CITY CAR SHARE.org
A Bay Area Nonprofit

Report on RFG Funded Plugin Hybrid Electric Vehicle Carshare Project

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Disclaimer

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1. Project Overview/Goals

The Bay Area Air Quality Management District ("BAAQMD") provided funding for a project to try Plug-in Hybrid Electric Vehicles (PHEVs) in carshare service. The funding was provided by a settlement fund from the Reformulated Gasoline settlement (RFG) and was administered by the Bay Area Clean Air Foundation (BACAF).

The Reformulated Gasoline Settlement Fund goal was to fund projects that deliver benefits related to reductions in vehicle emissions and/or fuel use through a broad range of strategies. The City CarShare project was designed to meet this goal by retrofitting a fleet of ten Toyota Prius vehicles with Plugin Hybrid Electric Vehicle (PHEV) capability and by putting them into carshare service as part of City CarShare's fleet. Vehicles primarily resided at the following locations during the project period:

Table 1. Locations of 10 Retrofitted Toyota Prii

Vehicle ID	Pod Location (cross/streets)	City
6306	3rd/16th	San Francisco
4906	Brighton/Ocean	San Francisco
2279	Center/Shattuck	Berkeley
7478	Clarence/Townsend	San Francisco
89	Parnassus/3rd	San Francisco
5471	Parnassus/3rd	San Francisco
20	Stanyan/Frederick	San Francisco
8245	Stanyan/Frederick	San Francisco
9538	Stanyan/Frederick	San Francisco
3418	Sutter/Divisidero	San Francisco

In addition to providing partial funding for the purchase and conversion of vehicles, the grant also provided funding for membership and public outreach to educate members and the general public about the benefit of PHEVs.

Although funding was not provided for the electric vehicle service equipment (EVSE) charging infrastructure, part of the requirements of the grant were to provide parking spots with charging stations so that the PHEVs would be able to charge their batteries from the electric grid. The charging stations were required to be equipped with the ability to meter electricity so that the amount of electricity used by each vehicle could be monitored and recorded. The parameters that were recorded for each vehicle included: number of trips, distance driven on each trip, gasoline consumed on each trip, and electricity consumed on each trip. This information was compared with several standard Toyota

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Prius vehicles of the same model year over the same period of time in order to compare gasoline consumption between PHEVs and standard hybrid vehicles.

2. About City CarShare

City CarShare is a 13-year old non-profit membership-based organization providing unattended access to a fleet of conveniently distributed vehicles, 24 hrs per day, 7 days per week for round trip use. Members pay for any time reserved /used and any miles driven, in addition to periodic (monthly/annual) membership dues. Fuel, insurance, maintenance is always included as part of the price. In 2011 City CarShare set three aggressive goals:

1. By 2020: Remove 20,000 vehicles off Bay Area roads.
2. By 2015: Reduce the environmental impact of our cars by converting half of our fleet to electric or alternative fuel.
3. By 2020: Reduce our members' collective driving costs by one billion dollars (vs. car ownership)

City CarShare, as a non-profit community-based organization, has a stated mandate of researching, advancing and deploying new socially and environmentally-friendly shared mobility solutions to the communities we serve.

Accordingly, this long-range PHEV conversion project was well suited to City CarShare, our round-trip model, and members' needs as follows: 1) a user base already familiar with Toyota Prius (constitutes about 35% of existing fleet) 2) provide longer duration and distance trips free of range anxiety; 2) educating the public to be comfortable with PEVs technology by alleviating range anxiety issues associated with standard full battery electric vehicles.

3. Outreach and Education

In order to achieve the goals around member acceptance, City CarShare conducted continuous outreach and education to our members and the general public. From in-car materials that made it clear how to use the vehicle and charging station technology, to on-line promotions and instructional videos, and presenting and demonstrating at several public events. Over the life of the project, City CarShare also participated in local EV ride and drive events to give non-members an opportunity to test one of these vehicles (See Appendix A for details).

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This report is intended to provide the data collected over the term of the project, and the results of the project in terms of emissions reduction and greenhouse gas reduction. In addition this report presents a "best practices guide" for other carshare organizations wishing to incorporate PHEVs into their fleets.

4. Summary of Results

The key findings of the RFG PHEV project are as follows:

- **PHEVs are well suited to carshare service.** The ability to operate under only electric power for the first 25-30 miles of the trip means that the majority of carshare trip miles will use electric power. For trips over 25-30 miles the PHEV reverts to hybrid mode, which means it is still operating more efficiently than conventional gasoline-powered vehicles.
- **Members enjoyed using the PHEVs in the fleet.** Because the car operated nearly the same as a conventional Prius there was no need to learn the idiosyncrasies of a new vehicle type. The only requirement was to remember to unplug the car at the start of the trip and plug it back in at the end of the trip.
- **Converting vehicles to PHEV did not prove to be practical.** There were several issues with the conversion technology that is discussed in detail in the body of this report. It is suffice to say that the cars were less reliable and required substantially more maintenance than other Toyota Prius vehicles in the fleet. The converted vehicles were out of service much more frequently and for longer times than the standard Toyota Prii (plural form of Prius), or other vehicles in the fleet. This was largely due to the fact that the technology used to do the conversion was new and un-tested coupled with the lack of trained technicians.
- **There are now PHEVs being manufactured by several companies that preclude the need to convert existing hybrid vehicles to PHEV capability**.
- **The converted PHEVs are not as efficient as vehicles designed to be PHEVs from the ground up.** For example, the Chevrolet Volt and the Ford C-Max Energi vehicles in the City CarShare fleet are both more efficient (based on gasoline usage) than the converted Toyota Prii.
- **The converted PHEV Prius had some noticeable drivability issues**. It would surge at certain speeds as the vehicle switched back and forth between hybrid mode and electric mode. This is a direct result of the vehicle being designed primarily as a hybrid.
- **There was a substantial and ongoing issue with members not recharging the cars when they returned to the pod.** This is actually two issues. First, members simply forgot that they were supposed to plug the vehicle in. Secondly, members would plug the vehicle in, but forget to energize the charging station by using the ChargePoint card. The good thing about the cars being PHEVs is that they would still operate in hybrid mode which meant no disruption in service due to low state of charge of the battery.

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- Several Marketing and Outreach Events highlighting PHEVs were conducted during the period in order to stimulate trial and continued use. Our campaigns were directed to existing members and potential new members. Members who drove the Prii PHEVs received discounts and earned credits.

