This is a Plug: TAC'S Electric Vehicle Sign Package

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Abstract

Due to the proMoTIion of sustainable transportation by various government agencies and the private sector, many electric vehicle (EV) signage initiatives were taken in the last few years. One unintended consequence of these good intentions is the design of traffic control devices aimed at EV drivers, but executed without proper consideration to the best practices that govern the field of traffic engineering. As an example, green surfaces, actually reserved for cycling facilities, are frequently used for EV reserved parking.

It was in this context that the Transportation Association of Canada's (TAC) Traffic Operations and Management Standing Committee (TOMSC) undertook the development of traffic control devices aimed at EV drivers. Prior to that, the TAC document *Handbook of Recommended Information Sign Symbols for Canada* (January 2008) already had a provision for an EV charging station directional sign, but that was an early effort from TOMSC at a time when no major manufacturer even offered an EV for sale in Canada. The design was basically that of the standard gas pump directional sign, but with the letters "EVC" added (for Electric Vehicle Charging). That sign saw little application as the EV community took offense to the fossil fuel analogy. With the new reality of electric mobility front and center, TOMSC set its sights on designing an Electric Vehicle Charging Sign that meets standards as well as the ever changing technological context in which it will be used. To that end, supplementary tab sign options were also developed to stay current with charging technology.

Parking regulations at charging facilities must also facilitate rotation and partial charging to offer renewed mobility to EV drivers, and not just privileged parking. Depending on services offered at the facility and the technical aspects of the plug-in vehicle, a full charge can take as little as 30 minutes or as much as 24 hours. Having the option to regulate maximum charging time is thus desirable from an operations standpoint. With this objective in mind, TOMSC also developed an EV Parking Sign to make sure charging facilities are effectively used to charge up EVs, and not just provide a parking place for electric vehicles.

This paper and presentation will present in detail TAC's Electric Vehicle Sign Package, while demonstrating to delegates the process that leads to the inclusion of a traffic control device in the Manual of Uniform Traffic Control Devices for Canada (MUTCDC).

Introduction

This paper is a summary of three TOMSC volunteer projects whose basic scope (the design of new signs), while simple in itself, brought added levels of complexity due to the passionate nature of the topic it carries: the electrification of transportation.

The final deliverables are signs that will lead drivers to charging stations for electric vehicles. Such signs will be included in the MUTCDC for reference and use by Canadian road authorities. However, many prior initiatives were taken in the larger realm of electric vehicles by various agencies. One unintended consequence of these good intentions is the design of signage and road markings directed at users of electric vehicles, but without proper regard to the standards and best practices that govern the field of traffic control device design and engineering, such as the "*Electric Circuit*" program launched by Quebec's Ministry of natural resources (MRN) and Hydro Quebec. Because of the sustainable aspect of electric vehicles, the color green is not only featured in all project documentation, but it is also applied to the signage and road markings the agency has developed. In Canada, traffic professionals know that the color green when applied to road markings is reserved for cycling facilities, while guide and information signs are currently moving from brown to blue.

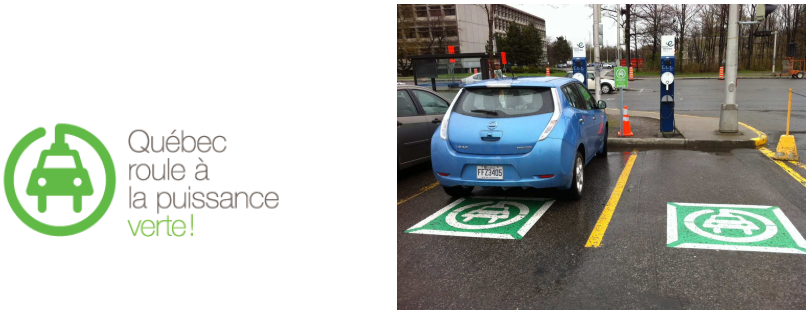


Figure 1: MRN logo and devices used in Quebec (source: MRN)

Serving a need

Because of the relatively short range they offer, EVs are very dependant on the availability of charging stations for their overall mobility. The TAC document *Handbook of Recommended Information Sign Symbols for Canada* (January 2008) already had a provision for an electric vehicle charging station directional sign (Figure 2), an early effort made at a time when no major manufacturer even offered EVs for sale in Canada. The design is basically that of the standard gas pump directional sign, but with the letters "EVC" added (for Electric Vehicle Charging).

