

## Appendix 3

# IMPACT OF ELECTRIC VEHICLES ON SYSTEM LOAD

The prospect of new load from the widespread adoption of plug-in hybrid electric vehicles (PHEVs) within City Light's service area was examined in the 2008 and 2010 Integrated Resource Plans (IRPs). This was before any PHEVs or battery electric vehicles (BEVs) were in the market. The battery-powered Nissan Leaf and PHEV Chevy Volt<sup>1</sup> made by General Motors are now available and many other manufacturers are planning to sell PHEVs and BEVs. This section builds on the analysis done in previous IRPs and applies analysis from pilot projects and regional councils to the Seattle City Light service area.

## INTRODUCTION

There are several pilot programs for electric and plug-in hybrids throughout the nation. Seattle is participating in the EV Project, a pilot program funded with \$130 million from the U.S. Department of Energy and \$130 million from the partnership between Nissan and ECOality. The EV Project's goal is to deploy over 10,000 charging stations and 5,000 electric vehicles in eighteen regions in six states and Washington D.C.

Besides the Puget Sound area and Olympia, other Pacific Northwest participating cities are Portland, Corvallis, Salem, and Eugene, Oregon. The EV Project supports purchases of the battery-powered Nissan Leaf with a range of up to 100 miles on a fully charged battery and the PHEV Chevrolet Volt made by General Motors with a 40 mile range on one battery charge.

Most charging for early adopters is expected to occur in owners' homes at 220-VAC/40 amp circuits (Level 2 charging). Although the batteries can be charged at 110-VAC/15 amp circuits (Level 1 charging from an ordinary household outlet) with a much longer charging time. DC/fast-charging stations (440-VAC/85 amp circuits) are being installed in public places for some charging. The first DC/fast charging station in the Seattle City Light service territory was installed in the first half of 2012 at Vulcan Real Estate's South Lake Union Discovery Center parking lot. Level 2 charging takes about four hours for

the Leaf and nearly three hours for the Volt, whereas DC/Fast charging can be accomplished in less than half an hour<sup>2</sup>.

The Washington State Department of Transportation is collaborating on the West Coast Green Highway project to install electric vehicle chargers along interstate highways. This project will combat "range anxiety" among electric vehicle owners and provide fuel for out-of-town trips with electric vehicles. The Electric Highway gives electric vehicle drivers range confidence that recharging is available should they want to travel between communities or make long distance road trips. Knowing that charging is easy and convenient helps encourage residents and businesses to buy and drive plug-in electric vehicles.

The Department of Energy hosts a Clean Cities campaign to reduce petroleum use in transportation. The City of Seattle used Western Washington Clean Cities Coalition federal funding to install 46 Level 2 charging stations to serve its EV fleet and 20 publicly available charging stations in five city-owned or managed garages around Seattle. This program also assists fleets in making smart, environmentally responsible choices through a voluntary certification program called Evergreen Fleets. The City of Seattle has achieved a four star certification and currently has 44 Nissan Leafs in its fleet of motor vehicles.

## ASSUMPTIONS

In the 2008 IRP, load from plug-in hybrid electric vehicles in 2029 was forecasted to be 67 aMW. The 2010 IRP forecasted a basecase load of 107 aMW and an aggressive case consumption of 170 aMW. More information is now available to evaluate the assumptions used to make these forecasts.

The Northwest Power and Conservation Council (NWPPCC) recently updated their sixth power plan estimates on the impact of plug-in electric vehicles in the region. The update was needed to incorporate slower new vehicle sales during the Great Recession, people keeping their cars longer, and electric vehicle sales varying with the price of gasoline.

Electric vehicles are forecast to contribute 130-580 aMW per year by 2030 to the regional load. In 2007, Seattle City Light accounted for about six percent of the total load in the Northwest. If six percent of the forecasted electric vehicle load was in the Seattle City Light service territory, the 2030 load would be eight to 36 aMW.

Four cities in Oregon are participating in the EV Project, and Seattle City Light service territory hosted 17 percent of the monitored EV Project charging stations during the first quarter of 2012 in Washington and Oregon, consuming 15 percent of the measured charging station power in Washington and Oregon. The Seattle City Light load from plug-in electric

<sup>1</sup> There is some controversy about whether the Chevy Volt should be characterized as a hybrid or an electric vehicle. It does have a back-up gasoline engine, as well as a rechargeable battery. Since the IRP is concerned with the impact of rechargeable vehicle batteries on system load, the distinction is not relevant to this discussion. (GM Volt Not Always All-Electric: Gas Engine Sometimes Helps Drive the Wheels; Company Says It Kept the Detail Secret Due to Patent, Wall Street Journal, October 13, 2010.)

