

Electric Vehicle Charging at Work

By Bob Bruninga, PE

American driving habits are based on a century of fossil fuel powered vehicles and gas tanks, which has created a significant misunderstanding of the electric vehicle (EV). The gas-tank, run-until-empty scenario and then fill-to-full at a public gas station is not how EVs are used. As shown in figure 1, a commuter EV will be plugged in at home and at work to maintain a full charge at the start of each trip in the morning and afternoon. Rarely will it be run to empty such that a search for a higher cost public charge will be desired.

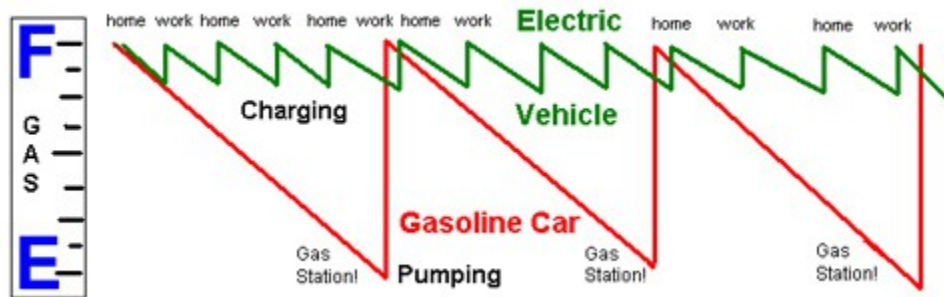


Figure 1. A battery is not a gas tank. Source: "Overlooking L1 Charging-at-work in the Rush for Public Charging Speed" in the proceedings of the 2012 IEEE International Electric Vehicle, Conference 4-8 March 2012 Greenville, SC

All EVs are designed to be charged overnight from a standard 115v outlet (level-1) which can give at least 32 miles of range in eight hours. The overnight charge plus another eight-hour, 115v charge at work, can give the EV driver a daily range up to 64 miles (independent of the size of the battery). This is far above the national average 40 mile commute and satisfies 90 percent of USA commute distances.

The EV is not intended to replace all gasoline vehicle usage, but is ideal for the commuter that can plugin at home and plugin at work. The commuter car spends at least 16 hours a day just sitting at home and at work as shown in figure 2. During these times, low-cost, low-speed L1 charging from 115v outlets is ideal.

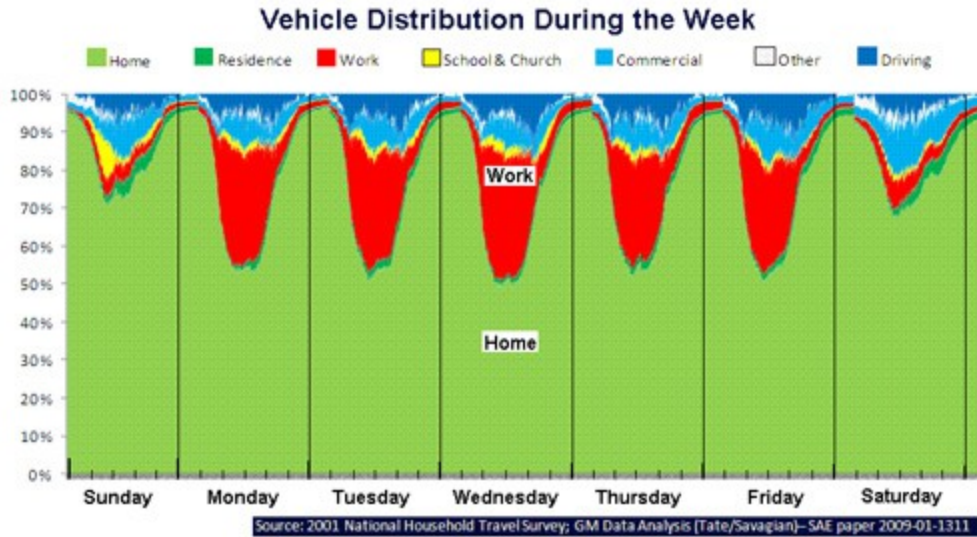


Figure 2. The average vehicle spends 90 percent of its time either at home or at work[1].

EV Charging: The General Motors model for charging an EV is shown in Figure 3. GM assumes the majority of all charging will be at home[2]. Next will be routine charging at work and only the tip of the charging pyramid will be at public charging facilities. To this pyramid we have added the probable electricity costs at each location. Public charging at three times higher electric rates than at home, is like looking for \$10 gas; a tactic usually avoided by most drivers.

