Appendix D

The 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 Integrated Resource Plan. At that time, automakers were making plans to bring both PHEVs and battery electric vehicles (BEVs) to market beginning late 2010. At least two automakers appear to be ready to make good on this promise. Nissan will begin selling the battery-powered Leaf in December of this year, and General Motors will have its Chevy Volt on the market at about the same time. For the 2010 IRP, data available for these two vehicles are used for the analysis of the impact of electric vehicles on system load.

Plug-In Hybrid Electric Vehicle Scenario in the 2008 IRP

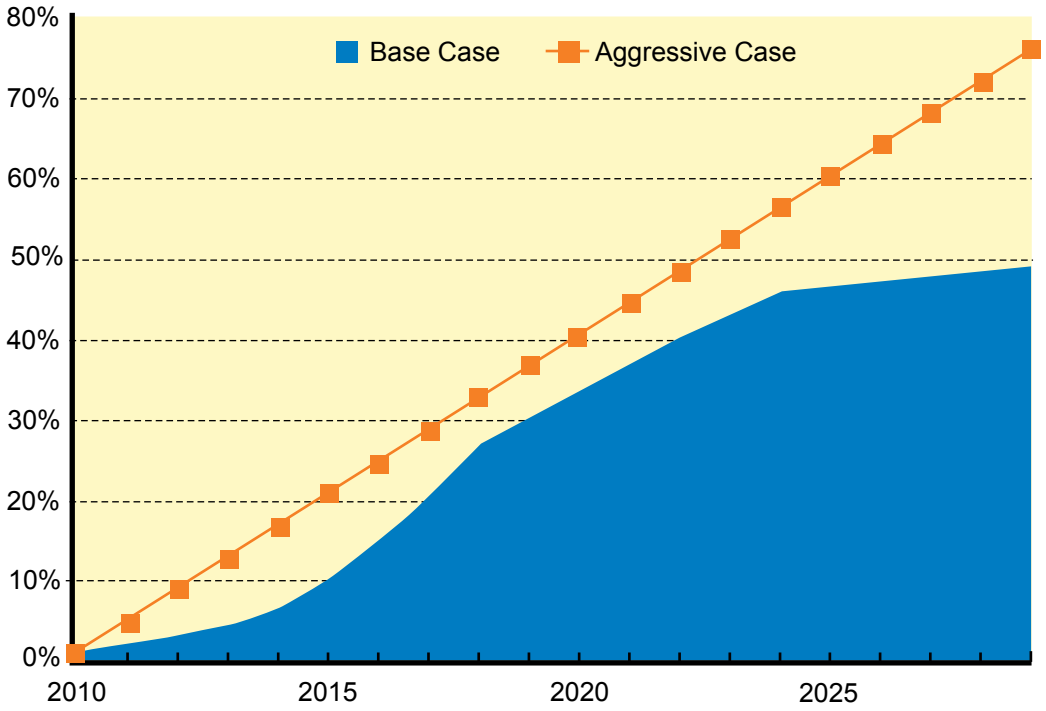
The impact of plug-in hybrid electric vehicles (PHEVs) on system load was examined in the 2008 Integrated Resource Plan. Assumptions from a July 2007 joint study by the Electric Power Research Institute (EPRI) and the Natural Resource Defense Council (NRDC) on PHEVs were used for the 2008 IRP's base case PHEV scenario. A second scenario with more aggressive assumptions was also evaluated.

The conclusions of the 2008 analysis were 1) that the impact of PHEVs on electricity demand is likely to be manageable for City Light, provided that the technology continues to be monitored and adequate resources are acquired ahead of time, and 2) that the amount and cost of new power resource requirements to serve this new load could be reduced if measures to encourage charging during off-peak hours were successful.

Assumptions common to both the base and the aggressive PHEV scenarios in 2008 were:

1. Commercial availability by 2010
2. PHEVs with a 40-mile range per charge (the highest range anticipated by EPRI in 2007)
3. Rate of new vehicle registrations per Washington household average of 10.6%
4. Replacement rate for PHEVs of 100%

Figure 1. Share of New Vehicle Sales



For the base case, EPRI/NRDC's rate of market penetration (49% by 2029) was used, as was their assumption of about 60% of charging occurring during off-peak hours. For the aggressive case, the rate of market penetration (76% by 2029) was much faster than the EPRI/NRDC assumption, and some battery charging was shifted from off-peak hours to the peak period, especially to the early evening hours when City Light experiences its peak load on the coldest days.

