they drove the Miles Wagon for various local trips however, the use of the LUV was diminished by the issue shortage or lack of off street parking at their home. Having to rotate/move their various cars in order to park and charge the LUV became a problem and, as a result, mitigated their participation in the study.

Household 4 (BS2): BS2 lived alone in a rental apartment above a detached garage in Redondo Beach; her primary vehicle was a 1995 Chevy Van. During a 2 month participation

that began in September, 2012 BS2 test drove the Miles Wagon. As a local owner of a woman's training studio and roller-derby athlete, BS2 drove the LUV to and from work as well as the beach (where she conducted outdoor activities with her clients). Additionally, BS2 used the Miles Wagon for all local errands and trips including shopping, entertainment and visiting friends; almost all of her local trips using the Chevy Van were replaced by the LUV. BS2 was able to creatively charge the Miles Wagon by running an extension cord from her second floor apartment down to the LUV as well as to charge while at her local studio; if need be, walking back to her home while the LUV charged over-night. BS2 did not experience any road mechanical problems however the poor quality of the lock system on the driver's side door resulted in the key breaking in the lock. The result was that BS2 lost a week's worth of time driving while a replacement key was found.

Household 5 (TC): TC lived in a single-family home in Redondo Beach. The family owned 2 vehicles including a Toyota Prius and a Ford Expedition SUV. As a stay at home mother of 3 children TC used the GEM to replace all local trips using the SUV. These trips included shopping and transporting her children to various local destinations. The TC family participated in the study for 2 1/2 months beginning in January, 2011. TC enjoyed her experience with the GEM and did not report any major problems or challenges.

Household 6 (SC): SC lived in a single-family home in North-East Manhattan Beach. SC and her husband owned 2 cars and had 2 children living at home during the course of the study. The family participated in the program from November through December, 2012. As a teacher at a local high school, SC used the Miles Wagon as her primary commute car. Additionally, the family used the vehicle for transporting their children to and from local activities; shopping and trips to their local gym. The family noted that the "overall experience was great" however, the LUV's top speed of 25 mph as well as several major arterial streets made some trips problematic

or impossible to take; additionally, it was noted that the Miles Wagon's range began to diminish towards the end of their participation.

Household 7 (NC): NC lived in a rental apartment complex in Redondo Beach. The household had two cars and did not have any children. At the time of the study, NC worked for the City of Redondo Beach Senior Services Department. NC was the primary driver of the Wheego Whip and used the LUV for 3 ½ months beginning in February, 2011. The LUV served as a replacement vehicle for all local trips during a two month period while her Honda Civic was being repaired. Typical trips included commuting to and from local work locations and shopping. NC had a positive experience driving the LUV and did not report any issues or challenges concerning the use or design-build of the Wheego Whip.

Household 8 (PC): PC lived in a rental single-family home in El Segundo. The sole vehicle for the household was a Toyota Prius. PC and his wife participated in the study for approximately 1 beginning in November, 2012. They drove the Miles Pick-up for all local El Segundo trips. PC was unable, however, to use the LUV for commuting to work at a local high school in Manhattan Beach because the City is an "island" surrounded on all sides by posted roads of 40 mph; thus diminishing their experience in the study. They did not have any issues concerning the operation of the vehicle but noted that the design-build of the Miles Pick-up was "utilitarian" and not amenable to taking both of them and their dog on local trips.

Household 9 (JC): JC was a Pastor who lived with his family (a wife and 3 teenage children) in a multi-unit pastoral building located in Redondo Beach. The family owned 3 cars and JC functioned as the primary driver of the LUV. Beginning in June, 2010, JC and his family participated in the LUV study for a period of 7 months. For the first 3 ½ months they drove the Columbia Summit which was followed by their subsequent use of the Wheego Whip for the balance of their participation. Nearly all of PC's local trips were taken using the LUV's. PC and

his family noticed an appreciable difference in the quality of their driving experience and the design-build of the Wheego Whip in relation to the Summit, preferring the former to the later.

Household 10 (LD): LD was a single self-employed professional who lived in a rented apartment in Redondo Beach. She her participation in the study began in August, 2012 and lasted one month. LD drove the Wheego Whip and was able to use it as her primary mode of transportation for the duration of her participation. Her travels included a short commute to the local pier where she taught scuba diving. Other trips included shopping, visiting friends and general errands. LD enjoyed her experience driving the Wheego however, due to several mechanical failures as well as a diminished range due to poor battery charging and hilly topography, she had a less than successful test of the LUV. On the other hand, the Wheego was the “perfect” type of LUV for her work and life-style and opened her eyes to the possibility of electric cars as her next vehicle purchase.

Household 11 (SD): SD and her family of two children and husband lived in a single-family home in Redondo Beach. Beginning in July, 2011, SD drove the GEM for 3 ½ months. The family owned a Suburban SUV and found that the GEM replaced many of the local trips during the course of the study. These trips included transporting children to various activities as well as shopping. Posted speed restrictions, however, curtailed trips to other frequent destinations that including Costco and SD’s gym. Additional challenges involving the GEM’s brakes required attention but did not diminish SD or her family’s overall experience.

Household 12 (ME): ME, his wife and two teenage children lived in a single-family home in Manhattan Beach. The family owned 2 vehicles and drove the Miles Wagon during the study. MH’s 2 month participated from June through August, 2012. As a contractor, MH was able to use the LUV to travel to many of his local job sites. MH also used the Miles Wagon for transporting his children to various activities and running other errands. No performance

issues were noted however issues concerning the maximum speed of the LUV as well as posted speed restrictions ultimately resulted in MH deciding to end his participation in the study earlier than expected.

Household 13 (CF): CF was a stay-at-home mother. CF, her husband and two teenage daughters lived in a single-family home in Redondo Beach. The family owned 3 vehicles and drove both the Miles Wagon and the GEM. Beginning in May, 2011, CF participated in the study for a period of 1 ½ months; driving the Miles Wagon for the first month followed by the GEM. CF was particularly enamored by the Miles EV and stated that they would likely “always have an electric vehicle in the family.” CF used the EVs to replace her Ford Bronco for many of her local trips. No performance issues were noted however there were issues with the design/build of the car regarding a door handle the broke and needed to be replaced.

Household 14 (RF): RF is a management consultant who lives in a single-family home in Hermosa Beach. RF participated in the program for a total period of 4 months beginning in June, 2011 for 1 month followed by another 3 months which began in August of the same year. CF drove the same Miles Wagon during each time period. As the primary driver of the LUV in a 3-person household RF was able to replace 95% of the trips made using one of the household cars. While there were no performance or service issues, CF did note that the design build quality of the “bubble” car was poor and that its functionality could have been increased if the Miles Wagon had a roof rack.

Household 15 (DF): DF, his wife and two elementary school aged children lived in a single-family rental home in Manhattan Beach. DF worked in the real estate field and, beginning in July, 2012, participated in the LUV study for a period of 2 months. During that time, DF drove the GEM which, according to him, was “perfect” for all his local trips; many of which involved showing and visiting various real estate properties that were on the market in his local area. The

GEM was also used for many of their local errands replacing one of the trips that might have been taken using the family's two hybrid SUV's. While no major performance issues or design/build issues were reported, the GEM did suffer two temporary experiences of "over-heating" resulting in having to temporarily having to park the EV to let the motor cool before continuing the trip.

Household 16 (CLF): CLF, her husband and teenage daughter lived in a single-family home in Hermosa Beach. CLF was a retired medical professional who participated in the LUV study for a period of 3 ½ months. Beginning in November, 2011 CLF drove the Miles Wagon which she described as very functional but whose design/build was poor and "rattily". As a two car household, CLF was able to replace many of the local area trips using the LUV. On the whole, CLF's experience was positive however, CLF did point out that due to time constraints, speed posting restrictions and range issues, there were times that she would have liked to use the Miles Wagon but couldn't.

Household 17 (KF): KF and her family of 2 grown children a teenager and husband lived in a single-family home in the hilly "Hollywood Riviera" neighborhood of Redondo Beach. The family owned 3 vehicles and, for a period of 2 ½ months, KF drove the Wheego Whip. KF was the primary driver and, as a semi-retired teacher, used the Wheego to travel to various neighborhood homes to work. Other common trips included shopping and transporting her teenage child to various activities. While the Wheego Whip was a "great car" to drive and generally reliable, challenges concerning the range and battery charge resulted in subtle shifts in driving behaviors to accommodate the topography of their hilly neighborhood; small design-build issues concerning the FOB and electrical system were noted, resolved and did not diminish the family's positive experience driving the Wheego.

Household 18 (JG): JG lived in a single-family home in near Riviera Village in Redondo Beach. The family owned 2 vehicles and test drove both the Vantage Crew Cab as well as the Miles Wagon from May through October, 2010. Both LUV vehicles were driven by JG, his wife and several office workers. The vehicles were used primarily for local business trips related to JG's property management business. During the course of the study both LUV vehicles had technical problems that resulted in on-site service. At this time JG, without permission, had the governor changed so that the vehicles could travel faster than the regulated 25 mph. Upon reflection, this was JG's challenge and concern with the technical and design/build issues for both LUV's. JG's participation in the program was terminated after learning of the technical change to the LUV.

Household 19 (MG): MG lived in a single-family home in the hills of South Torrance. MG, and her husband, two sons of driving age each owned their vehicle. From May through July, 2012 MG was able to use the Wheego Whip to significantly reduce the number of trips that were made using her Jeep. MG used the LUV for local trips for shopping, dining and other errands. While there were no significant issues or challenges that impeded her driving experiences there was an occasional issue of over-heating that resulted from travelling up the hilly terrain of her neighborhood. MG and her family's experience of driving the Wheego Whip was a positive one.

Household 20 (MH): MH and her husband own one car and live in a single-family home in South Redondo Beach. Both individuals were retired. Beginning in March, 2012 MH began driving the Wheego Whip for a period of 2 months. MH was able to substitute many of her local trips for shopping and other errands using the Wheego. Her experience as a participant in the study was, on the whole, positive. Though "rattly," MH and her husband had no issues concerning the design-build of the LUV or problems with the operation of the Wheego.

