## No Plug, No Rug

If we all had flying carpets for personal transportation then we might have a magic crisis, not an energy crisis. Before getting a flying carpet, we would still want to be assured that it would fly 150 Km a day without having to perform more magic to keep it going. Not that we often go that far, but given a national average of 50 Km a day, we go further about half the time and need to be assured we won't run out of magic. At least five independent marketing studies have confirmed the magic number of 150 Km a day is what an EV needs in range before the public will buy them. This probably reflects range fear, but also the occasional need to actually drive for 5 hours in traffic. A taxi or courier drives an average of 200 Km in an eight hour shift.

Well, just how much magic, or electricity do we need to go 150 Km? Speaking in rough terms, about 30 K Watt Hrs would mostly do for the average magic carpet ride. This is based on the experience of EV conversion hobbyists and a comparison to an average ICE car that gets about 10 liters / 100 Km. What is relatively invariant is the efficiency of the average car over the past 100 years. At least 200 W Hrs / Km is what it takes to move the compact family sedan. So where do we get that much magic quickly?

If we plug into the 'typical' electrical outlet so widely available in North America, we can only get about 1K Watt of magic energy. That means it would take about 30 hours to restore all the magic in our carpet. People need to re-charge daily: overnight will suffice as it does for cell phones. Obviously the 'typical' electrical outlet just won't do, and even these are not commonly available in parking stalls. Have you looked for a plug in an underground condo parking lot lately? In cold areas, Canada has a few plugs to supply automotive block heaters, but these are usually cycled on and off 50% of the time and so only deliver 500 Watts on average. This is enough for block heaters and cell phone charging, but not for an EV. No Plug, No Rug.

No matter how you configure this it would take more than the typical 15 Amp branch circuit outlet with 14 gauge wires which at 80% loading yields a nominal 1 KW after losses to be pulled to all parking stalls. The status quo won't do for anything more than a Low Speed Vehicle with a 40 Km range. Practically, even a PHEV-65 needs more.

Technically, what is needed is a minimum 2K Watt source in every parking stall for the average user. This yields 10 Km of driving for every hour of charging a compact sedan, or more for a larger heavier vehicle. Although the average driving distance is 50 Km / day, this only covers half the driving needs. At this rate, a 100 Km charge would take 10 hours and serve the vast majority. The occasional 150 Km drive would take 15 hours of charging leaving just nine hours a day for driving away from home.

To deliver a 2K Watt charge it takes 2+G @ 12 gauge wires on a dedicated circuit. This will provide the magic 2K Watt source continuously for EV charging. Two K Watt is the sweet spot: just enough at minimal cost. Conveniently, the 2009 Canadian Electric Code calls for a 5-20R( T-Slot) receptacle which also accommodates the 15 Amp appliance plugs now predominant.

Once the copper is pulled, it can be reconfigured in the future for faster convenience charging. This would use 220V at 20 Amps for a 4K Watt fast charge with any appropriate code approved switched plug. For those driving long highway distances or in

a hummer hurry, higher amperages and even faster charge rates would need heavier, costlier wire, but this is also allowed for. Overnight charging is adequate to address the vast majority of the basic need. However, convenience charging at public parking locations, destination parking lots, visitor parking, etc, could relieve range anxiety by providing some faster convenience charging. Faster charging is also harder on most battery technologies, reducing their life. Daytime charging increases peak loads which is why residential all night charging at off peak times is the preferred strategy.

This configuration allows for future changes. Secured or controlled access can be added at the charge point. Metering could also be added at the charge point. Payment or billing can be addressed in a variety of ways. Smart metering and vehicle to grid peak demand management technology are enabled. Market forces will sort out these issues. But, you can't do any of these future upgrades if the copper wire isn't pulled first. And you can't fly your carpet without the magic plug.

The telecommunications industry refers to this issue as the 'last mile' of copper. For EVs our last mile is really only from the house to the garage, or condo to the parking lot, but we still lack the copper. Unless we are induced with some magic, to bridge our last mile and beam the energy to our EVs, as cell phones do for telecommunications, we still need to pull that last few meters of copper wire.

We can pull the copper by changing the building codes at your local municipal, provincial or even national level, to require that plugs for electric vehicle charging be provided to all residential parking stalls. This is now supported by updates to the 2009 Canadian Electrical Code, which explains how this must be achieved.

A suggested building code example amendment is:

A. To amend Article 3.3.5.4. by adding Sentence (8) to read as follows:
*(8) "Each parking space or stall in a storage garage serving residential occupancies referred to in Subsection 3.3.4. shall be provided with means to accommodate electric vehicle charging systems in conformance with Sentence 9.34.1.6."*

B. To amend Article 9.34.1. by adding Sentence (6) to read as follows:
*9.34.1.6 Electric vehicle charging systems (See Appendix A) "A 5-20R receptacle(s) on a dedicated circuit shall be provided in every parking space or a parking stall of a storage garage or carport for use with the electric vehicle charging system"*

C. To add Appendix A Note on Sentence 9.34.1.6. to read as follows:
*"The intent of this requirement is to recognize a need for appropriate electrical infrastructure in parking spaces, of residential occupancies necessary to accommodate use of electrical vehicles. Specific requirements for installation of electric vehicle charging systems are located in Section 86 of the Canadian Electrical Code adopted for use in BC (BC Electrical Safety Regulation).*

The USA National Electric Code (NEC) does not require a dedicated circuit, nor does it specify the receptacle for Level 1 charging: this building code update example does so to ensure an adequate 2 K Watt charge rate and also specifies a standard plug. A change to the NEC to require these would be appropriate, then the building code could more traditionally specify that a receptacle be provided, leaving the implementation details to the NEC.

To make these changes in Vancouver, we worked closely with city staff responsible for

environmental issues without raising concerns to senior levels or other departments, yet staying within the working mandate of this department. Once the recommendation was prepared, it was slipped into a green building by-law initiative as a minor addition where it was approved unchallenged. Our experience is that most changes occur bottom up and top level elected politicians accept well developed recommendations that fit within broader policy. Highlighting a focus on EV charging when EVs are not yet prevalent invites criticism and challenges. Building a good working relationship with municipal staff was key to the success. Vancouver is leading by example and is now installing copper for EV charging in new residential parking spaces in the city at the rate of new construction or about 20,000 plugs per year. It is continuing to consider public charge points and renovation upgrades as well.

It is in the interest of EV enthusiasts, the EV components industry, developers and municipality planners to do this. Buildings last at least 50 years on average, cars only 16. Unless we start pulling copper now, emerging EVs will be killed off again for lack of electrical infrastructure, just like in the 1920s. History does have a way of repeating itself.

We need to start pulling copper immediately to build the infrastructure so EVs will come. We encourage other EV enthusiasts to follow this successful dream of magic carpets and start pulling the copper for EV charging. "Build it and they will come."
No plug, no rug.

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