5. Budget Summary

Overall, the total project was budgeted at roughly $900K, with the RFG Grant funding 56% and City CarShare matching 44%. Key expense categories were **Salaries and Wages** accounting for roughly $58K, **Contracting / Consultants** at roughly $166K, and **Materials / Equipment and Promotional Incentives**, accounting for roughly $671K (e.g. cars, conversion equipment/installation, signs, other in-car tracking devices; existing and prospective member pricing and promotional incentives).

6. PHEV Lessons Learned

There are a number of lessons learned through this project, most of which are implied in the previous sections, but are worth summarizing here.

PHEVs get better gasoline mileage than comparable hybrids

The mean-average carshare trip at City CarShare is about 23 miles. A vehicle that can operate in electric mode for 30-40 more miles, such as a PHEV, will result in the majority of vehicle miles traveled (VMT) using electricity rather than gasoline. This depends on the vehicle being recharged between each use. The resulting replacement of gasoline miles with “electric miles” is beneficial in many ways: lower operating costs, lower emissions, and lower greenhouse gas production at the tailpipe. Reduction in gasoline usage has numerous social, health, and economic benefits that have been well documented. What was proven in this project is that a PHEV with relatively low electric range is far more efficient in carshare service than in ownership models where the trip distances between charging are typically longer.

Members enjoyed driving PHEVs

Members generally enjoyed the benefits of driving PHEVs. They mentioned the fact that the gasoline engine did not come on as frequently resulting in a quieter and smoother driving experience. They also mentioned that they appreciated the fact that PHEVs are a benefit to the environment. There were some negative issues from members that are mentioned below, but overall members had a favorable impression of the vehicles when they operated as designed. Additionally, use patterns among members (e.g. the duration, distance and time of week/day), with the exception of BEVs, were similar to all other vehicle types in the fleet (Table 2). (BEV use, duration and distance is moderated by existing range limitations as well as the need to programmatically institute a significant “re-charge” interval between reservations [2 hrs] and allow limited overnight trips to facilitate recharging.)

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Table 2. Use Patterns Among Vehicle Types

	Converted PHEV	EV	OEM PHEV	Hybrid	ICE
Avg. Trip Duration (h:mm)	4:35	3:32	5:31	4:39	4:38
Avg. Trip Distance (miles)	24.3	15.0	27.5	26.1	24.1
Weekday Usage	47.2%	54.9%	44.5%	49.6%	47.1%
Weekend Usage	38.0%	39.2%	39.3%	35.8%	37.5%
Overnight Usage	14.8%	5.9%	16.2%	14.6%	15.3%

Furthermore, while there were significant service gaps with some vehicles -- that are apparent in the variations of trip numbers (because of unforeseen but persistent technology issues) -- the vehicles performed well in terms of emissions and fuel savings when they were in use, accounting for roughly 5.7 tons of GHG savings (Table 3).

Table 3. Usage Performance Data of Program to Date (2/1/12 – 8/31/14)

Vehicle ID	Trips*	Miles*	Energy Used (kWh)	GHG Saved (Kg)
20	445	10,606	10,88.717	547.256
89	710	19,458	2,325.73	976.803
2279	605	11,853	1,728.09	725.806
3418	449	12,047	1,669.73	701.285
4906	253	7,476.6	651.792	273.749
5471	282	8,924.9	334.728	140.586
6306	551	13,838	1,256.656	527.783
7478	265	7,960.1	1,061.038	445.64
8245	825	19,421	2,260.04	949.208
9538	335	9,076.7	1,028.459	431.959
TOTAL	**4720**	**120,662**	**13,404.98**	**5,720.075**

Training members to correctly plug the vehicle in is essential

PHEVs are no better than standard Prii (in terms of gasoline mileage, emissions, and greenhouse gas reduction) if the traction battery is not charged before each trip. There were several problems associated with correctly plugging the vehicles in for charging the traction battery system:

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1. **User Error – Trying to start the car while it was plugged in.** The most common symptom of a user error caused problem is a dashboard warning that states: "Hybrid System Error". When this error occurs the car cannot be driven. The most common cause (but not the only cause) of this problem is the driver attempting to drive the car while it is still plugged in or attempting to plug the car in before turning it off. This is a safety feature in that the car is disabled while the electrical plug is connected to avoid damaging the car, the charging cable, and/or the charging station. The fault can be cleared and the car will return to normal operation following a simple procedure which can be done by the driver. The procedure is as follows:

    i. Turn the car off – ensure that all dashboard lights are off.
    ii. Make sure the vehicle is not plugged in to the charging station.
    iii. Start the car and turn it off without attempting to drive.
    iv. Repeat step iii. 3-4 times until the "Hybrid System Error" notification no longer appears and the "Ready" light on the dashboard comes on.

    Once the "Ready" light appears on the dashboard, the fault is cleared and the car can be driven normally. After several episodes of members attempting to start the vehicle while plugged in and getting this fault we trained our support staff to take members through the fault clearing procedure. As members became more educated and aware of the necessity to unplug the vehicle before driving the problem became less frequent to the point that it no longer causes a concern. However, the problem still occurs from time to time. City CarShare feels that a better solution to the problem would be to have a specific warning message or warning light that indicates that the vehicle is plugged in rather than have the Check Hybrid System message illuminated. In discussing this with the conversion vendor, PICC, it was mentioned that it is not possible to create new messages in the Toyota vehicle management system and this was the best compromise.

    The other problems with the vehicle were not caused by driver error. The unfortunate thing is that most of the errors also caused the "Check Hybrid System" message to be illuminated on the information panel. Because of this there was no easy way to determine if it was the problem mentioned above (car plugged in) or if it was a more serious issue. The only way to tell if it was another issue was to plug a diagnostic tool into the On Board Diagnostic port in the car and read the error codes. This has to be done by a professional mechanic with a special diagnostic tool who is trained on the Prius and on the conversion system. In virtually every case where the "Check Hybrid System" message was illuminated and it was determined to not be the problem caused by the car being plugged in, the problem was with the conversion battery system. Tremendous amounts of time were spent diagnosing the problems with the battery system but in the end the issues were either 1) a bad battery module or 2) a bad charging system.

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2. **Members forgetting to plug in the vehicle.** The plug for the converted Prius PHEV was cleverly concealed behind the Toyota logo on the front of the car. This was done to minimize cutting of the body or bumpers to install the plug. Because it was so well concealed, members frequently could not find the plug and/or forgot they were driving a PHEV that needed to be plugged in. This is exacerbated by the fact that the PHEV Prius looks and drives exactly like other standard Prii in the City CarShare Fleet. City CarShare had to install signage in the vehicles reminding members to plug in. When a member failed to plug in a vehicle they were contacted with a reminder notice and warned that future failure to plug in could result in a fine.