Household 21 (ZH): ZH and her husband lived in a single-family home in Redondo Beach. The family owned 3 vehicles. Driving the Wheego Whip, ZH was able to replace trips previously made with her mid-sized SUV during the course of her 4 month participation in the study; ZH began drove the Wheego from October, 2010 through January, 2011. During that period, ZH used the LUV to commute to her part-time job at a local synagogue; additional common trips included shopping and regular trips to her gym. ZH's experience driving the Wheego Whip was a positive one and there were no real barriers or challenges other than noting the fact that possible destinations to El Segundo were impossible to access due to 40 mph posted speed restrictions for the LUV.

Household 22 (DH): DH, his wife and 4 children rented a single-family home in Redondo Beach. At the time of the study the family owned 2 vehicles however the household became a single car family after one of their cars was involved in an accident. Beginning in August, 2012 DH and his wife drove the Miles Wagon for a period of 2 1/2 months. During this time, DH and his family used the LUV as their primary vehicle replacing their Suburban SUV for a significant number of trips. The Miles Wagon served as the main mode of transporting their children to and from school as well as their numerous daily activities. The family used the LUV for shopping, doctor's visits and other errands, as well. Aside from the fact that the entire family could not safely fit into the LUV for travelling at one time, there were no issues concerning the design/build or performance of the Miles Wagon. The family had a very positive experience participating in the study.

Household 23 (SJ): SJ, her husband and two driving-age teenagers lived in a condominium in Redondo Beach. At the time of the study the family's sole vehicle was a BMW sedan. SJ and her family drove the GEM and participated in the study for 2 months from April through May, 2011. As a real estate agent SJ found the GEM to be an effective mode of transportation for the many local trips she took. The LUV also was useful for other local trips including shopping.

While SJ and her family thought the experience was positive they experienced mechanical problems with the charge of the battery. Other challenges included the drain on the performance of the GEM due to the hilly terrain of SJ's neighborhood and local areas that she travelled.

Household 24 (PL): PL and his wife were retired and lived in a single-family home in Manhattan Beach. PL drove the Wheego Whip and began his 3 month participation in the study in May, 2011. PL found that the Wheego Whip was able to replace many of his common local trips to such places as the community center, shopping and entertainment destinations. On the other hand, PL expressed disappointment that speed restrictions limited his choice to use the LUV for other trips. In terms of performance PL experienced poor range performance as well as issues with the charging technology that required maintenance. Both issues colored his experience to less than a positive experience driving the LUV.

Household 25 (KL): KL, her husband and 2 teenage children lived in a single-family home in Redondo Beach. The family owned 4 vehicles and participated in the LUV study for 3 months. Beginning in March, 2011, KL, her husband and employees of their Real Estate and Design/Build firm drove the Vantage CrewCab NEV. KL tried to find opportunities for the pick-up electric vehicle to be used in the day-to-day activities and trips of the firm however, due to the need to carry larger loads and travel more quickly to job sites the LUV was not used as she had expected. KL did find, however, that the CrewCab was useful for many of her personal local trips as well as her Real Estate business trips. The utilitarian design/build of the NEV was not a problem or concern for KL nor were there any noted performance or service issues during her participation in the study.

Household 26 (ML): ML is self-employed and lived in a single-family home with his wife and one child in Manhattan Beach; the single-family household has 3 vehicles. Beginning in

February, 2012 ML participated in the LUV study for a period of 3 months. During that time ML drove the Wheego Whip. The LUV replaced some of his local trips though there were perceived issues concerning the limited range as well as the fact that the NEV could not travel faster than 25 mph. There were no reported performance or service issues during ML's participation in the program.

Household 27 (DL): DL, his wife and son lived in a single-family home in Manhattan Beach; the household owned 3 vehicles. Beginning in April, 2012, DL and his son drove the Miles Pick-up for 3 ½ months. As a contractor, DL used the LUV as a utility vehicle for many of his company's local jobs. The NEV "came in handy for hauling" materials to construction projects. The design/build was appropriate to DL's needs and there were no issues concerning performance or service during his time in the study. The only issues that mitigated DL's experience concerned the range of LUV to reach jobs in areas like Palos Verdes as well as posted speed restrictions of 40 mph which limited the routes DL could drive.

Household 28 (SL): SL was a home-office IT professional; one-person household. SL rented a single-family home in North Redondo Beach and drove a Wheego Whip. SL began her 3 month participation in the study in December, 2011. SL felt that her driving behavior did not change significantly because "she drives like a little old lady anyway," however, after several uncomfortable experiences driving in fast moving traffic (streets where the speed limit was posted at 35 mph but traffic moved much faster) she became concerned about her safety – "not being seen". SL was happy with the design/build of the Wheego Whip however she was disappointed in both the fact that it would not drive faster than 25 mph and it's limited range.

Household 29 (AM): Both AM and her husband are retired and live in a single-family home in Torrance. The household has two cars and began their 2 month participation in the study beginning in June, 2012; the family drove the Miles Wagon during the course of the study.

Almost all local trips were taken using the LUV – “the Miles became like our family car”. Destinations included the bank, post office, shopping and even a weekly car wash for the LUV. During the study the Miles Wagon experienced a broken (forward/backward) switch which did not result in any loss of time but rather it was a minor inconvenience. AM and her husband thought the Miles Wagon was sufficient in terms of the design/build (i.e. enough cargo room) though they wished it had a greater range. The family thought, overall, that “it was perfect for their needs”.

Household 30 (JM): JM and his family of his wife and two children lived in a single-family home in Torrance. The household had two cars and JM began driving the GEM in March, 2011; he drove for a period of one month. Initially JM was excited about the prospect of using the LUV for daily local trips to work and to drop his children off at school. However his excitement was soon tempered by his frustration of finding routes on streets posted with speed limits of less than 40 mph. Alternative routes became cumbersome or presented issues of safety on streets that were 35 mph but where other cars travelled much faster. These issues resulted in JM requesting to end his participation in the study sooner than expected. There were no issues with the GEM other than the fact that it did travel faster than 25 mph.

Household 31 (JC): JC and his wife lived in a single-family home in Redondo Beach. The household had 2 cars and participating in the LUV study for a period of 4 1/2 months beginning in November, 2011. During the course of the study JC drove the Vantage Crew Cab. JC’s experienced a “good fit” driving the utilitarian LUV for his daily work trips involving destinations as part of his daily property management tasks. There were no reported design/build issues however the Vantage Crew Cab did experience a significant decline in range due to a failing or diminished battery.

Household 32 (MM): MM, his wife and 2 teenage sons lived in a single-family home in Redondo Beach; the household had 2 cars. Beginning in July, 2012 MM began his 2 month participation in the study. During that time he drove the Miles Pick-up EV. MM used the LUV for local errands and for transporting his family's kayaks to the water for recreation. MM did not experience any issues with the design/build of the Miles Pick-up, "it was just like he expected it (a pick-up with a flat-bed) to be". For MM, the challenge was the range and speed of the LUV. These issues became apparent on his first trip when he ran out of charge and needed to have the LUV towed home.

Household 33 (MMK): MMK lived with his girlfriend in a rental apartment in Redondo Beach; the household had 2 cars. Beginning in September, 2011, MMK began a 2 1/2 month participation in the study. During that time he drove the Wheego Whip. The LUV turned out to be a "perfect" vehicle for MMK because, as an itinerant local teacher, his daily travels took him to 4 schools all within the range of the LUV on easily found routes. MMK did not have any issues with the Design/Build of the Wheego Whip, however, he would have liked it to have a longer range. Additionally, MMK would have had better feeling of "safety" if the LUV could travel faster (in relative to other cars on the road).

Household 34 (KN): KN and her husband lived in a single-family home in Manhattan Beach; the household had 2 cars. KN began her 3 month participation in the study in January, 2011. During that time she drove the Wheego Whip. As a part-time teacher KN used the LUV extensively for her work as a tutor to local children. KN also used the LUV for many of her family's local errands. KN was "very impressed" with the Design/Build aspects of the Wheego Whip noting that it was very much like a "real car". Her primary criticisms were that longer trips (outside her neighborhood) required extra planning to find appropriate routes. Additionally, she found that the maximum speed of 25 mph ultimately resulted in longer trip taking more time than she would typically experience driving her normal car.

Household 35 (AN): AN, his wife and teenage child lived in a single-family residence in Manhattan Beach. The household had 2 cars and, beginning in February, 2012, they drove the GEM. During the course of the study AN was able to use the LUV for many of his work trips as well as for the majority of local destinations that he typically drove to using one of the family's cars. AN was an enthusiastic driver and found creative ways to haul his kayak and paddleboards to the beach using the LUV. AN had no issues or concerns regarding the Design/Build of the GEM, however he did experience a broken door handle and a malfunctioning "gear button that required servicing. AN was pleased with the range and had no issues concerning the maximum speed of the GEM.

Household 36 (SO): SO and his wife lived in a condominium in Redondo Beach. The household had 2 cars and, beginning in June, 2010, they began their 4 month participation in the study. During that time, SO first drove both the Wheego Whip followed by his testing the Columbia Summit. As a part-time caterer, SO incorporated the use of both LUVs for many of his work related trips. Additionally, SO used the LUVs for personal or family errands that included trips to the post-office, shopping and visits to the doctor's office. SO immediately liked his experience driving the Wheego Whip however it took longer for SO to feel comfortable and enthusiastic about driving the Columbia Summit; he came to this understanding after reconsidering the LUV as "a high-performance golf cart." SO noted that the "lack of Design/Build" of both LUVs relative to their cost. There were no mechanical problems during SO's participation in the study.

Household 37 (ROT): ROT and her boyfriend lived in a 4 person rental unit in Redondo Beach; the two primary drivers each had their own vehicle during the course of the study. Beginning in August, 2011, they shared a Wheego Whip for 2 months. The LUV was used for local errands as well as an alternative transportation option for commuting to work. Interestingly, because of posted speed restrictions, the LUV used as part of a commuter

connectivity strategy where ROT was able to connect to the Green Line light rail to complete the trip to work at an Aerospace company in Manhattan Beach. In terms of Design/Build issues the ROT noted that the Wheego Whip was lacking in cargo space. There were no mechanical issues however ROT did indicate that their other challenges included the lack of range for the LUV and the fact that the vehicle could not travel at a speed of 35 mph.