<sup>2</sup> Values are from Electric Vehicle Charging Infrastructure Deployment Guidelines for the Greater Seattle Area, Version 1.1, 2010, Electric Transportation Engineering Corporation.

vehicles would not be expected to exceed 20 percent of the total Northwest electric vehicle load, or 26 to 116 aMW in 2030. These estimates are generally lower than in the previous IRPs. BEVs and PHEVs were not yet available to consumers when the earlier estimates were made. Several other assumptions used to make the previous estimates can now be evaluated based upon more detailed studies than were available earlier.

**Vehicle Sales**

In 2011, plug-ins accounted for 0.03 percent of all new passenger vehicle sales. The electric vehicle penetration in 2011 was assumed to be more than one percent in the previous IRP forecasts. The NWPCC plug-in electric vehicle penetration rates are assumed to saturate at 10 to 40 percent of the new vehicle market by 2030. A larger percentage of new passenger vehicle sales were assumed to be plug-in electric vehicles in previous IRPs.

**Electricity Use Per Vehicle**

Previous IRPs assumed electric power consumption per vehicle of 2,477 kWh or 3,360 kWh increasing to 3,949 kWh. The actual values from the EV Project analysis of 135 electric vehicles in the Seattle City Light service area from January to March of 2012 project to 2,005 kWh annually per vehicle. This new information leads to a decrease in the load from electric vehicle chargers.

**Total Electricity Use**

In the first quarter of 2012, the EV Project monitored 135 home-charging packages and 47 publicly available chargers in the Seattle City Light service area. Almost 70 MWh of energy was used at the monitored charging stations in Seattle City Light service area during the first quarter; this is an average of about 0.03 MW for the three-month period. With this usage rate, more than 4,000 electric vehicles will be needed in the Seattle City Light service area to produce one average MW of electricity use during the year.

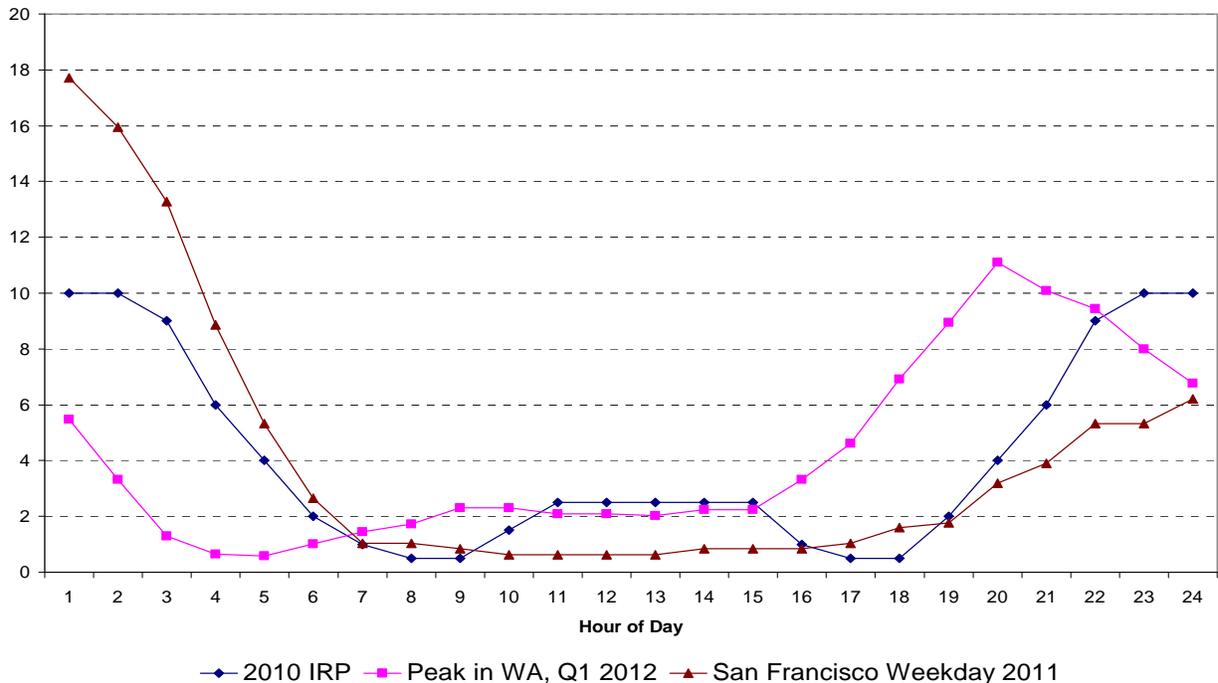
The NWPCC reported 1,239 registered Volts and Leafs in Washington at the end of 2011, and to date, the Department of Planning and Development has issued 480 permits for EV charging stations.