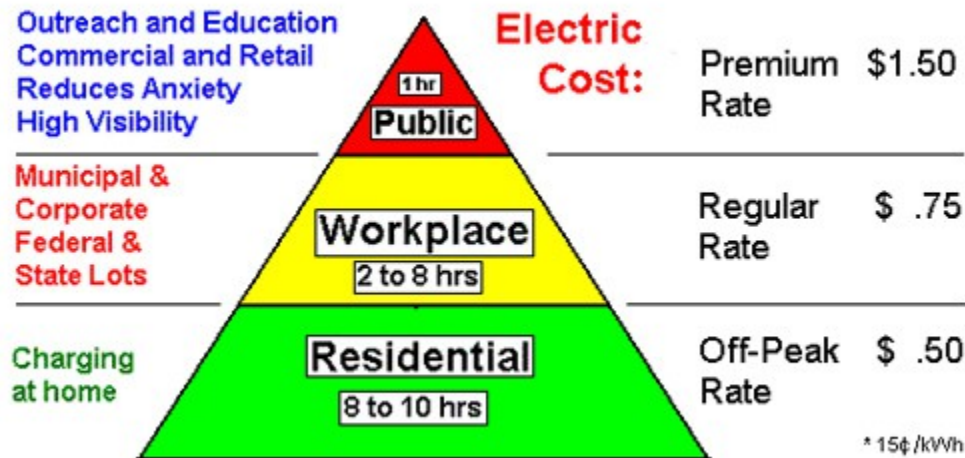


Figure 3. The three layer GM charging pyramid and added notes on electricity costs[2].

Commuter Distances: For the full implications of the charge-at-work scenario, the US Department of Transportation (DOT) statistics [3] for one-way distance to work are shown in figure 4. These data show about 90 percent of all U.S. commutes are 32 miles or less. The narrower green bars show the low cost per day, and the resulting total cost per month for each distance at the bottom in red.

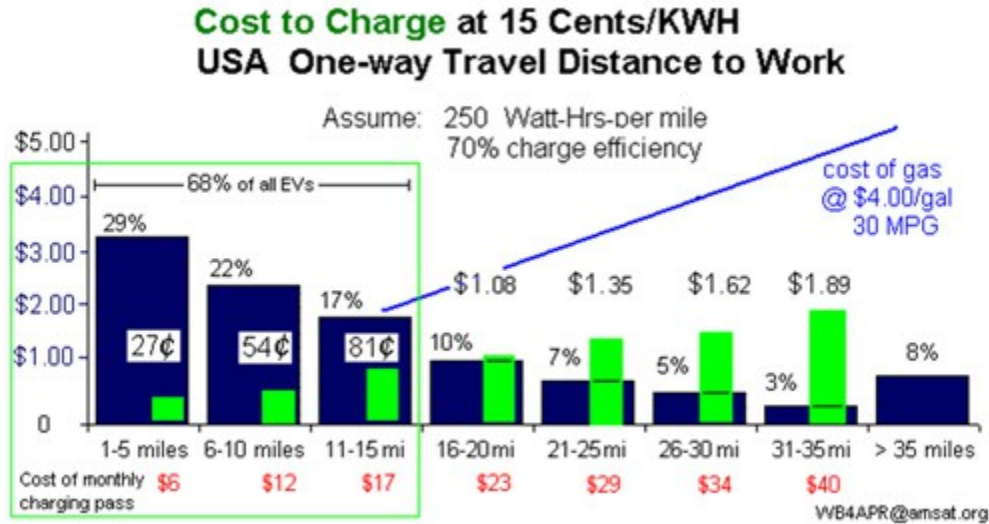


Figure 4. DOT one-way commute distances overlaid with daily and monthly electricity cost data.

Level-2 Charging: Figure 5 uses the same data to show how placement of Level-2 chargers at-work or other eight-hour daily parking lots wastes more than 80 percent of the available charging capacity. The red bars show the hours to charge (L2) for each of the commute distances. In almost 70 percent of the cases, the EV is fully charged in under an hour, leaving the L2 charger unavailable to anyone else during the remaining seven or more hours of the day. Even 90 percent of all commuters are fully charged in under two hours.