Household 38 (DR): DR, his wife and two teenage children lived in a single-family home in Redondo Beach. The household had two cars and began their 3 1/2 month participation in the study in November, 2010. DR drove the GEM during his time in the program. The LUV was used as a substitute for his mid-sized SUV and replaced most local trips, including a short work commute to local office space where DR worked as a manufacturing entrepreneur. The LUV also served to replace the use of their family car(s) for many local errands as well as dropping off their children for different activities. DR's choice to not travel further afield was based on his experience of GEM's lack of speed relative to other cars (even in posted areas of less than 35 mph. DR noted that the GEM's Design/Build quality was not good; examples included water seepage into the LUV when it rained and the windows fogging up while driving. On the other hand, his family's experience with the "Egg" was very positive resulting in DR's serious consideration that his next family car purchase will likely be some type of electric vehicle.

Household 39 (KR): KR, his wife and two teenage children lived in a single-family home in Torrance; the family had 2 cars during the course of the study. Beginning in April, 2010 KR and his family began a 3 month period of testing the Wheego Whip. The LUV was used by KR to occasionally replace commute trips to a local city government office where he worked. As an enthusiast for the project KR would also encourage other staff to test drive the LUV. KR and his wife would also use the Wheego for local errands and to drop off their children for various after school activities. While KR was able extend his travel range by plugging the LUV into an outlet at work his trips were limited by both the posted speeds of major arterial streets (40 mph) as

well as the slow speed (and time) for travelling based on the limitations of the LUV itself. KR reported that the overall experience was positive however he did have issues with the Design/Build of the Wheego Whip when 2 different keys broke off in the handle of the door.

Household 40 (RS): RS, his wife and young adult child lived in a single-family home in Redondo Beach. The family drove 3 cars during the time of their participation. For 2 months, beginning in June, 2011, RS drove the Vantage CrewCab. As a semi-retired contractor RS used the LUV as his primary work vehicle; it replaced his Toyota truck for the short trips to local job sites. Additionally, RS and his family were able to use the LUV for other local errands. In his opinion, the LUV “fit perfectly” for his family’s transportation needs. While there were no Design/Build issues the Vantage CrewCab did require service to replace both a faulty battery meter as well as a diminished battery. Both issues resulted in the poor experience of KS running “out of juice” while driving as well as the reality of a diminished range.

Household 41 (KS): KS, her husband and two small children lived in a single-family residence located in Redondo Beach; the family had 2 cars during the course of the study. KS and her husband began their 3 ½ month participation in the program beginning in April, 2011. For the first 2 ½ months KS was the primary driver of the GEM. The balance of her time in the project was spent driving the Miles Wagon. As a mother and part-time student, KS used the LUV for transporting her children to school and other activities. Additionally, KS often used the GEM for many of their local errands like shopping and taking the family dog to a local park for exercise. KR felt that the overall utility of both different LUVs was great for replacing the trips she might make using the family SUV. However, KR did note the significant Design/Build differences between the GEM and the Miles Wagon. KS preferred, on the whole, the fact that the Miles Wagon was “more like a miniature car” with expected design features while the GEM made “more noise” and had poorly designed aspects like seat-belts that were uncomfortable and cup-holders that were placed in areas that were hard to use.

Household 42 (BS1): BS1 and her husband lived in a single-family home in Hermosa Beach; their household had 2 cars during the period of their participation in the study. Beginning in December, 2011 BS began driving the GEM. BS had many part-time jobs but used her LUV primarily for local errands, trips to the beach and other entertainment activities. BS was an enthusiast for the project and enjoyed “passing gas stations” in her LUV. Charging was facilitated by running an extension cord through the family’s front door to reach the GEM. While BS had no mechanical issues during her experience in the project she have challenges with Design/Build issues like having no defroster or locks that did not function easily.

Household 43 (BS3): BS3 and his wife had one family vehicle and lived in a single-family home in Gardena. Beginning in September, 2011, BS test drove the Miles Pick-up for a period of 2 months. Living in Gardena with many of the arterial streets posted at 40 mph presented early challenges to BS in terms of finding routes to drive to common destinations including work at a local aerospace company in Manhattan Beach. BS drove the LUV infrequently however, on occasion, BS was able use the utility of the pick-up for hauling personal items. On the whole, though, the Miles Pick-up was seen by BS as being poorly built. One major Design/Build quality that made his experience using the LUV less than adequate was bench seating (instead of back-seat). Moreover, BS experienced was further dampened when he experienced mechanical problems while driving in fast moving traffic which resulted in having to pull over and restart the LUV. Ultimately, these issues required an on-site service call to adjust the timing of the motor.

Household 44 (SS): SS lived in a 2 person single-family home in Torrance. At the time of the study the household had 2 cars. Beginning in June, 2011, SS drove the Wheego Whip for a period of 2 months. As an aerospace engineer, the LUV became SS’s primary commute vehicle to work replacing his Toyota sedan. The LUV’s slow speed of 25 mph caused SS anxiety while driving on 35 mph posted streets. This challenge of find “zigzag” routes at first seemed a

negative to SS but, upon reflection, it created a consistent commute time to work. SS noted that the Design/Build of the LUV was poor. He experienced broken glove box handles, LED lights that flickered for no apparent reason and a vehicle that seemed to be loosely constructed so that it shook under certain conditions.

Household 45 (VT): VT and her husband are retired and lived in a single-family home in Redondo Beach; the household had 2 cars during the time of the study. Beginning in June, 2011, VT drove the Wheego Whip for a period of two months. VT used the LUV for local trips to exercise, doctor's office visits and transporting her grandchildren. Some experiences like travelling to the pier for the July 4th fireworks were seen as positive by VT however, her experience was colored negatively due to both mechanical and Design/Build challenges that occurred during her participation. These issues included a diminished battery which affected the LUV's range, lack of cargo space and locks that malfunctioned.

Household 46 (KT): KT, her husband and two elementary-age children lived in Hermosa Beach; the household had 2 cars during their participation in the study. Beginning in June, 2011 KT began her 3 month participation in the program driving the GEM. As a stay-at-home mother KT used the LUV for transporting her children to school and other activities. Additionally, she was able to use the GEM for many of the local errands that she would normally have used her VW Jetta. According to KT, they "loved the experience" and had no issues in terms of the Design/Build of the LUV. The only issues that were noted included the limited range of the GEM and the speed restrictions of travelling on major arterial streets. Following KT's positive experience in the program the family made the choice to become a single car family.

Household 47 (ST): ST, her husband and two elementary school age children lived in a single-family rental home in Redondo Beach; the family had 2 cars during the course of their participation in the study. ST participated in the LUV study for a total period of 7 1/2 months.

The first 6 months were spent driving the GEM and were followed by 1 ½ months of testing the Miles Wagon. As the primary driver, ST used the LUVs extensively to shuttle her children to school and after extra-curricular activities. ST used the LUVs for other domestic errands that included shopping and entertainment and her part-time crafts business. ST did not report any specific Design/Build issues however she noted that her driving behavior and experiences were colored by issues of diminished battery charge in both the GEM and Miles Wagon. The GEM could only be driven in the morning and the Miles Wagon would not hold its charge. These issues resulted in limited driving and the occasional feeling of “range anxiety” when driving distances farther afield. Ultimately, the Miles Wagon (twice) required its batteries to be replaced. While appreciating the LUVs they tested had battery challenges, the family, ultimately, decided (after their participation in the study) to purchase a new GEM as an addition to their household.

Household 48 (MV): MV lived in a 4 person household with 2 elementary school age children in the City of Lawndale; the household had 2 cars during the course of the study. Beginning in February, 2012 MV participated in the study for a period of 1 ½ months. During that time MV test drove the Miles Wagon. As an architect MV used the LUV to commute to work and run local errands. MV used his experience as an avid cyclist to consider and plan his driving routes with the LUV. He noted, however, that speed restrictions of 40 mph limited his driving into El Segundo and areas of Torrance, thus, limiting some of his desired trips with the LUV. MV had strong feelings that LUVs like the Miles Wagon he drove should be utilitarian – simple in design with limited (or few) features; he was critical that the costs for the repair of (cosmetic) damage to the Miles Wagon would cost as much as it did. On the whole, however, MV could see the advantages of driving the LUV, particularly, if and when the price reflected the value and efficiency of the car’s performance.

Household 49 (MW): MW, his wife and two teenage children lived in a single-family home in Manhattan Beach; the household had 3 cars during the course of the study (including Honda Civic natural gas vehicle). Beginning in May, 2012, MV drove the GEM for a period of 2 ½ months. MV worked either from his home or on the road as a self-employed cinematographer. He used the LUV for most of his local “trips around town” including shopping and shuttle the kids to various activities. MV was also able to mount a roof rack on the GEM so as to carry his family’s surf boards down to the local beach. The family enjoyed their experience testing the LUV and had no real issues concerning the Design/Build or those of a mechanical nature. The only note of interest was that the brakes were “soft” and required attention to make sure that they were turned inwards when parked downhill. Additionally, there was a finicky “rocker” switch that worked but was loose.

Household 50 (RW): RW and her partner shared a single-family home in Torrance; the household had 2 cars during the course of the study. Beginning in November, 2011, RW participated in the program driving the GEM for 1 ½ months followed by testing the Wheego Whip for an additional 2 months. RW primarily used the LUVs for her daily work commute to a South Bay City Hall office. RW experienced challenges with the range of the GEM because she was unable to charge at work. The topography of her commute trip (i.e. hills) drained the LUV’s battery to a point where she would be limited to only the return trip from work before needing to recharge. Mechanical issues concerning the GEM’s brakes were a further challenge and, ultimately, led to RW being given the Wheego Whip to test. RW perceived the Wheego Whip as being “more like a real car” next to her experience of driving the GEM however, RW noted that both LUVs had Design/Build issues in terms of cargo capacity and ergonomically being comfortable for larger individuals.

Household 51 (KY): KY, her husband and three children lived in a rented single-family home in Manhattan Beach; the family had 2 cars during their time in the study. KY was a stay-

at-home mother how worked part-time as an accountant. For 2 1/2 months, beginning in September, 2012, KY drove the GEM. KY was the primary driver and she found great utility in the LUV in terms of transporting her children to school and their various after school activities. Almost all of her local trips for shopping and other family errands were supplanted by using the LUV and “not having to drive my big gas-guzzling SUV.” KY noted that the GEM’s brakes were soft but other than having to be sure that car was parked properly (so that it would not accidentally roll) it had no real mechanical issues. The Design/Build of the GEM was as KY expected. The family’s participation in the study resulted in their becoming LUV enthusiasts; they purchased a new GEM – “seeing the value of having this kind of vehicle for their family.”