3. **Members not understanding how the charging station works.** The ChargePoint charging stations that are used by City Carshare in all PHEV pods require a ChargePoint card to activate the flow of electricity. Normally the plug on the ChargePoint station cannot be removed from the holster on the station until the ChargePoint card is used to activate the station. However, members often did not return the plug to the holster when they unplugged it at the beginning of their registration. Instead they would drape the plug and cable over the charging station and when they returned they would plug it back in without re-activating the station. (It should be noted that the stations de-activate when the plug is removed for safety and security reasons). By plugging in and not re-activating the station, the member thought that s/he had correctly returned the vehicle, but in fact no electricity was flowing to re-charge the traction battery. This became a bigger issue than forgetting to plug the vehicle in and continues to be a minor issue. City CarShare personnel monitor the vehicles to ensure that they are plugged in and charging but when this failure mode occurs, it is impossible to tell if the member forgot to plug in or forgot to activate. This resulted in more frequent visits to vehicles by field technicians.

4. **ChargePoint cards missing.** One other issue around charging is that the ChargePoint cards were frequently lost or could not be found in the vehicles. City CarShare provides a visor pack that contains the various cards needed to drive the vehicles such as gasoline credit cards, garage entry cards, and the ChargePoint cards. All of these cards get lost or stolen from time to time but there was a higher incidence of missing ChargePoint cards. This can be attributed to the procedure for charging the vehicles. It is believed that the procedure (listed below) was difficult to complete without putting the ChargePoint card in a pocket or purse where it was easily forgotten and not returned to the visor pack. The procedure is as follows
    a. Park and turn off the vehicle
    b. Take the ChargePoint card from the visor pack
    c. Exit the vehicle with the ChargePoint card
    d. Use the ChargePoint card to authorized the station
    e. Open the charge port door and the charge port cover
    f. Remove the charging plug from the holster on the ChargePoint station

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g. Plug the plug into the vehicle
h. Ensure that the ChargePoint station is activated by reading the display
i. Return the ChargePoint card to the visor
j. Lock the vehicle using the City CarShare fob.

Between steps d and j there are several operations that may require two hands and it is inevitable that the ChargePoint card will be set down or put in a pocket or purse.

It would be beneficial if the process could be simplified by eliminating the need for the ChargePoint card. Some possible ways this could be accomplished include wireless charging and/or wireless vehicle identification by the charging station.

Examples of Instructional Materials:

Figure 1. In-Car Guide

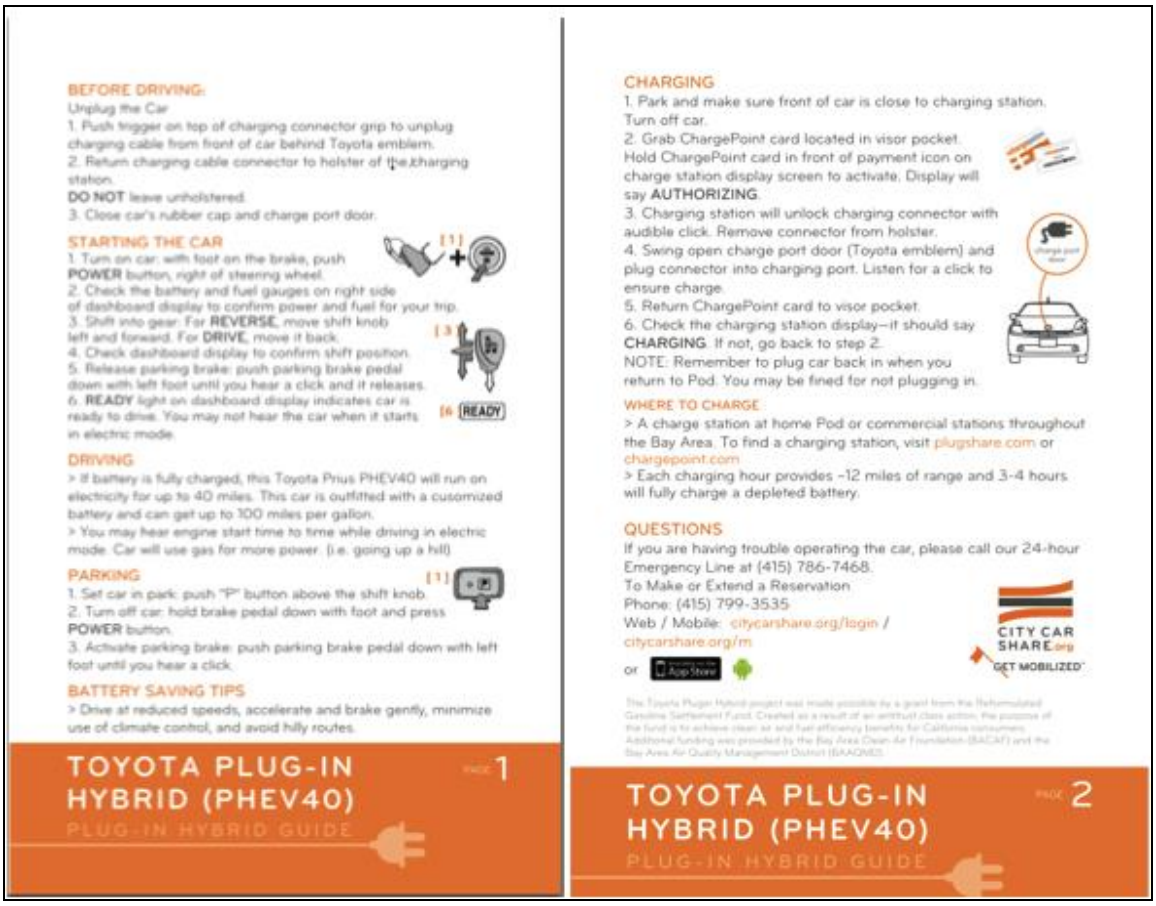

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Figure 2. On-Line Video (image only, will not play):

To Play go to: http://citycarshare.org/member-lounge/vehicle-guides/toyota-prius-plug-in-hybrid/

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Charging station infrastructure is an ongoing issue

One of the key lessons learned in the implementation of PHEVs in a carshare environment is the importance of electric vehicle charging infrastructure. In order for a PHEV to be most effective at reducing the use of gasoline and maximizing the "electric miles" driven, the vehicle must be plugged in and fully charged before each use. This requires that each parking spot where PHEVs are assigned have a dedicated charging station available and that the member base be well trained in the use of the charging station. City CarShare experienced several difficulties in getting charging stations installed as well as getting members to properly use the charging stations. These experiences will provide a guide for other carshare organizations as they adopt PHEVs and BEVs into their fleets.