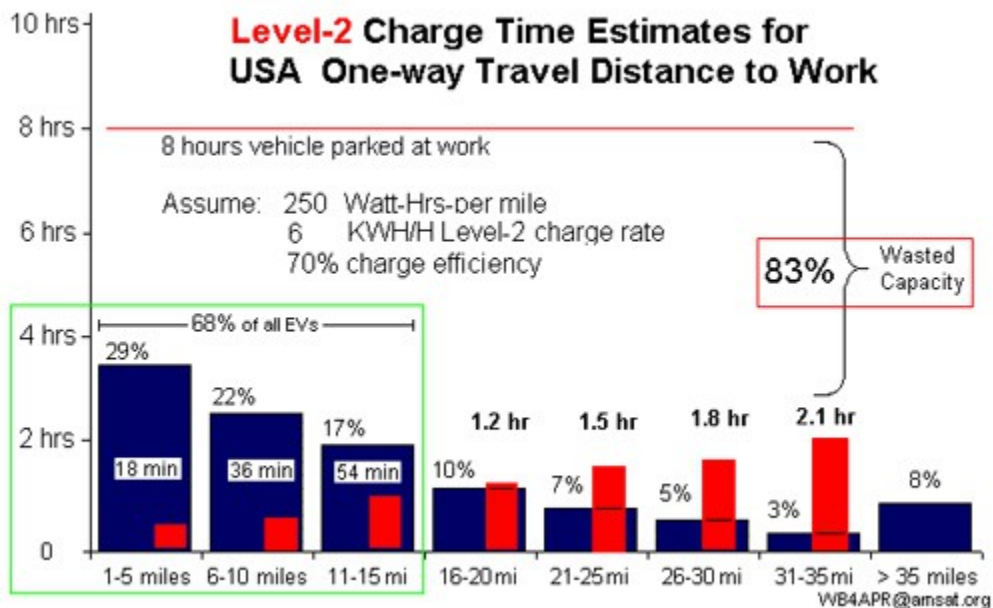


Figure 5. DOT commutes with L2 charge hours showing wasted capacity.

L1 Charging (115v outlets): In contrast, 115v outlets at work can fully charge 90 percent of all commuters in eight hours or less (L1). This data is quite reliable since vehicles leave home in the morning after an overnight full charge and usually go straight to work, leaving errands and

activities for the afternoon/evening. Thus, commuter EVs arrive at work with a charge-need well correlated with their individual distance to work. After being plugged in all day (L1), then, they leave work fully charged as well.

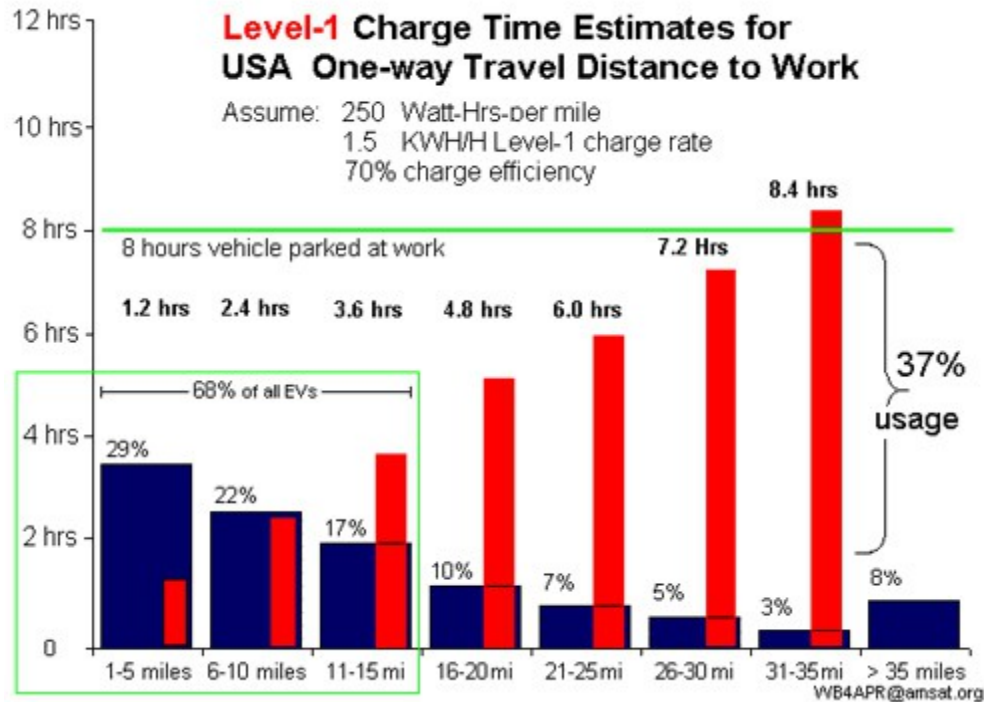


Figure 6. DoT commuting distance with charge hours using 115v outlets (Level-1 charging).