Appendix C Data

Table 7: Full emissions analyses

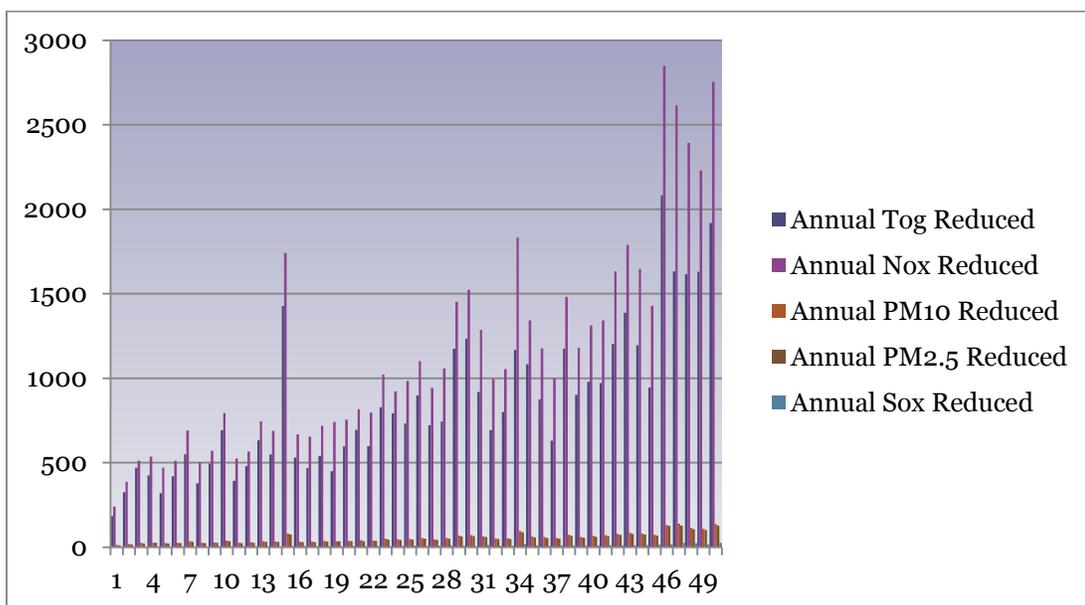
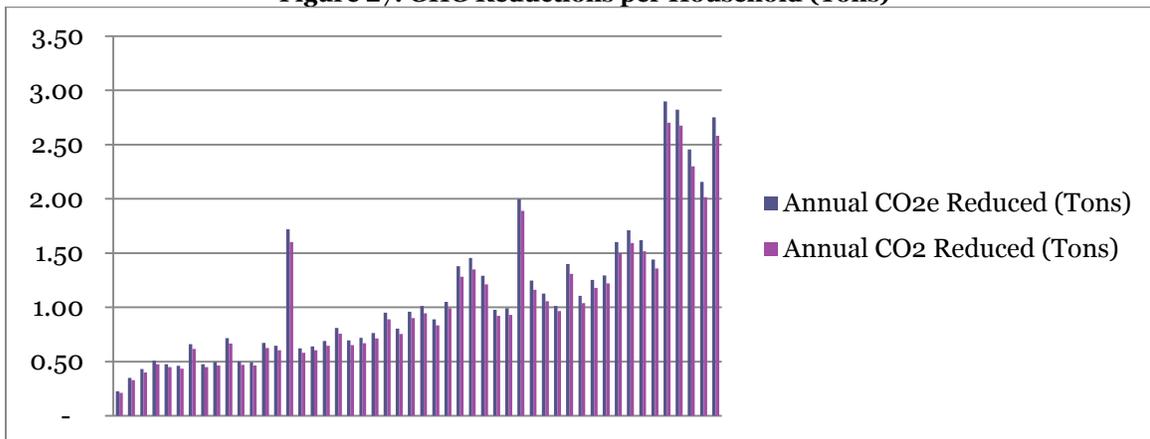
	Min	Max	Ave
%TOG Reduction	6%	59%	26%
%CO Reduction	5%	52%	23%
%NOx Reduction	5%	50%	22%
%PM10 Reduction	4%	49%	21%
%PM2#5 Reduction	4%	48%	21%
%SOx Reduction	2%	40%	16%
%CO2 Reduction	4%	41%	18%
%CH4 Reduction	5%	53%	23%
%CO2e Reduction	4%	41%	18%

	Min Grams	Max Grams	Ave Grams
TOG Savings/Yr	325.74	2,081.64	905.49
CO Savings/Yr	4,323.27	8,660.39	12,791.96
NOx Savings/Yr	387.46	2,848.42	1,215.76
PM10 Savings/Yr	18.93	136.29	59.81
PM2#5 Savings/Yr	17.31	128.08	55.65
SOx Savings/Yr	1.57	25.52	9.48
CO2 Savings/Yr	327,101	2,700,763	1,109,966
CH4 Savings/Yr	45.86	441.77	159.09
CO2e Savings/Yr	349,455.29	2,897,530	1,184,815

	Min	Max	Ave
Weekly VMT	11.20	104.67	39.96
Weekly Gallons Saved	0.55	5.13	1.96
Weekly Gas Cost Saved	\$2.47	\$23.08	\$8.81
Weekly Electricity Cost	\$0.03	\$0.31	\$0.12
Weekly Fuel Savings	\$2.44	\$22.77	\$ 8.69
Annual Gas Savings	\$28.54	\$266.71	\$101.83
Annual Fuel Savings	\$126.71	\$1,184.19	\$452.11

	Min Grams	Max Grams	Ave Grams
TOG Savings/Wk	6.26	40.03	17.41
CO Savings/Wk	83.14	551.16	246.00
NOx Savings/Wk	7.45	54.78	23.38
PM10 Savings/Wk	0.36	2.62	1.15
PM2#5 Savings/Wk	0.33	2.46	1.07
SOx Savings/Wk	0.03	0.49	0.18
CO2 Savings/Wk	6,290.40	51,937.76	21,345.49
CH4 Savings/Wk	0.88	8.50	3.06
CO2e Savings/Wk	6,720.29	55,721.74	22,784.90

Figure 27: GHG Reductions per Household (Tons)



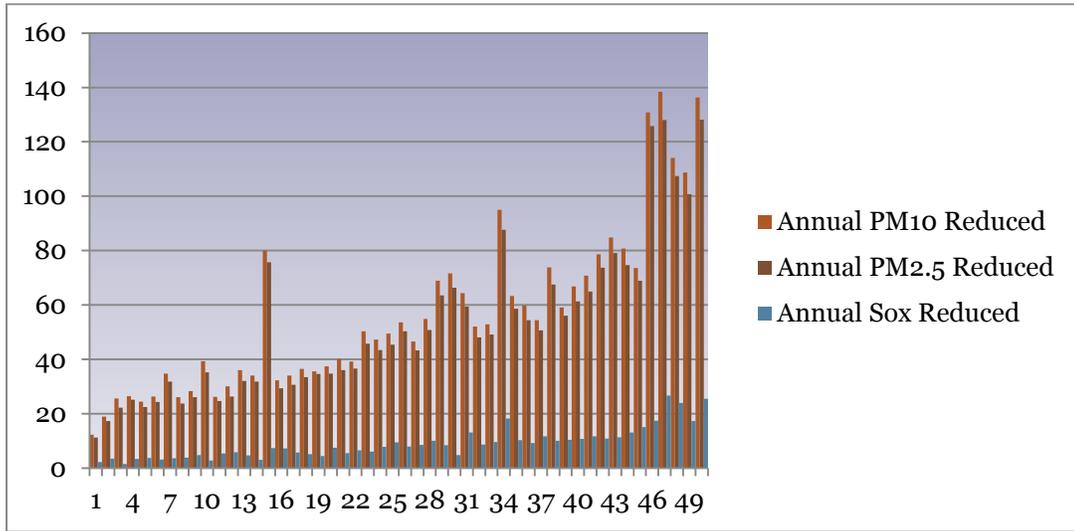


Table 8: Driver Age and Gender

	Primary Driver					
	16-24	25-34	35-44	45-54	55-64	65-74
Male	0	4	2	9	5	4
Female	0	1	6	13	4	3