For the most part, City CarShare uses public parking lots, garages, and parking structures as locations for vehicles. Installing charging stations at these locations proved to be difficult, expensive, time consuming, and the property owners were not always willing to allow charging stations to be installed on their properties even at no charge.

- **Expense** – While charging stations are becoming less expensive to purchase, they still represent a large investment for City CarShare. A typical installation for a single port charging station started at $10,000 at the beginning of the project. Costs have come down and now the cost for installing a dual-port station is about $11,500. The cost of installing the station is about 50% equipment and 50% installation costs. Although City CarShare retains ownership of the charging stations, the cost of installation (running conduit, wiring, physical mounting of the unit, etc.) is not recoverable if it is necessary to move the parking spot to another location. So each location has to be carefully considered to ensure that it will be a well-used location before making the investment.
- **Time Investment** – Normally the parking contract for a City CarShare location is fairly straightforward and takes a minimal amount of time. With the addition of an EV charging station the negotiation process is prolonged. This is due to the term of contracts being much longer and the concerns of property owners (discussed below) being more acute. It was not unusual for a parking contract to take 4-6 months to negotiate.
- **Property owner concerns –** When approaching a parking property owner for the installation of charging infrastructure on their property there are a number of concerns that need to be addressed. Our experience was that property owners were not at all willing to bear any of the expense of installing a charging station. Secondly, property owners had concerns about how the electricity for charging the vehicles was to be paid for since our charging stations were to be connected to their electrical system and metered through their meters. Thirdly, City CarShare asked for a longer parking contract than usual due to the unrecoverable expense of installing

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the charging stations. All of these issues added up to making it much more difficult to negotiate a parking contract with parking property owners.

- **Electricity payments –** City CarShare developed a plan for paying the property owner for electricity used to charge vehicles. The property owner was offered $30 per month as a flat fee with the ability to view the amount of electricity used by the charging station at each location. The estimated amount ($30/month) was calculated based on average miles driven, estimated miles/kWh, and estimated electrical rates. Over the two year period no property owner has ever asked for more money based on the kWh usage reports that were supplied to them.
- **Peak demand charges –** Few property owners are aware of Peak Demand Charges, but those who were aware had some concerns that the EV charging stations could increase their Peak Demand charges. In one case (UCSF) they factored in demand charges as part of the monthly flat fee which increased the monthly fee to $43.
- **Electrical Infrastructure –** Most garages and parking structures do not have substantial extra electrical service capacity. Each EV charging port requires a dedicated 220/207 volt, 40 amp circuit. Several garages that were prime candidates for EV parking did not have sufficient capacity or were saving the spare capacity for public charging stations. This had the effect of reducing the potential locations for parking EVs. In particular, all parking structures owned by the City of San Francisco were not available for City CarShare EVs due to the program to install public charging stations in them.

Maximizing the benefits of PHEVs may reduce vehicle availability

In order for a PHEV to provide maximum benefit in terms of the reduction of gasoline usage and minimizing emissions of pollutants and greenhouse gases, it must be fully charged before each use by a member. In order to be fully charged the PHEV requires about 3 hours of charging time at the POD. This is based on a 10kWh battery and a 3kw charging system. However, one of the key objectives of carsharing is to maximize the use of the vehicle by minimizing the amount of time that the vehicle spends parked at the POD. City CarShare normally has a 15 minute time between uses to allow for late return and/or early pickup of the vehicle. Naturally, the 15 minute period is often longer because the cars are not reserved throughout the day. However during the busiest times, typically evenings and weekends, it is quite normal for cars to be returned by one member and taken out by another member with only 15 minutes between reservations. Because PHEVs require 2-3 hours of charging between uses they are not fully charged during these busy times. One possible remedy is to adjust the wait period between reservations to be longer than 15 minutes. City CarShare did adjust the time for BEVs to 2 hours between reservations since BEVs absolutely must be charged before each use. However, the decision was made for PHEVs to leave the wait time at 15 minutes with the knowledge that they would not necessarily be fully charged, thus sacrificing electric miles, during the busiest times. This was

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considered a reasonable trade-off in order to maximize the use of the vehicles. In practice we discovered that the vehicles went out fully charged about 80% of the time. This is an area for further investigation. There is a possibility of making the wait times be dynamically adjusted based on previous usage and/or estimated trip distances. This idea was not within the scope of this project but may present an opportunity for further investigation.

Vehicle Conversion Complications

Traction Battery Module Quality Issues. Battery modules make up the traction battery system. There are 11 battery modules in the PICC traction battery system that is installed on the City CarShare PHEVs. Each battery module is, in turn, made up of multiple battery cells. The manufacturer of the battery modules is a Chinese battery manufacturer. During the course of the project it was determined that the quality of the battery modules was insufficient to allow the battery system to function properly in many cases. To diagnose which battery module was causing the problem the malfunctioning battery system has to be partially disassembled and each module individually tested for its ability to charge and discharge properly. This is a very time consuming task that can take several days to diagnose due to multiple charge/discharge cycles of the multiple battery modules that make up the battery system. Once a bad battery module has been identified it can be replaced and the car can be put back into service after the battery system has been reassembled and re-charged. Battery modules, however, are fairly expensive and not easily obtained. To make matters worse, it is difficult to mix new battery modules with older battery modules in a single battery system due to the possibility of charge imbalance between the modules. It takes a highly trained technician to diagnose and repair the battery system in this situation and often requires multiple battery systems be disassembled and individual battery modules tested so that the ones with matching characteristics can be assembled into a battery system. It should be mentioned at this point that all battery systems were covered by a 1 year warranty from the conversion vendor, PICC. However, during the term of the project PICC began having financial difficulties and was unable to stand behind their warranty. Because of the inability to get repairs paid by warranty City CarShare engaged a local shop, Pat's Garage, to work on the battery problems encountered in the PHEV fleet. This necessitated shifting some budget from outreach to maintaining the conversion systems.