2010 IRP Electric Vehicle Scenario

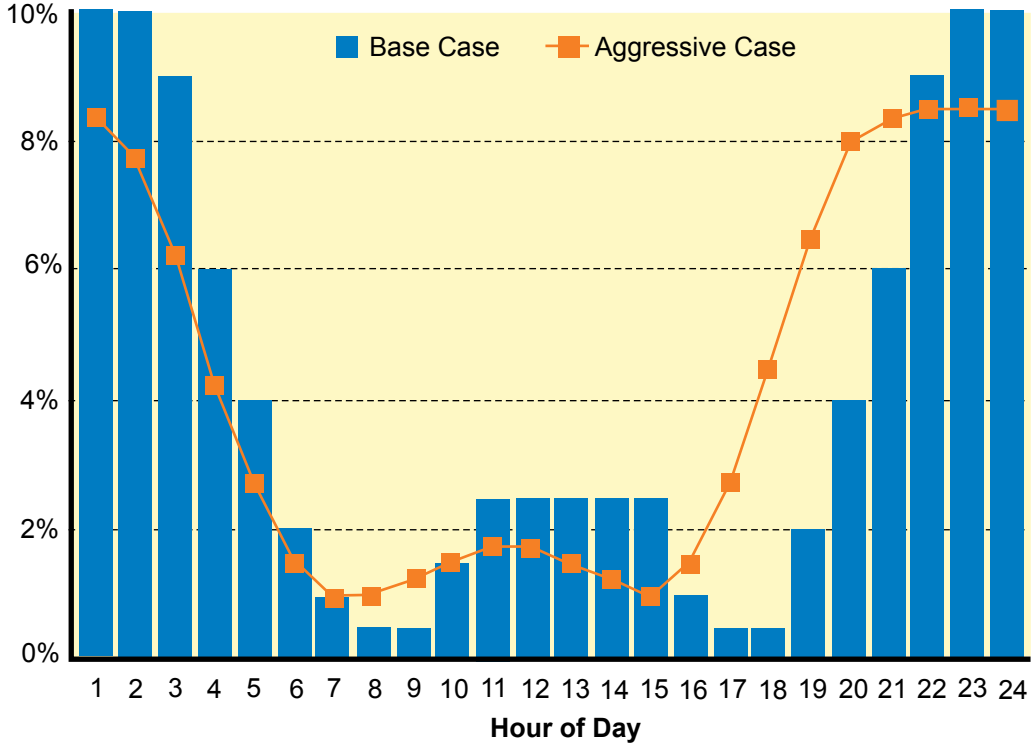
Assumptions

For the 2010 IRP analysis, instead of a generic 40-mile range plug-in hybrid electric vehicle, data for a mix of the Nissan Leaf (a BEV with a 24-kWH battery and a 100-mile range) and the Chevy Volt[1] (a PHEV with a 16-kWh battery, back-up gasoline engine, and a 40-mile range) were used. The Leaf is assumed to dominate in City Light's service area at first because it is being promoted through a Department of Energy pilot project with a commitment to installing a charging infrastructure. The initial mix in City Light's service area is 75% Leafs and 25% Volts; by 2029, the mix is 50% of each.

Most charging 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. The Level 3 charging stations (440-VAC/85 amp circuits) are being installed in public places will be used for some charging. Because of its shorter range, the Volt seems more likely to need to be charged away from home (10% of charges) at a Level 3 charging station, while the assumption for the Leaf is fewer charges away from home (5% of charges). Level 2 charging takes about four hours for the Leaf and nearly three hours for the Volt, whereas Level 3 charging can be accomplished in less than half an hour.[2]

Assumptions about rates of market penetration are the same as in the 2008 analysis, as are the consumption patterns over a 24-hour period. For the base case, market penetration reaches 49% by 2029, and 39% of charging occurs during peak hours, 6:00 am to 10:00 pm. For the aggressive case, market penetration reaches 76% by 2029, and 49% of charging occurs during the peak period.