All Drivers						
	16-24	25-34	35-44	45-54	55-64	65-74
	11	15	15	38	20	10

Secondary Drivers						
	16-24	25-34	35-44	45-54	55-64	65-74
	11	10	7	16	11	3

Figure 28: Average Weekly Destinations by Increments of Distance Traveled

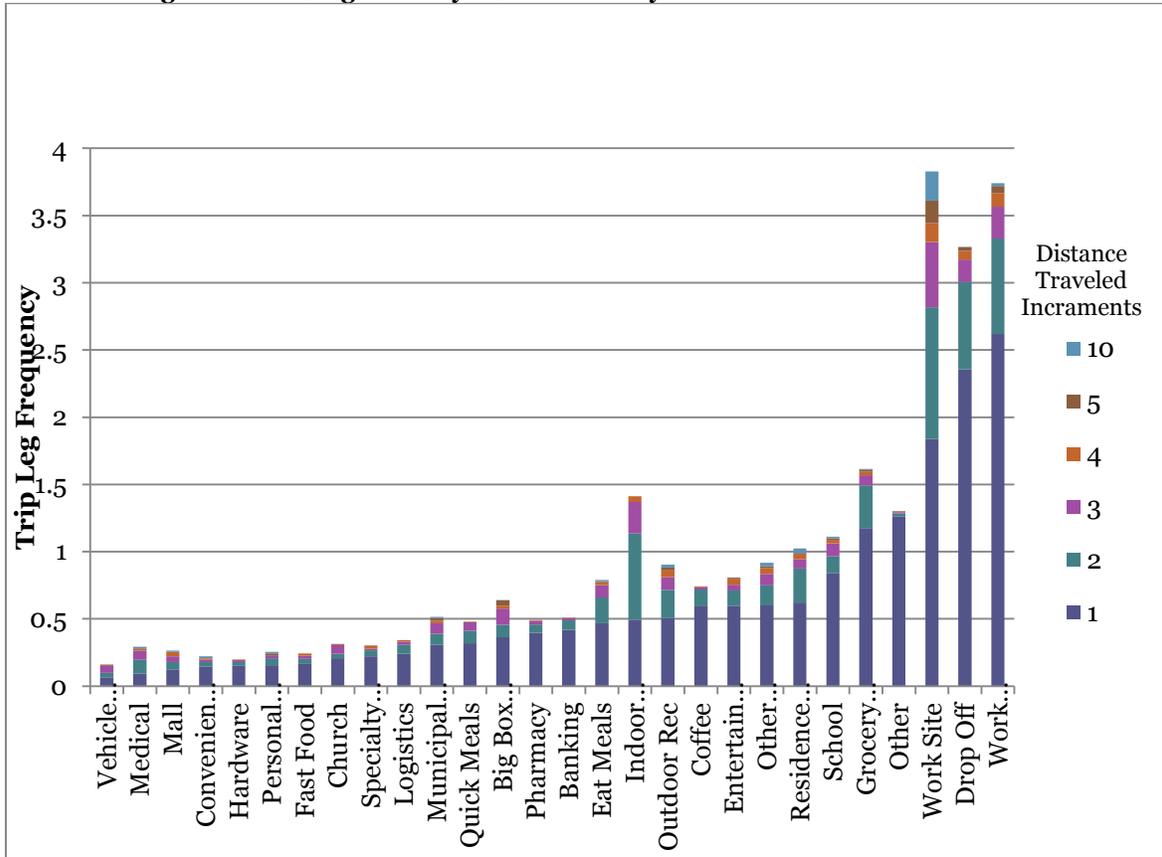


Table 9: Percent of Weekly VMT and Trips Served by LUV Vehicles

Unique House Hold	% Weekly VMT Served by LUV	% Weekly Trip Legs Served by LUV	% of Weekly Round Trips served by LUV
1	43%	74%	69%
2	55%	79%	79%
3	9%	20%	24%
4	6%	31%	36%
5	17%	35%	38%
6	9%	57%	76%
7	26%	40%	44%
8	6%	26%	30%
9	13%	50%	63%
10	18%	42%	44%
11	14%	25%	32%
12	11%	36%	39%
13	12%	24%	27%
14	43%	55%	62%
15	14%	30%	32%
16	16%	34%	42%
17	23%	68%	68%
18	5%	23%	29%
19	25%	52%	52%
20	12%	22%	24%
21	32%	74%	76%
22	22%	48%	55%
23	9%	25%	28%
24	22%	76%	74%
25	11%	19%	29%
26	15%	72%	66%
27	29%	35%	28%
28	33%	62%	65%
29	15%	28%	29%
30	33%	27%	41%
31	19%	28%	28%
32	17%	37%	44%
33	10%	57%	59%
34	6%	22%	34%
35	10%	40%	44%
Min	5%	19%	24%
Max	55%	79%	79%
Ave	19%	42%	46%

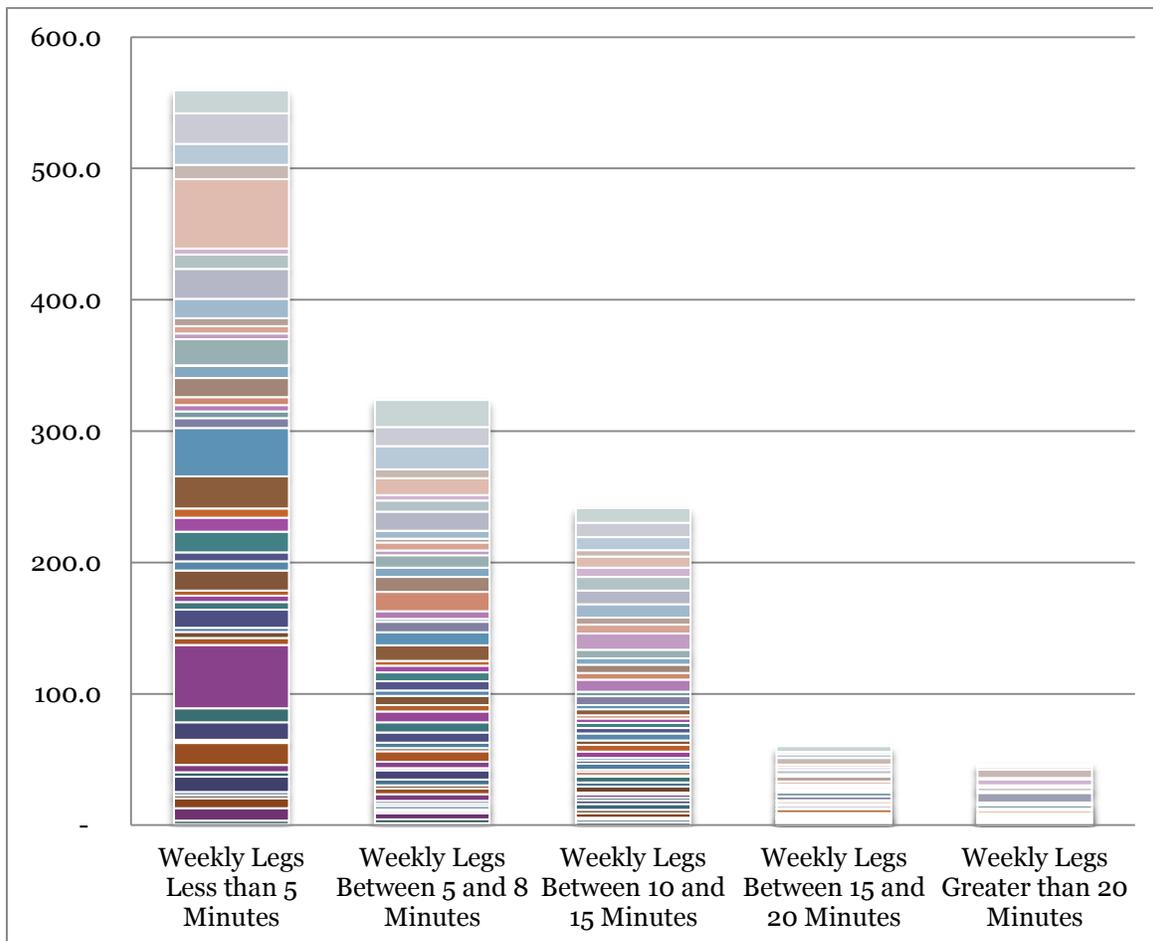
Figure 29: Count of Trips by Leg Duration (each color represents an individual's behavior by week)

Figure 30: Count of Trip Legs by Start Time (each color represents an individual's behavior by week)