Traction Battery Charging System Issues – Difficult to Monitor. The battery charging system is a separate system from the battery management system. There were several failures of the battery charging system over the term of the project. These failures necessitated replacement of the battery charging system in the vehicle. When the battery charging system fails, the PHEV continues to operate in an apparently normal way. It is not apparent to the driver that there is a problem because the car automatically goes into hybrid mode if the battery is depleted. Because of this it was necessary to continuously check the PHEV fleet to ensure that the vehicles were taking a charge when plugged in. If a

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vehicle has been driven and then plugged in correctly it should take a charge that is approximately equal to the number of miles driven times the average electric mileage which is 4 miles per kilowatt hour. As an example, a car that has been driven 10 miles should take a charge of about 2.5 kWh. Fortunately the ChargePoint system provides means of monitoring the vehicles to see how much charge they are taking. By establishing a routine of checking each car at least once a week City CarShare was able to detect when a battery charging system had failed. It should be noted that when a battery charging system failed it left the battery system at a low state of charge which can be detrimental to the health of the battery system if not remedied within 8-10 days. In the early stages of the project at least 2 cars went several weeks with undetected failed battery charging systems that caused some battery module failures.

12 Volt Battery Problems – Required Adding a 12 Volt Charger to the PHEVs. In addition to the high voltage traction battery that drives the electric motors of the PHEV, each vehicle has a standard 12 volt automotive battery to operate the normal electrical systems of the vehicle such as lights, windshield wipers, electric door locks, radio, etc. City CarShare experiences a high number of dead 12 volt batteries on standard vehicles when the vehicles are used infrequently. This is because the vehicle management system (called VALU) that is installed on all City CarShare vehicles uses 12 volt current when the car is parked and turned off. The VALU system is the system that read the member fob and opens the doors when the member arrives for a vehicle reservation. The system also communicates to the City CarShare Network Operations Center via cell phone modem in order to transmit usage and receive reservation data. The current draw of normal City CarShare vehicles is low enough that the vehicles can typically go about 1-2 weeks between uses. However, we found that the converted PHEV Prius fleet was having frequent dead 12 volt battery problems after only a day or two of not being used. This problem was traced down to the fact that the traction battery management system and the traction battery charging system drew additional 12 volt current while the traction battery was charging. (All plug-in vehicles such as the Nissan Leaf and Chevrolet Volt have the same problem so the manufacturers of these vehicles have installed a system that charges the 12 volt battery from the traction battery during the traction battery charging cycle. This is called a DC-to-DC system because it uses high voltage direct current to create the necessary low voltage direct current to charge the 12 volt battery). This resolution to this problem was to install a small 12 volt charging system in the PHEVs that used the 220 volt AC input current from the J1772 plug. As long as the J1772 plug was active the 12 volt battery would be charged and the battery management system could not deplete the 12 volt battery. This necessitated some additional engineering as well as a fleet retrofit.

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APPENDIX A – Examples of Marketing Materials and Promos

1. New and Existing Member Promotion:

Overview: From October 2013- April 2014, City CarShare planned a PHEV promotional program for new and existing members and implemented it:

Concept: Incentive to join and to check out PHEVs.
Goal: 300 members who participate
Timeframe: Launch in December 2013. Give members until March 31 to drive PHEVs.

Incentives for Awards

Members who opted into the program got credits when they used any of the Prius PHEVs

LEVEL I:	Share PHEV **at least 2 times:**	$10 credit
LEVEL II:	Share a PHEV **5 times:**	$25
LEVEL III:	Share a PHEV **10 times:**	$50
LEVEL IV:	Share a PHEV **11 + times**:	$75

Target Audiences

New member sign up incentive using promo code: Sign up with only a $10 application fee + $30 driving credits if you commit to join PHEV program by using promo code ($45 value). For members who didn't use the promo code when signing up, we sent an email that let them know about the program and to opt-in.

Existing members were encouraged to opt-in to the program. We had a website page with a sign up form on it.

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Rules

- New members need to use the Promo code on their application to opt in and get credits.
- Existing members can simply email or call us to opt in.
- Valid for members on personal use membership plans only (Individuals and households, students, employee personal use plans)
- Trips must be completed by midnight, March 30, 2014
- Members must drive the cars (accrue mileage) for each trip
- Hourly and Flat Rate trips apply

Promotion Marketing Plan

Marketing to Members and "Non" Members required different vehicles and messaging. Samples of materials are included below.

New Members:

- Created webpage for promo that served both new and existing members
- Posted large banner on City CarShare's home page linking to PHEV page
- Placed an Online Banner Ad – Ran Feb 2-March 15— Results
  - CTR .10% (high end of industry average)
  - One ad among three for campaign which yielded 1,231,089 impressions and 811 clicks and 155 actions
- Sent out reminder email about the promotion on February 22 and March 14.
- Posted to our Facebook page. Any fans that aren't members would see the incentive
- For every new member, we included text about the program in their confirmation within our automated e-mail system

This promo was during the winter when there aren't tabling opportunities. So we implemented an online strategy to get the word out.

Members:

We have a limited number of touch-points for members and used every one of them. For example we:

- Highlighted the promo in each of our January, February, and March e-newsletters (via e-mail)
- Web page and home page banner (mentioned above), form on web page that allowed members to opt in.
- Reminder emails to those members who opted in (mentioned above)
- Posted an announcement on Log in page linking to the PHEV promo web page
- Facebook, G+, and twitter posts
- Text on all member bills announcing the program

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Results

29	New Members joined through the Promo
188	Existing (or "newly minted") Members Opted-in
217	Total Participating Members
113	**Total number of reservation**

2. Get Electric, Get Mobilized Ride and Drive Materials and Promo

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3. Summer Challenge June, July, & August 2012:

CITY CAR SHARE.org

A BAY AREA NONPROFIT

Get Mobilized™ | Login | JOIN US

WHAT IS CAR SHARING? | WHY CITY CARSHARE? | CARS & LOCATIONS | PLANS & PRICING | GET INVOLVED

Unplug for a Chance to Win Prizes

Get Electric, Get Mobilized Summer Challenge June, July, & August 2012 Winners

Congratulations to our three big winners, 20 additional winners and everyone who participated. During the months of June, July, and August, over 500 of you participated.

Thanks to these EV pioneers, there were 2,091.3 fewer pounds of CO_2 emissions in the Bay Area. As a seal of exceptional carsharing and a badge of EV pride, click here to download the image to post to Facebook or use as a screen background.

The Challenge

Show your Bay Area tech-savvy style by sharing the latest that car technology has to offer ... and be greener while you're at it. This summer, we're challenging our members to unplug from the daily grind and get electric.

Whenever you reserve a **City CarShare electric-based vehicle during the months of June, July or August, you will automatically be entered in a drawing to win some awesome prizes.** The more you reserve, the better your chances!