The EV Project will continue reporting usage statistics until the end of 2013, providing additional information about electric vehicle charging. City Light will continue to monitor the issues and update forecasts of the load from plug-in electric vehicles.

**CHARGING TIME OF USE**

The EV Project tracks the electricity use at the charging stations in 15-minute increments. The data are reported quarterly by the Idaho National Laboratory for each region of the project. In Figure 1 the profile of charging energy used in Washington State on the day with the peak 15-minute power value is shown.

**Figure 1: Charging Pattern**



In data from the first quarter of 2012, the charging demand gradually increases in the afternoon starting at about 4 p.m. The EV charging load is lightest between 4 a.m. and 8 a.m. The charging pattern used in the 2010 IRP base case scenario is also shown, along with the median charging pattern in San Francisco as measured by the EV Project in 2011. San Francisco has a time of use rate that makes the electricity cheaper after midnight. For the Washington State peak day, 70 percent of the energy use is in the peak load hours. In San Francisco, 75 percent of the energy use at charging stations is in the off-peak hours between 10 p.m. and 6 a.m. This data suggests that the time of use charges are very effective in moving the energy use to off-peak hours. The base and aggressive charging profiles used in the 2010 IRP were more balanced in the distribution between heavy load and light load hours than the charging patterns seen in the EV Project.

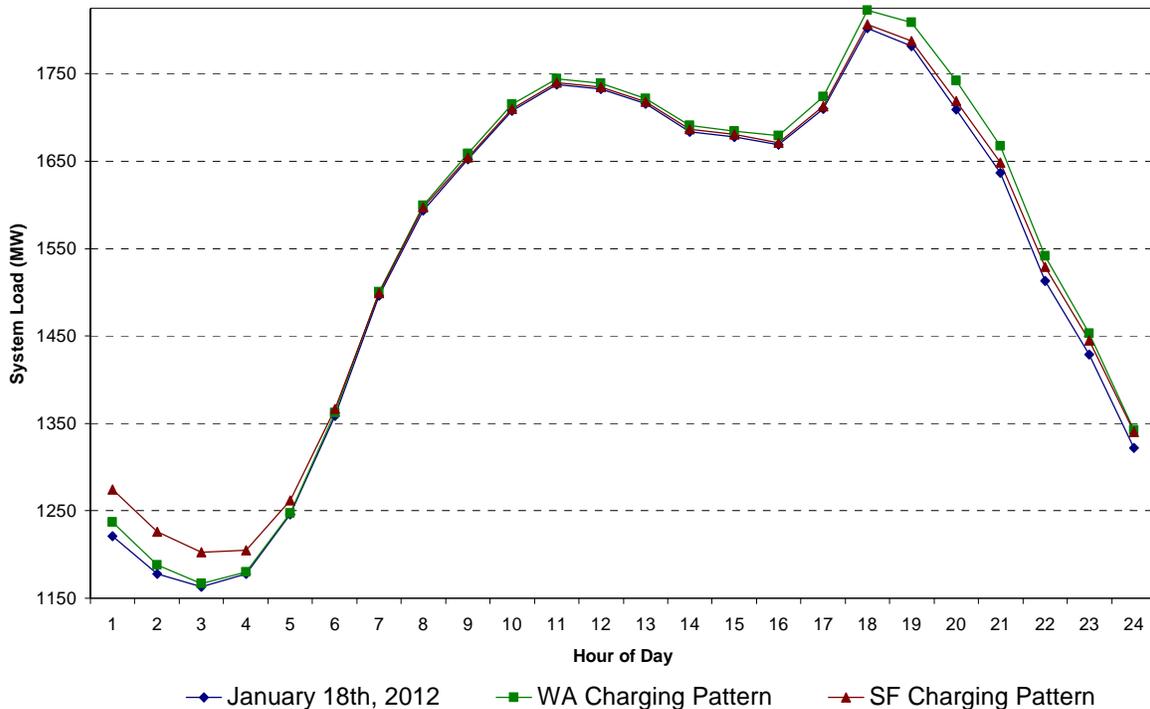
For residential charging stations, two thirds of the charging events had the vehicle connected for more than four hours and the vehicle was drawing power for three hours or less. The average length of time a vehicle was connected on a week day was 7.4 hours and it charged an average of 1.9 hours. The vehicles were usually connected for a longer period of time than they were charging, indicating that there may be flexibility to charge the car at a different time of day, during the same charging event.