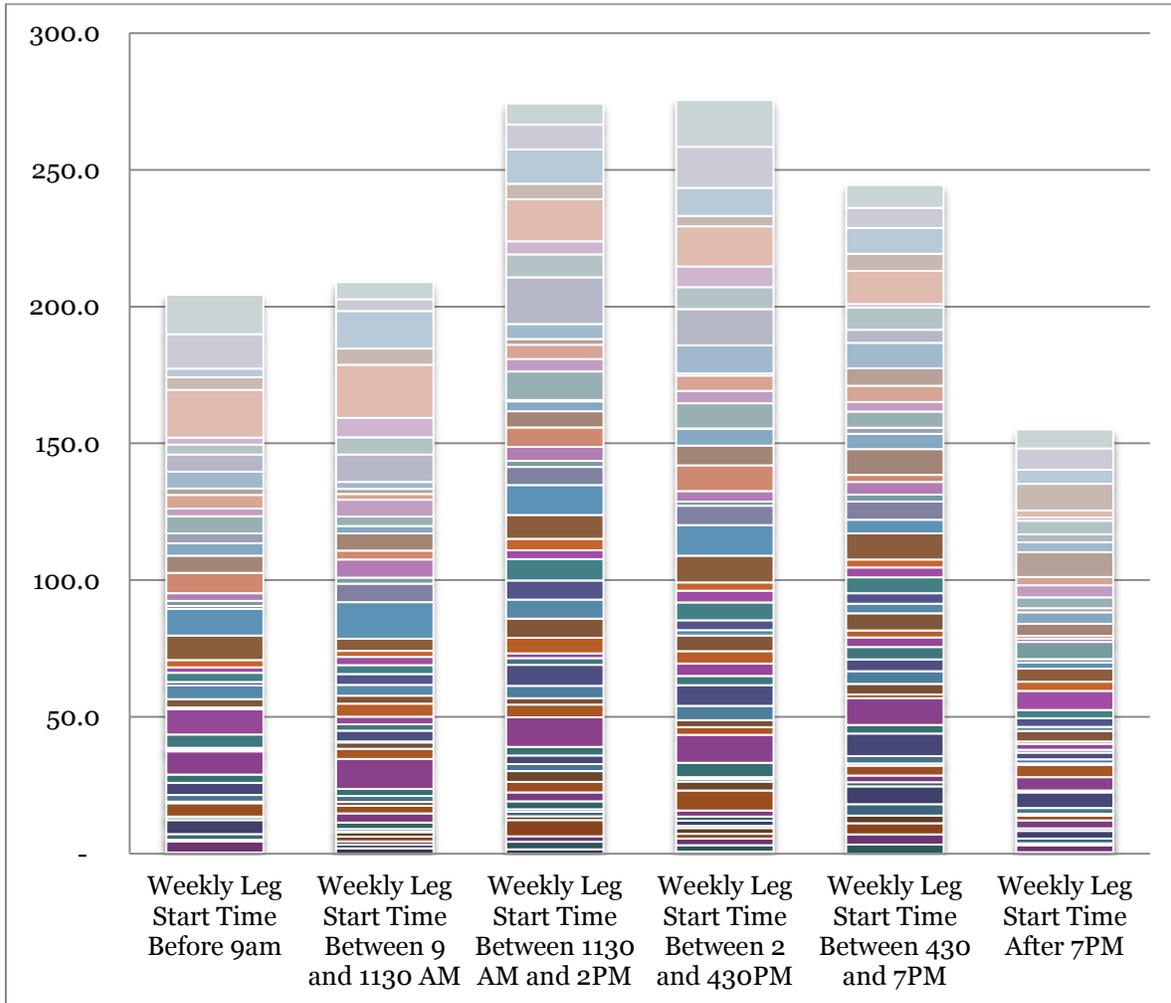


Table 10: Subjective Feedback from 2002 CEC Study of NEVs

Positive Comments	Suggested Improvements
<ul style="list-style-type: none"> • 30-mile range per charge always seemed sufficient to drivers • Most found 110-volt charging very convenient (esp. compared to full-size Electric Cars) • Since the NEV's can be charged by a simple 110 outlet, rather than any special charging system, the vehicles are easily charged at the solar charging site, the charging outlets specifically created, and multiple other locations throughout the City, such as the regular facility they are stored • A citizen who once owned a large manufacturer's vehicle, noted that the simple plug and onboard charging system was a big advantage over his special "inductive" charging system • Most liked easy access with open sides • GEM Shortbed NEVs seemed to be most practical single-choice NEV • Most drivers liked "quiet" motor, dependability and gas savings • Most found turning radius good with Shortbeds and 2-Passenger NEVs • Drivers liked Clean-Air (Zero-Pollution) of NEV vs. conventional cars • Drivers liked size of Longbed for carrying bulky equipment and gear • Drivers liked faster speed, range and stable ride of NEVs compared to golf carts • Some liked Supercharger fast-charging capabilities (15 to 20 Minutes to charge) • Drivers liked comfortable seats in 4-Passenger NEVs • Drivers liked ease of parking and 	<ul style="list-style-type: none"> • 25-mph top speed seemed slow to most after driving conventional cars (Slow speed not a problem with some on short commutes but 35 mph top speed preferred) • Many would like to see more roads to drive on (re. 35 mph limitation) • Some found ride too firm/bumpy (esp. Longbeds at dips) • A few would have felt more secure with doors of some kind • Most found turning radius insufficient with Longbeds and 4-Passenger NEVs • Drivers felt seats in the Utility NEVs were too upright • Some longer legged drivers needed more leg room in utility versions • Some remarked about lack of crash protection (esp. from sides) • Some would like to see better bumpers front and rear • Solar charging on roof would be good feature • Adjustable steering wheel • Open sides windy, exposed to splashing • Some found it a challenge to stay out of way of faster traffic • Most did not like the side mirrors (too small and floppy) • Some would like to see short-bed attachment for 2 or 4-Passenger NEVs • Some would like to see Dump-Bed feature for Longbeds (Airport Grounds Crew — CPS) • Open sides to promote spontaneous, fun conversations with public • Better quality battery-charge indicator Gauges

<p>maneuverability of NEVs due to small size</p> <ul style="list-style-type: none"> • Low purchase costs and low maintenance costs <p>appealed to NEV purchasers</p> <ul style="list-style-type: none"> • Most said lots of fun to drive, especially in getting good remarks from public while on the road! <ul style="list-style-type: none"> • Newer recent Private-Party and School District <p>NEV purchasers were enthusiastic about their NEV purchases and their high initial mileages per day and month indicate dedication to the product (some in the 200 to 400 mile per month range).</p>	
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Scale of Riviera Village Applied to Neighborhood Design

There are about 3.5 million square feet (a little over 800 acres) of commercial area in RV, including streets and surface parking lots. Assuming about 25% of the area is streets and parking lots, the building footprint would be about 2.6 million square feet (about 600 acres). Because many of the buildings are 2 stories and a few are over 3, the internal space might be around 4 million square feet.

This scale of center could be developed on 4 corners of an intersection that are ¼ mile square producing a footprint of over 5 million square feet (assuming 25% for parking) at one story. However, no such developable intersections are likely to be found in the SB.

The smallest possibility would be one corner that is 1/8 mile square; or 435,600 square feet. Assuming 25% for parking would allow for a 325,000 square foot building footprint, or 653,000 if built at two stories. Even with four corners available to develop, the result would be a center with 2.6 million square feet of commercial space – about half the size of Riviera Village.

Returning to the hot spot inventory, 400 businesses at 3,000 square feet each would require 1.2 million square feet of space – about 2 corners 1/8 mile square of 2 stories.

Many existing commercial strips between intersections are ¾ miles long and 1/16 miles deep built at one story less 25% for parking means there are about 1 million square feet on each side of the corridor. This means that the new neighborhood centers built at two stories on two corners of an intersection can absorb all of the existing strip commercial less under-performing businesses.

Appendix D Data methods

GPS data processing

The following metrics are calculated based on GPS travel data:

- VMT
- Radial Trip Distance
- Radial Distance From Home
- Round Trip Distance
- Travel Time
- Dwell Time
- Cold Start Identification

The specific calculation methods are detailed below.

VMT

VMT is calculated for each trip based on the change in odometer over the course of the trip.

Radial Trip Distance

Trip distance is calculated using a trigonometric function based on the start point and end point to view radial distance traveled. Specifically, trip distance is calculated by taking the Δ Latitude and Δ Longitude from two consecutive ignition points and converting them into miles north/south and miles east/west then taking the square root of the squared distance north/south plus the squared distance east/west.

$$A = \Delta \text{ Latitude} \times 69$$

$$B = \Delta \text{ Longitude} \times 69.1 \times \cos(\text{Longitude}/57.3)$$

$$R = \sqrt{(A^2 + B^2)}$$

Where:

R = Radial trip leg distance

Radial Distance from Home

To calculate the distance traveled to or from a specified destination such as the vehicle's "home parking space," the same calculation formula is used as is used to calculate radial trip leg distance, but the starting point of the trip leg is replaced with the coordinates of the home location.

Round Trip Distance

Round trip distance is calculated based on manual input where each trip leg is identified as the first, second, third, or fourth (etc.) leg of a journey since the vehicle was last parked at the home site. Once each leg is coded by leg number, round trip distance is calculated using nested if statements that functionally subtract the odometer point at the beginning and end of a trip. The manual input allows for statistical trip chaining analysis as well.

Travel Time

Travel time is calculated by finding the time delta between the ignition on and ignition off data points.

Dwell Time

Dwell time is calculated by finding the time delta between ignition off and ignition on points. Due to variations in how data providers supply the GPS data, some iterative data processing was necessary to find the true next ignition on point.

Cold Start Identification

To demarcate cold starts a conditional calculation using "IF" statements based the Stop Time is used. In this calculation a stop time of 2.5 hours or greater is marked as a Cold Start. To correct for false data points such as flipping the on switch more than once due to no engine noise or the occasional re-parking a second calculation is used so only cold starts of 'actual trip legs' are recorded.

Vehicle Emissions Analysis based on Vehicle Use Analysis

Emissions are calculated on a trip by trip basis to capture cold starts (Bag 1), warm starts (Bag 3), and hot running emissions (Bag 2). By segmenting each trip based on the theoretical thermal profile of the engine (as defined by Bag 1, 2, and 3) a greater level accuracy is achieved in the measurement of air quality pollutants.

The following methods describe the process and formulas used to calculate Bag one two and three emission factors for the average passenger fleet vehicle in LA County as well as the emission factors used to calculate NEV power plant emissions and the resulting emission reductions realized by driving an NEV

Calculating LA County Average Fleet emissions factors:

To obtain California passenger car fleet average emissions for bag 1, 2, & 3 emissions factors we used the EMFAC 2007 emissions modeling software. Total Organic Gasses, Carbon Monoxide, Nitrogen Dioxide, Methane, and Particulate Matter 10 are calculated independently for each temperature related combustion cycle (Bag 1, 2, & 3)

To calculate these factors we filtered the data output files to define the LA County passenger fleet composition by vehicle class and to isolate the relevant emissions factors. Bag 1 and Bag 3 emissions factors were output from EMFAC in MY2 file formats while hot running emissions were calculated based on modeled California fleet emissions output in a BDN file format. Bag 2 emissions were calculated on a modified VMT basis.

CO₂ and SOX were calculated separately on a per mile basis as they are not included in Bag 1 and 2 EMFAC output files and because CO₂ & SOX emissions are unrelated to engine

temperature. Data for CO₂ and SOX emissions were output in the above-mentioned BDN file. EMFAC emission units are Tons whereas trip specific calculations should be calculated in grams. The final numbers from each of the calculations described below are converted to Grams before they are used to calculate the emissions of a trip.

CO₂ and SOX Emissions (All Bags)

CO₂ and SOX emissions factors are the same for bag 1, 2, and 3 and are calculated on a VMT basis using the tons per mile traveled across all model years for each vehicle class and converted into a combined figure for each passenger vehicle classification. These emissions factors are multiplied by their percentage of total passenger vehicles from each vehicle classification. The modified emissions factors are then summed to display the passenger fleet average emissions factors.

CO₂ and SOX Emission calculation (calculated separately using the same method):

$$\begin{aligned} \text{LDA EPM} &= \text{ET/VMT for LDA} \\ \text{LDT1 EPM} &= \text{ET/VMT for LDT1} \\ \text{LDT2 EPM} &= \text{ET/VMT for LDT2} \\ \text{Passenger fleet average CO}_2 \text{ or SOX emissions per mile} &= \end{aligned}$$

$$\begin{aligned} &((\text{LDA EPM}) * (\text{LDA} / (\text{LDA} + \text{LDT1} + \text{LDT2}))) + \\ &((\text{LDT1 EPM}) * (\text{LDT1} / (\text{LDA} + \text{LDT1} + \text{LDT2}))) + \\ &((\text{LDT2 EPM}) * (\text{LDT2} / (\text{LDA} + \text{LDT1} + \text{LDT2}))) \end{aligned}$$

Where:

LDA = Number or “population” of Light Duty Autos
 LDT1 = Number or “population” of Light Duty Truck 1s
 LDT2 = Number or “population” of Light Duty Truck 2s
 ET = Total emissions for all model years
 EPM = Emissions per Mile
 VMT = Vehicle Miles Traveled

Warm and Cold Starts (Bag 1 and 3)

For each vehicle classification bag 1 and 3 emissions factors from EMFAC for each class of passenger vehicle for each model year vehicle on the road (back to 1967) is multiplied by 3.5 to obtain emissions released during the first 100 seconds of operation to obtain actual emissions for cold start events (bag 1) and warm start events (bag 3). The number 3.5 was supplied by CARB based on technical details of the EMFAC outputs for bag 1 and 2. It is assumed that in low speed vehicles and suburban settings the starting emissions are released over the course of the first mile of travel. These emissions factors for each model year are multiplied by their percentage representation in vehicle ownership within each class of passenger vehicle. The emissions factors are then summed to display the emissions factors for each vehicle classification.

To get the CA Average Fleet emissions factors we multiply emissions factors for each vehicle classification against the percentage ownership rates for each comparatively for Light Duty Autos, Light Duty Trucks 1, and Light Duty Trucks 2. The sum of the final numbers for each emission factor is the average of the modeled emissions of California's passenger vehicle fleet.