Charging Distance versus Charging Time: Range anxiety and public charging fears are further perpetuated or misdirected by the common presentation metric of *hours-to-full-charge-from-empty* as shown in the left hand table of figure 7. Instead, this same data can be presented as *miles-per-8-hour-charge* for at-home and at-work charging as shown on the right. Compared to the typical 10-15 mile commute for 50 percent to 70 percent of all EV owners, the eight-hour overnight and at-work charge is completely adequate up to 64 miles a day for all EV car models independent of their overall battery capacity. What counts is only the length of the commute:

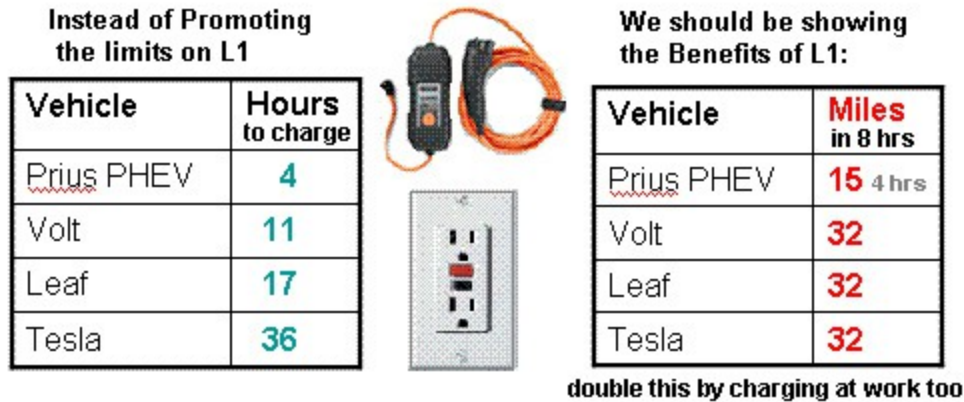


Figure 7. Presenting miles-per-8hr-charge instead of hrs-to-full-charge is less alarming to commuters.

Pay-in-to-Plug-in: For 50 cents to \$1 a day for charging-at-work, there is little need for complex metering and payment systems. Employers can simply collect a monthly charging fee of \$10 to \$20 a month and issue a “charging pass” for EV employees to plug in to available outlets, as shown in figure 8. This informal system can be managed by the employer as easily as they currently manage parking passes and monitor handicapped spaces in their employee lots or garages [4].

Figure 8. (depicted at right) A monthly employer charging pass costing the same as the electricity used is an easy way to implement charging at work using existing or future 115v (L1) outlets.



Recommendations:

An EV is generally not a one-for-one replacement for a wide ranging-general purpose gas car but is optimum for the commuter with a place to plug it in at work. Every EV comes with a standard 115v charging cord. The public focus on *fast public charging* (L2) is off-target based on the century old gas-tank legacy. The EV is more of a commuting appliance, to be plugged in at home and at work, than the legacy *go-fill-up-fast-at-a-public-charging-station* experience of the American public. We should:

- Not oversell EVs as gas car replacements across the board and where inappropriate
- Recognize that charge-at-home and charge-at-work covers 90 percent of all USA commutes
- Encourage Employer charging-at-work to double the EV commuter’s range
- Encourage informal monthly pay-in-to-plug-in programs for the ~ \$1/day cost of electricity
- Educate the public of the advantages of L1 charging at home and at work
- Encourage L1 charging to avoid peak loads and neighborhood utility clustering problems
- Encourage L1 charging from standard outlets to avoid expensive electrical work
- Place L2 fast chargers at shorter-duration spaces for easy access to more cars per day
- Discourage L2 chargers in long-term/daily lots where 1-hr charged cars block usage

- Recognize that utility load leveling can be easily accomplished in bulk employer lots
- Avoid magnifying L2 issues/concerns/problems where L1 solutions also exist

The 200 million EV goal in 30 years will not be met with the single-minded focus on public L2 charging. The EV is a very significant part of the solution to our future energy, environmental and national security problems. We must not let misinformation, and public confusion based on a century of quick-fill-up-gas-tank legacy undermine or slow this radical new technology. As the commuter learns the benefits of EVs and charging at-work, the expensive quick public EV charger will eventually be as little used as the spare-gas-can-in-the-trunk is used by gasoline drivers.

[1] 2001 National Household Travel Survey; GM Data Analysis (Tate/Savagian)-SAE paper 2009-01-1311

[2] Presentation by Dr. Mary Beth Stanek, Director, Environment and Energy Policy and Commercialization, General Motors Company, Washington DC EV Forum, 12 Dec 2011

[3] US DoT, Bureau of Transportation Statistics, Omnibus Household Survey. Research and Innovative Technology Administration.

[4] <http://aprs.org/payin-to-plugin.html>



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- See more at: <http://www.todaysengineer.org/2012/feb/ev-charging.asp#sthash.HUcysBZ1.dpuf>