Figure 2. Charging Pattern



Results

The EPRI/NRDC average electric power consumption per vehicle (a PHEV with a 40-mile range) used in the 2008 analysis was 2,477 kWh annually, somewhat lower than the estimates for the Leaf and the Volt. The average consumption per vehicle in the 2010 analysis is 3,360 kWh in the first year, and 3,949 kWh by the end of the 20-year planning period when the mix of vehicle types reaches 50:50. This change in average consumption per vehicle results in a contribution to annual system load of about 107 aMW, or about 40 aMW over the 67 aMW calculated for 2029 in the 2008 base case.

As in the 2008 analysis, the share of new vehicle sales (market penetration) by 2029 was assumed to be 49% for the base case (EPRI/NRDC), and 76% for the aggressive case. Given the assumption about the mix of Leaf- and Volt-like electric vehicles over the planning period, annual consumption in 2029 is 107 aMW in the base case and 170 aMW for the aggressive case, as shown on the accompanying graph and table.

Figure 3. Scenario Comparison

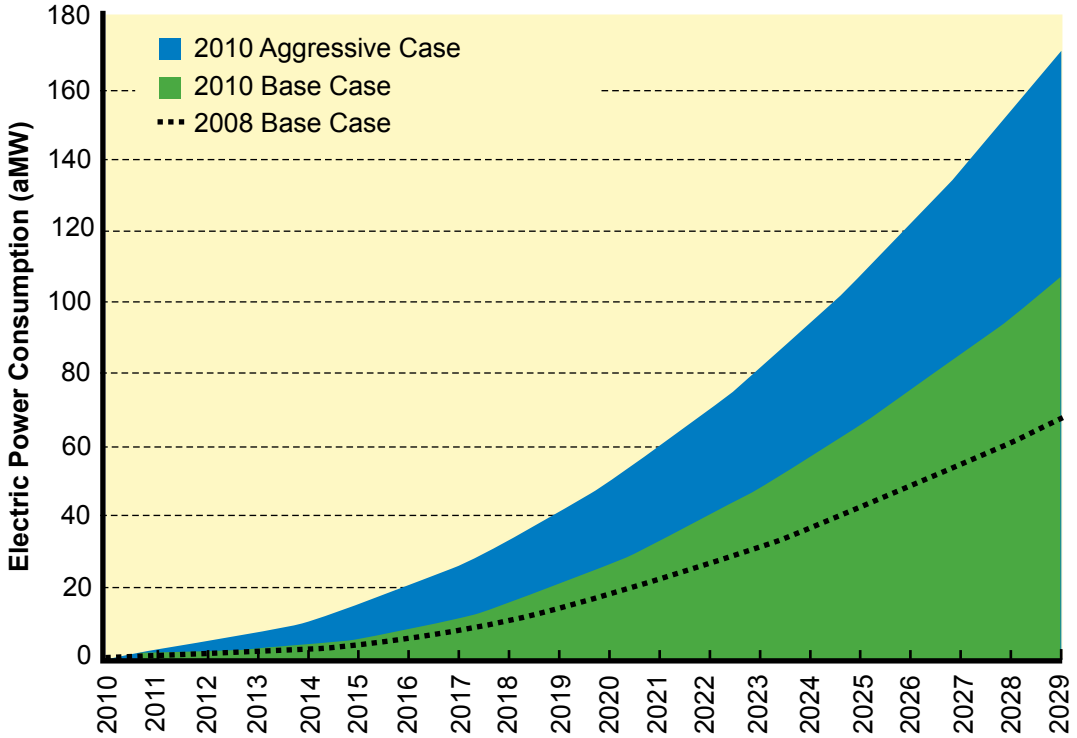


Figure 4. Scenario Comparison

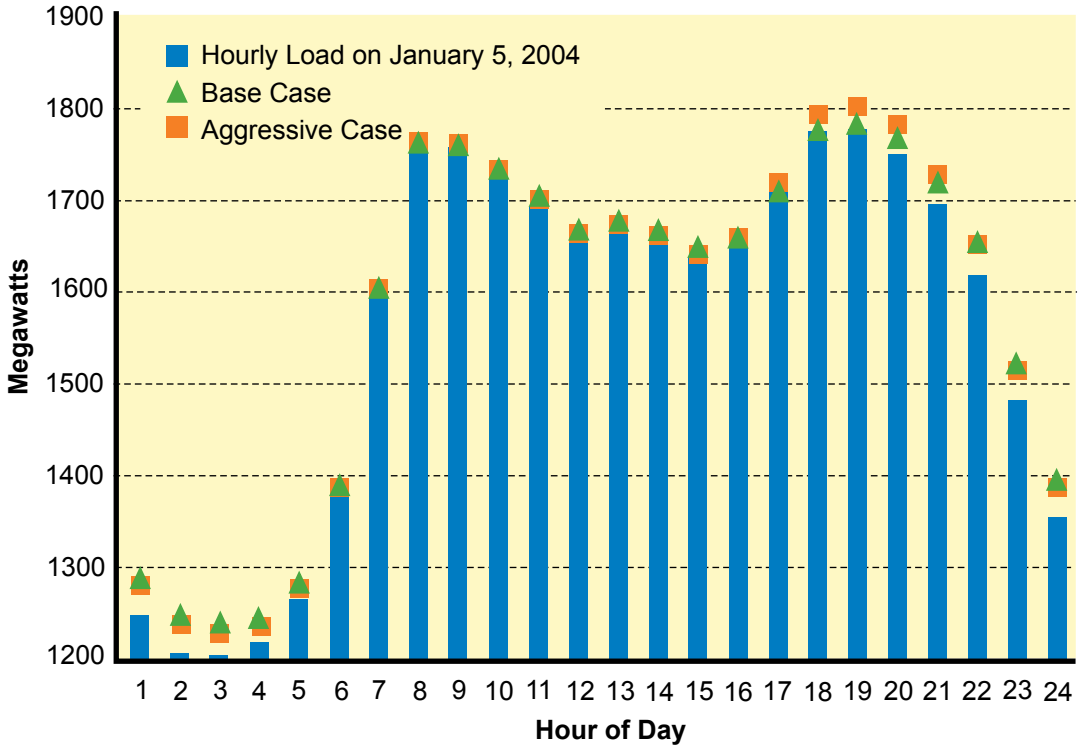
	Base	Aggressive
Market Penetration	49% by 2029	76% by 2029
Annual Battery Charging per EV by 2029	3,949 kWh	4,745 kWh
Percent of Charging On-Peak	39%	49%
On-Peak 2029 Consumption	42 aMW	83 aMW
Annual 2029 Consumption	107 aMW	170 aMW

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 EV load of, say, 400 megawatt-hours to load on a cold winter day (such as January 5, 2004, for example) demonstrates how peak will be affected. The accompanying graph shows EV load with the base case charging pattern and the aggressive case pattern. In this example, the peak hour increases by 8 megawatts in the base case and by 26 megawatts in the aggressive case.

Conclusions