Prizes

- First Prize, Winners Choice: **$500 Clipper Card or $500 in driving credits!**
- Second Prize, **$300 driving credits**
- Third Prize, **$200 driving credits**

20 BONUS prizes: Winner's Choice: City CarShare Umbrella or Hat

These are our electric-based vehicles: *Mitsubishi i-MiEV, Nissan Leaf, Chevrolet Volt, Toyota Prius PHEV40, and the Ford Focus Electric (coming soon). To learn more about how we are electrifying carsharing, click here.*

Everyone Wins!

If you take this fun quiz, you'll become a Get Energized, Get Mobilized Ambassador. All Ambassadors will get a fun badge to

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4. Events and Presentations:

2012

- **Sept 17-18**
  - Electric Vehicle Week, Charge Across Town event, Embarcadero, SF (tabling and PHEV display), Reception (Rick Hutchinson, CEO City CarShare spoke about our program—included PHEV in speech)
- **Nov 14**
  - EV training with members. Included Ride and Drives for some participants. City CarShare's EV expert (Mike Harrigan) and lead fleet tech (Michael Nelson) taught members the basics about using our Plug-ins. Cars we brought to site so members could see features first hand. Partnered with a Meet up Group.

2013

- **Feb 28**
  - East Bay Clean Cities PHEV workshop
  - East Bay Clean Cities Coalition in conjunction with the NorCal Northern Nevada Chapter of NAFA and the Municipal Equipment Maintenance Association, Suisun City. Tabling displays included PHEV information, locations, and one-sheet on our plug-in program. Mike Harrigan gave overview of PHEV program.
- **June 8**
  - EV Consumer Education Workshop, SF Public Library, promoted all plug-ins (drove participants)
- **Sept 4**
  - Pleasanton Green Scene Fair, displayed Scion iQ and PHEVs.
- **Sept 22-24**
  - EV week, Charge Across Town event, Displayed EV banner and PRIUS PHEV
- **Nov 27-Dec 2**
  - Future Drive Expo, displayed Prius PHEV, i-Miev, and Scion iQ

2014

- **July 16**
  - Hacienda Ride and Drive, Pleasanton, promoted Scion iQs , EVs and PHEVs)

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APPENDIX B – Conversion Process and Post Conversion Experience

Description of Conversion Process

During the process of applying for the grant it was determined that a local company called "3Prong" would do the conversion of the vehicles from hybrid to PHEV. 3Prong had previously converted two Generation 2 Prii for City CarShare and the cars had been used for about 2 years at that point with minimal problems. However, after the award was granted it was discovered that 3Prong would not be able to convert the new generation of Prii (Generation 3) that was called for in the grant. Toyota had made substantial changes to the Prius in going from Generation 2 to Generation 3 and the system that 3Prong had devised for conversion would not work in the later models. After several meetings with 3Prong it was decided to begin a search for a different conversion system vendor.

City CarShare developed a specification for conversion of Model Year 2011 Prii to PHEV operation and circulated the specification to multiple vendors who had indicated interest in the project. At the time of undertaking (early 2012) there was no existing "off-the-shelf" conversion system available for the 2011 Prius. Most conversion manufacturers had heard that Toyota was intending to bring their own PHEV Prius to market and did not believe that it would be economically feasible to compete with an OEM product.

The City CarShare PHEV Specification is as follows:

- Designed to fit 2011 Toyota Prius
- Electric Range: nominal 40 miles
- Li-ion battery system mounted in rear cargo area of vehicle
- Nominal battery capacity: 10 kWh
- J1772 compliant on-board battery charging system, including plug receptacle
- Modifications to allow electric mode operation to at least 60mph
- Modifications to allow electric mode operation until battery drops below 20% state of charge
- Automatically reverts to standard hybrid operation upon battery depletion
- Diagnostic information available through standard CANbus operation
- Minimal modifications to vehicle interior and exterior

After a long process of talking to many possible vendors it was determined that only one vendor was willing to undertake the process of converting ten Generation 3 Prii to PHEV. The vendor selected was Plug-in Conversion Corporation (PICC) located in San Diego, California. PICC demonstrated an early version of their system to the satisfaction of City CarShare and it was subsequently determined to convert and test a single vehicle before proceeding with the conversion of the remaining nine vehicles.

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The first conversion was done by PICC in their shop located in San Diego area. The vehicle was brought to City CarShare and tested for about two weeks. Testing included driving the car in typical carshare service (10-25 mile trips), as well as running the vehicle until the battery was depleted through several cycles on longer trips of 50-100 miles. Battery charging was tested using a standard ChargePoint charging station. Subsequently the vehicle was entered into carshare service and used by several City CarShare members with no issues reported. See the report issued at the completion of testing (Appendix C – Toyota Prius PHEV40 Technical Description).

Upon completion of the testing cycle City CarShare entered into an agreement with PICC to convert the remaining nine vehicles. The completion of the nine vehicles took several months due to battery system supply chain issues encountered by PICC. By July 31, 2012 all 10 vehicles had been completed and were put into car share service. Each vehicle was assigned to a pod with a ChargePoint charging station so that its electricity usage could be monitored. City CarShare had several other Plugin Electric Vehicles at this time including the Chevrolet Volt, Nissan Leaf, and Mitsubishi i-MiEV that were also assigned to pods with ChargePoint stations. Cars were frequently re-assigned to ChargePoint equipped pods throughout the area so that the maximum number of members could have easy access to the vehicles.

In several test drives by City CarShare personnel of each of the ten converted Prii it was determined that the vehicles could achieve over 100 mpg on trips of 50 miles. This was accomplished by fully charging the battery system at the ChargePoint equipped pod prior to driving. Then a 50 mile trip comprised of a mix of city and highway driving was undertaken with the driver being careful to drive conservatively to maximize the use of the electrical drivetrain and regenerative braking. These trips averaged 38 miles in all-electric mode. Between 35 and 40 miles into the trip the vehicle would automatically transition to hybrid mode. While in all-electric mode the gasoline engine would operate automatically when necessary during acceleration, hill climbing, and upon initial startup. The operation of the gasoline engine could be monitored using the standard Prius display.

It was noted that during the electric-mode operation surging could be detected when the gasoline engine automatically turned on and off (for acceleration, hill climbing, etc.). This effect was more noticeable when the state of charge of the battery was lower. Subsequent adjustments to the battery management system minimized this effect but it was never completely eliminated. Once the battery was depleted and the vehicle switched to hybrid mode the surging did not occur. Members who drove the PHEV Prii mentioned the surging from time to time but it was not considered a driving hazard. It should be mentioned that the standard Prius exhibits some surging as well when driven at highway speeds.