Data from the EV Project can also be used to look at the peak electrical vehicle charging load relative to the average value. In the first quarter of 2012 in Washington State, the energy used on the peak day was one-and-a-half times as much energy as was used on an average day. The energy used in the peak hour was more than three times the energy used in an average charging hour.

Any effect that electric vehicle load will have on system peak will depend upon the charging pattern. System load typically peaks in the early evening on a cold day in the winter. Adding a hypothetical EV load of 400 megawatt-hours to load on a cold winter day (such as January 18, 2012, for example) demonstrates how peak will be affected.

Figure 2 shows EV load from the peak day in Washington State and a median day in San Francisco. In this example, the peak hour increases by five megawatts using the charging pattern in an area where it is cheaper to charge vehicles after midnight and by 21 megawatts in a pattern from the peak use day in Washington State. The load is increased 20 MW or more between midnight and 4 a.m. for the case where time of use rates apply.

**Figure 2: Effect of Charging Pattern on System Peak**



## DISCUSSION

*“The impact of the electric automobile is not expected to be a significant factor until about 1990. Its contribution to the system load will be nearly all off-peak, and is estimated to be about 5 percent of the residential average load previously predicted for 1990.”*

– City Light 1974 Load Forecast

Perhaps the electric vehicle load that City Light anticipated in 1974 is about to materialize. At this time, there are efforts on many fronts to remove obstacles to the widespread adoption of electric power for on-road transportation. Federal, state, and local governments are offering a variety of incentives to purchasers of such electric-powered vehicles. Many automakers are bringing new plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) to market. There are pilot programs being conducted around the U.S., several with the benefit of economic stimulus funds. Promotional material touts both the low cost of operating electric-powered vehicles and the reduction in greenhouse gas production.

The main obstacles to the commercialization of electric vehicles are cost, battery technology, lack of infrastructure, and lack of public knowledge. Automakers are working to perfect lithium-ion batteries and bring down their price.

Lithium-ion batteries pose a safety concern because of overheating, and their efficiency degrades over time. Public EV charging stations are being installed by public-private partnerships to curb the “range-anxiety” of EV owners. It seems probable that electric vehicles will at first find a niche market among affluent urbanites, especially those concerned about the environmental impacts of the combustion engine.

Besides the effect on the load, electric vehicle charging stations affect the distribution system. There is a small chance that a transformer will malfunction if it is servicing many electric vehicle charging stations and most stations start charging cars at the same time. A similar sort of overload is possible with other electrical appliances. It is possible that a transformer will not be able to cool down at night and will fail earlier in its lifetime if vehicles are charged all night long. Seattle City Light monitors transformer performance so repairs can be made to transformers quickly.

In parts of the country where utilities consistently have an excess of baseload generation (primarily coal and nuclear) that is cheap and available during the off-peak period, electrical vehicle charging during the off-peak hours would be a boon. Such utilities are motivated to impose incentive rates for battery recharging during the off-peak period. In the Pacific Northwest, though, utilities like City Light that depend largely on hydro generation very rarely have a need to dispose of excess generation during off-peak period because of their storage capability. City Light rates are based on cost-of-

service, but the difference between on-peak and off-peak rates may not be sufficient to induce electric vehicle charging during the off-peak period.

City Light’s Conservation division fielded the Residential Customer Characteristics Survey before 2010, asking customers if they owned a hybrid, a plug-in hybrid, or an electric vehicle. Less than one percent (0.6 percent) reported owning a PHEV or a BEV. Only 5.4 percent reported owning a hybrid, though these vehicles have been available for many years. City Light will continue to monitor the contribution to system load of electric vehicles as the market for them develops.

## SUMMARY

The conclusions of the 2010 IRP analysis still hold – load growth due to the adoption of electric vehicles will be manageable, so long as the utility continues to monitor the growth of this particular end-use, and costs of any new resources needed for serving this load can be reduced to the extent that charging occurs in the off-peak period.

In part due to the Great Recession, electric vehicle sales have not been as high as previously predicted, and the assumed future load is correspondingly reduced. The EV Project’s initial data shows that time of use rates are successfully used to shift the electric charging load to off-peak hours.

The information on electric vehicles is expanding along with the use of electric vehicles and future analysis of the impact of electric vehicle charging will be updated with more information from the EV Project, NWPCC and additional sources.