Bag 1 Emission calculation (repeated for each emission type except CO₂ and SOX):

$$B1MyrE = B1MYrF * 3.5$$

$$B1MYrE\% = B1MyrE * Myr\%$$

$$LDA\ B1 = \text{Sum of } B1MYrE\% \text{ for each model year}$$

$$LDT1\ B1 = \text{Sum of } B1MYrE\% \text{ for each model year}$$

$$LDT2\ B1 = \text{Sum of } B1MYrE\% \text{ for each model year}$$

Fleet Bag 1 emissions =

$$((LDA\ B1) * (LDA / (LDA + LDT1 + LDT2))) +$$

$$((LDT1\ B1) * (LDT1 / (LDA + LDT1 + LDT2))) +$$

$$((LDT2\ B1) * (LDT2 / (LDA + LDT1 + LDT2)))$$

Where:

B1MYrE% = Bag 1 emissions reduced by ownership ratio

B2MYrE% = Bag 3 emissions reduced by ownership ratio

B1MYrE = Bag 1 emissions for each model year

B2MYrE = Bag 3 emissions for each model year

B1MYrF = Bag 1 emission factors for each model year

B2MYrF = Bag 3 emission factors for each model year

MYr% = (Number of vehicles per model year) / (total number of vehicles in class)

Hot Stabilized Emissions (Bag 2)

Bag 2 emissions are calculated for each vehicle classification by dividing the running emissions for each emission type (per vehicle classification) by the EMFAC modeled VMT minus the total number of trips taken (per vehicle classification). The subtraction of total trip is used to reduce each trip distance by 1 mile to account for the cold or warm start that is calculated separately.

$$\text{Bag 2 emissions factors} = \text{RE} / (\text{VMT} - \text{TT})$$

Where

RE = Running emissions for all model years

VMT = EMFAC Modeled VMT

TT = EMFAC Modeled Total Trips taken

PM2.5

PM2.5 emissions are calculated as a factor of PM10 emissions. For gasoline-fueled vehicles, CARB assumes that 97% of particulate emissions are less than 10 µm and that 90% of particulate emissions are less than 2.5 µm. Thus, PM2.5 equals 90/97ths of PM10 for gas vehicles. For diesel-fueled vehicles, CARB assumes that 100% of particulate emissions are less than 10 µm and that 92% of particulate emissions are less than 2.5 µm. Thus, PM2.5 equals 92/100ths of PM10 for diesel vehicles. These factors are consistent across Bag 1 and Bag 3 start events and Bag 2 running emissions.

$$\text{PM2.5 LDA} = (90/97 * \text{PM10} * \text{LDA G\%}) + (92/100 * \text{PM10} * \text{LDA D\%})$$

$$\text{PM2.5 LDT1} = (90/97 * \text{PM10} * \text{LDT1 G\%}) + (92/100 * \text{PM10} * \text{LDT1 D\%})$$

$$\text{PM2.5 LDT2} = (90/97 * \text{PM10} * \text{LDT2 G\%}) + (92/100 * \text{PM10} * \text{LDT2 D\%})$$

Where

G% = Gasoline-fueled vehicles/Total number vehicles

D% = Diesel-fueled vehicles/Total number vehicles

N2O Calculation

N₂O emissions are calculated using a factor of .0415 times NOX emissions.¹¹ This factor is consistent across vehicle classes; Bag 1 and Bag 3 start events, and Bag 2 running emissions.

$$N_2O = NOX * 0.0415$$

Calculated Emissions Factors

Table 11: California passenger fleet average emissions from BAG 1, 2, & 3¹²

Bag 1 Average Grams/ColdStart (CA)									
	TOG	CO	NOX	PM 10	PM 2.5	SOX/mi	CO2/mi	CH4	N2O
LDA								0.0	0.0
Average	0.7610	8.5119	0.5696	0.0275	0.0255	0.0042	435.9158	438	236
LDT1								0.0	0.0
Average	1.0589	12.8088	0.7784	0.0360	0.0331	0.0052	527.3335	627	323
LDT2								0.0	0.0
Average	0.8373	10.2928	1.0038	0.0584	0.0542	0.0053	540.8814	499	417
Passenger								0.0	0.0
Fleet Average	0.8202	9.5395	0.7080	0.0365	0.0338	0.0046	474.8494	479	294

Bag 2 Average Grams/HotRunningMile (CA)									
	Run ning TOG	Run ning CO	Run ning NOX	Run ning PM 10	Run ning PM 2.5	SOX/mi	CO2/mi	Run ning CH4	Run ning N2O
LDA								0.0	0.0
Average	0.1383	3.0458	0.2780	0.0158	0.0147	0.0042	435.9158	336	115
LDT1								0.0	0.0
Average	0.2538	5.3204	0.5357	0.0206	0.0190	0.0052	527.3335	450	222
LDT2								0.0	0.0
Average	0.1669	3.9992	0.5197	0.0358	0.0332	0.0053	540.8814	423	216
Passenger								0.0	0.0
Fleet Average	0.1610	3.5924	0.3740	0.0215	0.0200	0.0046	474.8494	373	155

Bag 3 Average Grams/WarmStart (CA)									
	TOG	CO	NOX	PM 10	PM 2.5	SOX/mi	CO2/mi	CH4	N2O
LDA								0.0	0.0
Average	0.3156	3.8578	0.3715	0.0142	0.0132	0.0042	435.9158	793	154
LDT1								0.1	0.0
Average	0.5092	5.9854	0.5311	0.0181	0.0167	0.0052	527.3335	089	221
LDT2								0.0	0.0
Average	0.3331	4.7376	0.6418	0.0281	0.0260	0.0053	540.8814	891	266
Passenger								0.0	0.0
Fleet Average	0.3459	4.3661	0.4616	0.0182	0.0169	0.0046	474.8494	857	192

¹¹ Supplied by CARB

¹² Emission factors were calculated in 2011 using the EMFAC fleet composition for 2011.

Calculating LUV emissions

Emissions for Electric Vehicles are theoretically unrelated to temperature and are therefore calculated on a mile per mile basis. The emission factors are calculated by dividing energy use by VMT and comparing that to known power plant emissions factors. The specific emission factors used were calculated in the report: California Energy Commission's Demonstration of Neighborhood Electric Vehicles Consultant Report P600-02-020F published on July 1, 2002.

To calculate the emission from a NEV vehicle over a period of time VMT is multiplied by each emissions factor¹³ displayed below:

TOG	0 Grams per mile
CO	0 Grams per mile
NOx	0.000377 Grams per mile
PM10	0 Grams per mile
PM2.5	0 Grams per mile
SOX	0 Grams per mile
CO2	61 Grams per mile
CH4	0 Grams per mile*
N2O	NOX x 0.0415*

Calculating Emission Reductions

To calculate the emissions reductions first the theoretical emissions must be calculated to display what the emissions would have been had the trip been driven in a CA Fleet average vehicle. To do this each trip (marked by an ignition on and an ignition off event) is given a classification of a warm or cold start as well as the associated emissions from the start event. Trips longer than one mile in length must also include hot running emissions. To calculate the hot running emissions we subtract 1 from the total miles traveled for the designated trip and multiply by the Bag 2 emissions factors. Adding the emissions from start events and hot running emissions provides the total weight of emissions for each emission type for each trip.

*The NOX/N2O conversion was supplied by CARB

We then sum the theoretical emissions over the designated time period and subtract the calculated power plant emissions to display the emissions reductions achieved by driving an NEV.

Definitions

Bag 1 – Cold Start Emissions

Bag 2 – Hot Running Emissions

Bag 3 – Warm Start Emissions

Average LA County Passenger Fleet Emissions – Average emissions from Bag 1, 2, & 3 for the California's fleet of passenger vehicles

Electric Vehicle emissions – Emissions from power plants resulting from the use of EVs

Emissions Factors – Multipliers used to calculate emission rates

Trip function and the built environment

The GPS data can stand on its own for statistical vehicle use data analysis, but a function analysis of what individuals used their vehicles to do requires a manual entry destination/function analysis to be completed. The destination/function analysis is completed by viewing each destination on a map to determine categorically what the purpose of each trip was. The map information is combined with trip log data and common destination surveys to provide guidance to the individual subjectively assessing the functional category of each destination. The functional categories were determined based on the need for each category as seen in the frequency of destination visits. Potential categories that did not represent a significant number of stops were bundled into higher level categories while highly represented

categories have been broken into subgroups for additional analysis. The functional categories that were used by the SBCCOG for this analysis are:

- Banking
- Big Box Shopping
- Church
- Coffee
- Community Meetings
- Convenience Store
- Drop Off
- Eat Meals
- Entertainment
- Fast Food
- Fueling
- Grocery Shopping
- Hardware
- Indoor Athletics
- Logistics
- Mall
- Medical
- Municipal Services
- Other
- Other Shopping
- Outdoor Rec
- Personal Services
- Pharmacy
- Quick Meals
- Residence Visit
- Residential
- Return Home
- School
- Specialty Grocery Shopping
- Vehicle Services
- Work Related
- Work Site

The travel data table is augmented by using a GIS platform to assess the built environment of each destination. This is done by performing special joins on modified versions of NAICS and Anderson Land Use coded shape files provided by SCAG. The output of this process illustrates the Anderson Land Use code for each trip destination (where the vehicle was parked on a parcel

not street parking) and a count of the NAICs codes within a defined buffer zone from the destination point (parking spot).

Statistical Analysis

Each trip is analyzed line by line on a spreadsheet built to assess data for each individual driver. That data is then populated into a database table where all travel data is stored. Using driver id to perform 'grouping' analysis, the duration of the data collection period is then used to normalize the data from each driver or vehicle for which data was collected. The normalized data period that was selected was one week. With a normalized weekly travel behavior for each unique data stream, the baseline data and the test vehicle data are able to be compared for each household resulting in NEV mode share, functional use comparisons, emission reduction potential etc. Additionally the trip data is assessed via average trip function counts for each trip function in a one week period, for individuals and averaged across households.

Survey Data Collection & Focus Groups

Post participation surveys were collected via an online platform to assess opinions about the vehicles, the available infrastructure, and the needed infrastructure, changes in driver perception of NEVs along with demographic data used to segment the survey and travel pattern data.