Post Conversion Experience with PHEVs

By July of 2012 all vehicles were put into standard carshare service. The terms of the grant called for the vehicles to be offered to members at the lowest hourly rate that City CarShare offered. This meant that

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the PHEV Prius fleet would be priced at $1/hour less than a standard Prius and ensured increased interest and demand from the City CarShare members. The PHEV Prius vehicles have all had usage throughout the project, and City CarShare was able to collect reasonable usage statistics between July 2012 and January 2014.

During this time all of the vehicles in the PHEV Prius fleet had various problems. Some problems were due to user error and some were electrical problems that could be traced to the conversion system. Reiterating for the purpose of emphasis: every vehicle was out of service for a substantial amount of time (2 weeks or more) during the term of the project. This is in contrast to other vehicles in the fleet that typically spend only a few out of service days over the course of year unless they are involved in a major accident.

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APPENDIX C – Toyota Prius PHEV-40 Conversion Technical Information

1. **Vendor Identification**

   Name and address of conversion vendor:
   Plug-In Conversions Corporation
   12900 Brookprinter PL STE 100
   Poway California 92064
   Kim Adelman, CEO, (858) 486-9972
   Plug-In Conversions Corporation (PICC) is a California corporation.

2. **Experience**

   PICC systems have been installed domestically and internationally in over 60 conversions to date. We are the system designer and manufacturer. Projects have included China Light & Power (CLP), Hong Kong Electric (HKE), Omaha Public Power (OPPD), CSIRO in Melbourne Australia, automotive OEM manufacturers in Japan, University of Munich, Toyota del Ecuador, S.A., Monterey Peninsula College, and many individual end-users in the U.S.

   Corporate Summary
   San Diego based Plug-In Conversions Corporation (PICC) was founded in June, 2007 to help restore and protect our environment by converting as many Hybrid Electric Vehicles (HEVs) as possible to Plug-In Hybrid Electric Vehicles (PHEVs). In December 2008, Gold Peak Industries North America, Inc. (GPINA), a subsidiary of GP Batteries International, took a minority equity position in PICC. Note that PICC uses Luscious Garage as their local installer in San Francisco.

3. **Conversion Description**

   - Plug-In Conversions Corporation (PICC) designs and manufactures PHEV conversion systems for 2004-2012 Prius vehicles.
   - The PICC system replaces the OEM Nickel Metal Hydride (NiMH) traction battery pack provided by Toyota with a larger Li-Ion traction battery pack.
   - Proprietary display and control systems are installed.
   - An onboard traction battery charger compatible with J1772 Level I and Level II charging is installed.
   - A J1772 inlet is installed in the rear bumper.
   - After on-grid charging, the system maximizes the use of electricity vs. gasoline until the charge is depleted. At charge depletion the vehicle automatically reverts to normal factory HEV operation until the next on-grid charge

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4. Operation

Grid Charging

When plugged in (grid charging) the high voltage onboard charger re-charges the pack while monitoring safety conditions. When the plug is removed, the vehicle is automatically set to "PHEV" mode. A full charge takes about 4 hours and grid consumption is about 10 kWh.

Driving

When the vehicle start button is pressed, all systems are powered on. If the vehicle is still plugged in, it will not start and an error message is displayed on the dashboard. When the J1772 connector is removed the driver can start the car.
In addition to normal factory "Hybrid" mode, there are two additional driving modes available whenever the pack is not depleted.

(1) "**PHEV**" "short trip" mode uses only electric power at any speed unless driving demand (e.g. hard acceleration or steep hill) requires momentary additional gas engine assist. In this mode the driver experience is the same as a factory Prius but mileage is greatly enhanced to well above 100 mpg under many driving conditions. "PHEV" "short trip" mode range is about 50 miles until the pack is fully depleted and the car automatically reverts to factory "Hybrid" mode.

In "PHEV" mode the driver can select "short", "medium" or "long" trip to optimize use of the battery – faster discharge for short trips, slower discharge for longer trips – which can help increase overall fuel economy.

(2) "**True EV**" mode will allow electric only operation at speeds up to 70 mph, unless an urgent situation requires immediate maximum acceleration. In "True EV" mode, the vehicle has good acceleration at speeds below about 40 mph on level terrain, and noticeably less power available for acceleration at higher speeds. If the accelerator is depressed fully during an urgent situation, full engine power is immediately available and the car automatically switches back to "PHEV" mode.

Maximum range in this mode is about 40 miles at speeds below 40 mph, about 30 miles at speeds up to 50 mph, and about 20 miles at higher speeds. Range is dependent on temperature, terrain, and driving habits.

After starting the car, the driver need not take any additional action, and can proceed in "PHEV" mode until the pack is depleted. If desired, the driver can select "True EV" mode or "Hybrid" mode. Selecting "Hybrid" mode will inhibit further discharge of the pack until "PHEV" or "True EV" mode is selected.

5. Real World Experience

City CarShare received the first converted Prius from Plug-in Conversion Corporation in mid-January, 2012. The car was tested for two weeks previous to being put into service on January 31. During this