Even with new consumption assumptions based on actual vehicles that are finally coming to market, the 2010 base case is still well below the aggressive case. The conclusions of the 2008 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.

Figure 5. 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 as early as the end of this year. There are pilot programs being conducted around the U.S., several with the benefit of Economic Stimulus funds. There are also programs to support electric transportation in other countries. 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, and lack of infrastructure. Early models are likely to be priced to sell. 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. Lack of infrastructure for charging batteries contributes to "range anxiety," adversely affecting sales. 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.

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 vehicle charging during the off-peak period.

City Light's Conservation division recently fielded the Residential Customer Characteristics Survey, asking customers if they owned a hybrid, a plug-in hybrid, or an electric vehicle. Less than one percent (0.6%) reported owning a PHEV or a BEV. Only 5.4% reported owning a hybrid, though these vehicles have been available for many years. City Light customers who are participating in the DOE Leaf project should start driving them before the end of this year. City Light will continue to monitor the contribution to system load of electric vehicles as the market for them develops.

[1] There is some controversy about whether the 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 we are concerned here with the impact of rechargeable vehicle batteries on system load, the distinction is a matter of indifference. See 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.

[2] These values are from Electric Vehicle Charging Infrastructure Deployment Guidelines for the Greater Seattle Area, Version 1.1, 2010, produced by the Electric Transportation Engineering Corporation.