Focus groups were held approximately every 6 months with participating households. Approximately half of the participating households were represented at the focus groups. Each focus group was informal in nature beginning with an open ended description of each household's experience driving an NEV. This 'driver testimonial' section was followed with a detailed exploration of each vehicle, use limitations, infrastructure limitations, etc. Each event was video recorded and transcribed for future analysis.

Appendix E Data limitations

Data cleaning

GPS data collection is far more precise than survey based travel diaries yet GPS data comes with a different set of problems. With GPS based data there is often ‘noise’ or falsely reported trips. Additionally, as with most consumer electronics, GPS data recorders are subject to occasional freezing resulting in periods where no data is recorded. While these issues are not uncommon, they represent a rather small portion of the sampled data. To overcome these issues, protocols for detecting and correcting the data are required.

To remove noise from the data we have removed all trips where the distance traveled was under 0.05 miles. These are assumed to usually represent the need to re-park or move their vehicle and are unrelated to travel behavior. To detect missing data, quality control formulas need to be built into the calculation spreadsheets to call attention to potential trouble areas. Indicators include the calculated average speed of travel, distance traveled, trip duration, and dwell time. Where these metrics are outside what can be reasonably expected these trips are flagged for further attention.

Some of these missing data points are caused by malfunctions in the data provider’s software and can be corrected by inspecting the raw data files while other missing data points were caused by the participants where they dropped of a child at school or mail at a post box without turning off the vehicle. Other missing data points are simply not recorded in the raw data. Where the missing data point is the start or end of a trip, the data point is simulated based on previously recorded data for that trip destination. Where the missing data is not a single point but a blackout period where the data was not recorded, the period where no data was produced was subtracted from the total trial period allowing normalization processes to maintain validity.

In comparing two data sets, the analytical validity depends on the duration of the data collection. Where the data collection period is short there is potential for atypical travel to skew the resulting analysis. To overcome the challenges posed by recording atypical travel, the data collector must interview the participant to identify atypical travel. Where such trips are identified, they need to be removed from the analysis and should be replaced with simulated typical travel for that period of time.

Evolution of data collection techniques

At the outset of the LUV research 3 wire GPS data devices were installed in each NEV. The three wires included two wires for power and one to record key or 'ignition' events. These units were maintained in the NEV vehicles for the full duration of the research. After working with this data source for approximately four months, the SBCCOG research team decided to experiment with the addition of new data sources.

The first of these additions was a set of battery powered GPS devices activated by motion sensors. Participants were asked to carry these cell phone sized devices with them for a one week period. The addition of this data source allowed the identification of household travel demand baselines. The particular devices that were selected were some of the most advanced on the market, but were plagued with short battery life and a data retrieval interface that regularly crashed. Given the difficulties with these particular devices a competing devices with greater battery life was used. Unfortunately, the increase in battery life appears to have been achieved by reducing the power of the GPS receiver, resulting in poor performance that required large batches of data to be rejected.

The lack of battery power to support the collection of travel demand baseline data pushed the SBCCOG research team to explore other data collection methods. In the end, easy to install vehicle mounted devices were installed in each participating households privately owned

vehicles for a one to two week period. These devices simply plug into the onboard diagnostic ports that were required by CARB on all new vehicles starting in 1996. These devices performed far better than the battery powered units. The downside to these units was that they did not ‘store and forward’ data as the NEV mounted devices did, but rather transmitted data live via the cellular network, as the NEV mounted devices did but did not have a mechanism to store and forward in circumstances where cellular reception was less than optimal. This did not have significant impacts on the collected data, but did result in ‘jumpy’ recorded travel routes.

In addition to the collection of travel data, the SBCCOG attempted to collect energy consumption data for the NEVs. Some data was collected through the use of three different models of commercially available energy meters. These meters are intended to measure the electrical consumption of household electronics and while they were rated to handle to load drawn by an NEV, the continuous power draw lead to overheating of plastic components on multiple models. Due to safety concerns, collection of this data stream was terminated.

Vehicle data only

With the introduction of handheld battery powered GPS devices it was the intent of the SBCCOG research team to document and analyses walking, biking, and transit demand in addition to automobile demand. Unfortunately the formulized spreadsheet based data processing required to identify travel mode as to computationally demanding for Microsoft excel. In place of a spreadsheet based analysis participants were asked during focus groups about their walking, biking and transit use and almost universally reported that while walking and bike were utilized for exercise, none of these modes of travel were used with any regularity.

NAICS Dictionary

Table 12: Trip Purpose or Function NAICS Dictionary

Banking
522 - Commercial Banking, Savings Banks, Credit Unions, Activities related to credit intermediation (mortgages, etc.)
523 - Investment Management, Securities Activity, Financial Advising, etc.
Big Box Shopping
442 - Furniture & Home Furnishing Stores
443 - Electronics and Appliance Stores (Consumer & Household)
444 - Home Centers, Paint and Wallpaper Store, Hardware Stores, Lawn & Garden Equipment Suppliers
448 - Clothing Stores, Shoe Stores, Jewelry Stores
451 - Sporting Goods, Hobby Stores, Sewing/Craft Stores, Book Stores
452 - Department Stores, Warehouse Clubs, General Merchandise Store, Discount Department Stores
45321 - Office Supplies and Stationary Store
45391 - Pet & Pet Supply Stores
Church
8131 - Religious Organizations
8133 - Social Advocacy Organizations (Social Rights, Human Rights, Environmental)
8134 - Civic and Social Organizations

Coffee
7225 - Restaurants and Other Eating Places
Community Meetings
8134 - Civic and Social Organizations
Convenience Store
44512 - Convenience Stores
Drop Off
Eat Meals
7224 - Drinking Places (Alcoholic Beverages)
7225 - Restaurants and Other Eating Places
Entertainment
711 - Performing Arts & Spectator Sports
712 - Museums, Historical Sites and Similar Institutions
7131 - Amusement Parks and Arcades
7132 - Gambling Industries
Fast Food
7225 - Restaurants and Other Eating Places

Fueling
447 - Gasoline Stations
Grocery Shopping
44511 - Supermarkets and Other Grocery (besides Convenience Stores)
Hardware
444 - Home Centers, Paint and Wallpaper Store, Hardware Stores, Lawn & Garden Equipment Suppliers
Indoor Athletics
71394 - Fitness & Recreational Sports Centers
71395- Bowling Centers
Logistics
491 - Postal Service
492 - Couriers and Messengers
493 - Warehousing & Storage
Mall
442 - Furniture & Home Furnishing Stores
443 - Electronics and Appliance Stores (Consumer & Household)
444 - Home Centers, Paint and Wallpaper Store, Hardware Stores, Lawn & Garden Equipment Suppliers

446 - Health and Personal Care Store (Pharmacy, Cosmetics, Beauty Supply, Optical, Food Supplement Stores)
448 - Clothing Stores, Shoe Stores, Jewelry Stores
451 - Sporting Goods, Hobby Stores, Sewing/Craft Stores, Book Stores
452 - Department Stores, Warehouse Clubs, General Merchandise Store, Discount Department Stores
453 - Misc. Retailers (Florist, Office Supply, Gift Stores, Used Merch Stores, Tobacco Stores, Misc. Stores)
Medical
621 - Ambulatory Health Care Services (Doctor/Dentist Office, Medical Labs, Outpatient Centers)
622 - Hospitals
Municipal Services
92 - Public Administration
Other
Other Shopping
442 - Furniture & Home Furnishing Stores
443 - Electronics and Appliance Stores (Consumer & Household)
444 - Home Centers, Paint and Wallpaper Store, Hardware Stores, Lawn & Garden Equipment

Suppliers
446 - Health and Personal Care Store (Pharmacy, Cosmetics, Beauty Supply, Optical, Food Supplement Stores)
448 - Clothing Stores, Shoe Stores, Jewelry Stores
451 - Sporting Goods, Hobby Stores, Sewing/Craft Stores, Book Stores
452 - Department Stores, Warehouse Clubs, General Merchandise Store, Discount Department Stores
453 - Misc. Retailers (Florist, Office Supply, Gift Stores, Used Merch Stores, Tobacco Stores, Misc. Stores)
4453 - Liquor Stores
Outdoor Rec
71219 - Nature Parks and Other Similar Institutions
71391 - Golf Courses and Country Clubs
71382 - Skiing Facilities
71393 - Marinas
Personal Services
812 - Personal & Laundry Services (Hair, Nail, Skin, Beauty, Diet)
8112 - Electronic Equipment Repair and Maintenance
8113 - Commercial/industrial Machinery Repair and Maintenance

8114 - Personal and Household Goods Repair and Maintenance
624 - Social Assistance (Individual and Family Services, Child Care, Rehab)
561 - Administrative and Support Services (Employment Services, Business Services)
Pharmacy
44611 - Pharmacies and Drug Stores
Quick Meals
7225 - Restaurants and Other Eating Places
Residence Visit
814 - Private Households
Residential
814 - Private Households
Return Home
814 - Private Households
School
61 - Educational Services covers elementary and secondary schools, junior colleges, colleges, business schools, technical and trade schools, other schools and educational support services.
Specialty Grocery Shopping
4452 - Specialty Food Stores (Meat, Fish, Fruit & Vegetable Markets, Baked Goods, Confectionary, Other)

Vehicle Services
441 - Motor Vehicles & Parts Dealers (New/Used Dealers, Automotive Parts & Accessory Stores, Tire Stores)
8111 - Automotive Repair & Maintenance
Work Related
Work Site

The South Bay sub-region, auto dependent and facing the end of the era of inexpensive energy, in 2004 began research to identify an affordable transportation strategy for prospering in this coming new era. A primary finding was that a high percentage of trips taken in the 8 study areas were a few miles or less.

Initially, vehicles were loaned to participating households for 6 months at a time. This long duration allowed the research team to assess changes in NEV use over time. Vehicles were loaned to selected household for unlimited use with no cost to participants other than for battery charging. With five NEVs in the program, the 18 month demonstration period would therefore allow 3 rotations so that in the end the project would include 15 households.

P27 This higher rate of use of NEVs for local trips that would have been a cold start trip in a typical car cause the criteria air pollutant reductions to be higher than the percentage of trip legs served by NEVs. Further augmenting the difference between GHG emissions and criteria air

pollutants percentage reductions is the fact than NEVs are used only for short distance travel. By their nature they do not absorb any of the long distance travel demand.