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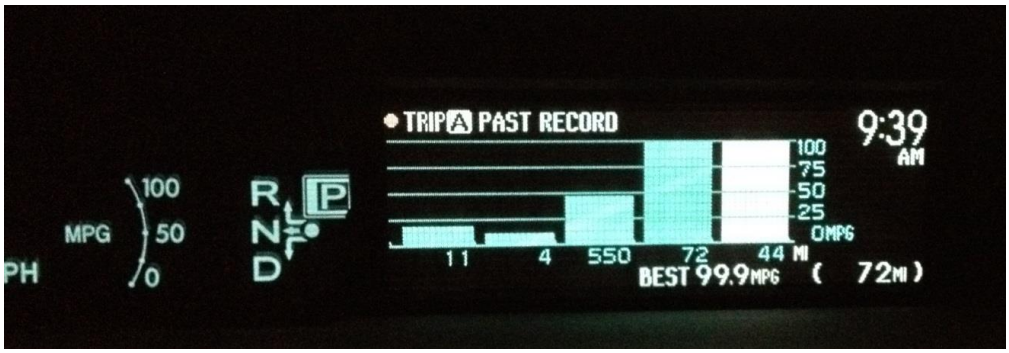
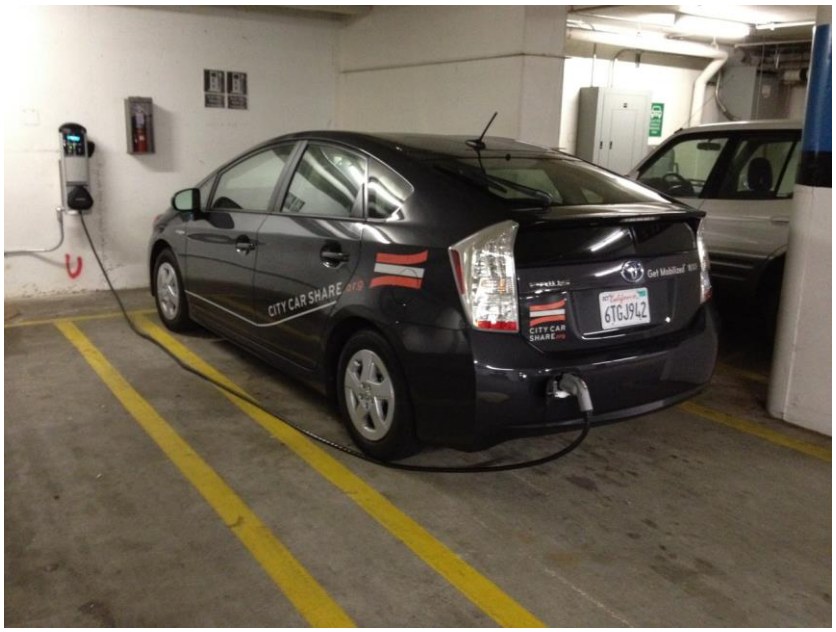
time the car achieved better than 100 mpg in 4 separate trips of over 40 miles mixed city and freeway driving. Each trip was started with a full electrical charge in the battery system. The car was operated in PHEV short trip mode (described above). The battery system reached depletion level at about 32-35 miles and ran the rest of the 40 miles in standard Prius Hybrid mode with the switch from PHEV mode to Hybrid mode taking place automatically. After 4 such trips the car had used less than 1 gallon of gasoline indicating that the car was actually getting closer to 160 mpg for the 40 mile trips.

6. Photos



Prius Mileage showing the 550 mile trip from San Diego (48mpg in hybrid mode), 72 mile trip around Bay Area (100+ mpg in PHEV battery depletion mode), and 44 mile trip around Bay Area (100+ mpg in PHEV battery depletion mode). Note that the Prius trip computer does not calculate fuel economy above 99.9 mpg.



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Prius PHEV-40 plugged in and charging at Civic Center garage.

The Prius PHEV-40 10kwH battery pack (just behind the rear seat), battery management system and 3kw on board charger (closest to camera). The battery management system hinges up for access to spare tire. There is a carpeted cover for this that hides the system. Cargo capacity is slightly impacted but rear seats still fold down to offer substantial cargo carrying capacity.

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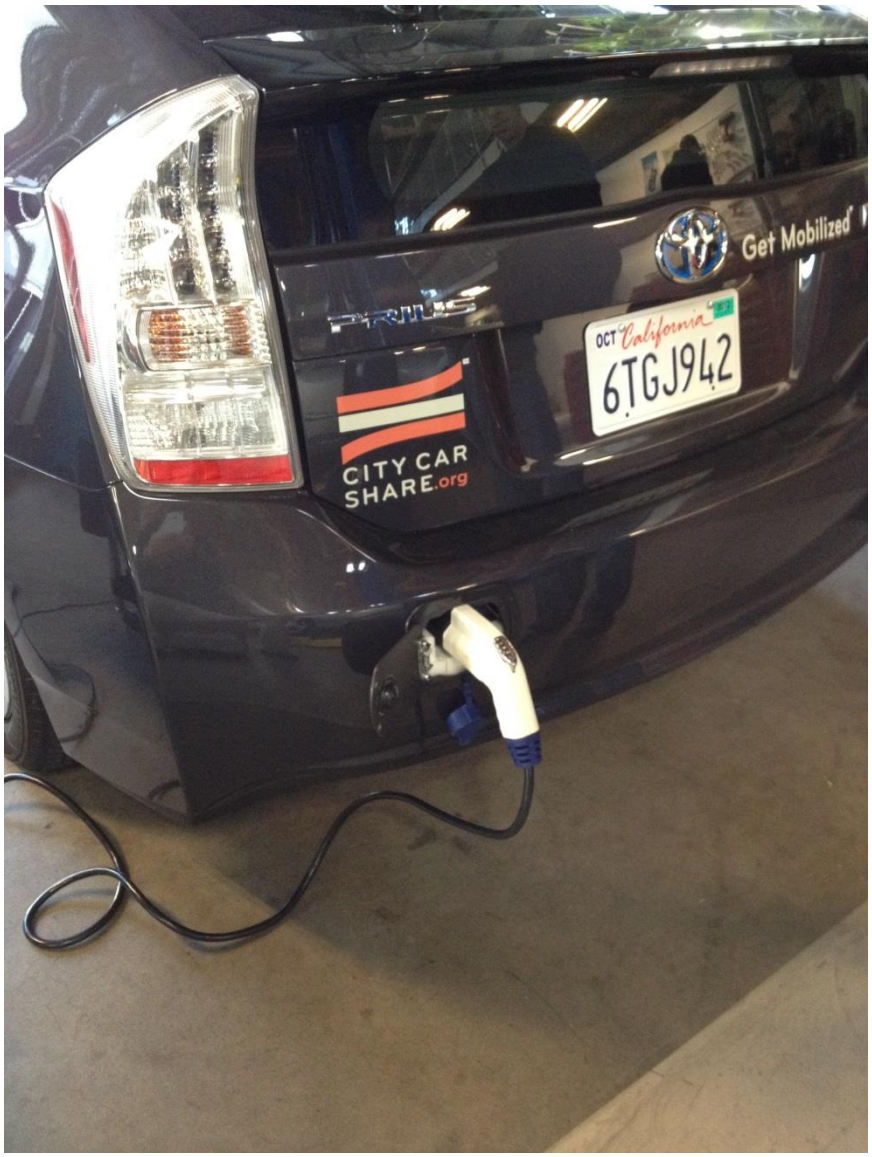

Close up of the J1772 (220 volt, 15amp) connector plugged into the Prius PHEV-40. The car will plug into any J1772 standard charging station. Note that the plug will be moved to the front in future cars to make it more user-friendly. The socket on the car is weather proof when closed.

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