Prior to its recent sign update, the Federal Highway Administration (FHWA) also had an EV charging sign based on their fuel pump pictogram, with optional tab, as seen in Figure 3. TAC was contacted in late 2009 by Electric Mobility Canada (EMC), a non-profit special-interest group "*dedicated to advancing electric transportation solutions*" that designed its own signs and offered them for consideration by TOMSC.

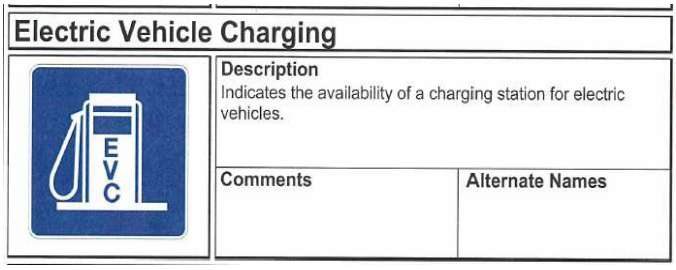


Figure 2: Existing TAC EV charging sign

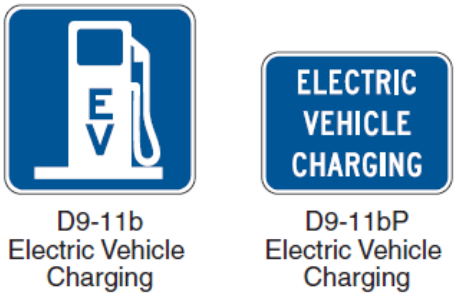


Figure 3: Old version of FHWA EV Charging sign and tab sign (source: FHWA)

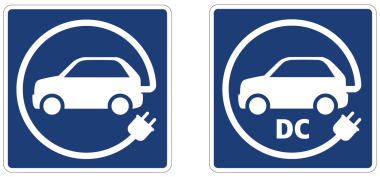


Figure 4: Sign proposals supplied by EMC

During the fall 2011 TOMSC meeting, a vote was held that led to the creation a volunteer project around the need for an improved EV charging sign. It was recommended that developed signs should be based on pictograms to make them easily understandable by all people, regardless of the language they speak.

1- The Electric Vehicle Charging Sign (TOMSC Project 319)

As is often the case when deploying new technology, plug standards and electric vehicles themselves have seen a rapid pace of evolution in the last decade. The standard for the charging stations being deployed right now across Canada has only been in place since vehicular model year 2010 (SAE J1772). EVs currently on the market are not all equals when it comes to recharging. While most use the standard SAE J1772 connector, not all of them are able to use the higher-voltage "quick charge" stations due to the limits of on-board components. Just like "regular", "premium" and "diesel", we may need more than one "fuel" at these charging facilities and depending on service availability this will affect what's to be shown on the signs. We must avoid sending the driver of a battery-depleted EV to a facility he can't use. Having established that there is a need to indicate the type of charging available at a given facility, three design elements must be part of the proposed Electric Vehicle Charging Sign: a clear,

word-less pictogram meaning "charging station", the levels, voltages, "quickness" or type of recharge available and some standard directional indications (arrows and / or distance).

The Project Steering Committee (PSC)'s proposal to achieve this is to use a main sign for the charging station component, and then to use tabs for the recharge type and directional elements. This approach will also prolong the lifespan of the main sign, adapting only the tabs to the technology aspect of the message, service changes or new deployments.

Design philosophy of the Electric Vehicle Charging Station main sign

Before the project process and comprehension testing had advanced on our side of the border, the FHWA went through such a process and developed updated sign options for charging stations, using a pictogram in the basic shape of a fuel pump. The comprehension testing in the US has shown that familiar fuel pump pictograms send a well-understood message of "fuelling up" on energy. Sign options from EMC and the MRN, for example, don't carry the notion of refuelling, putting the emphasis on the EV itself. When designing a traffic control device, comprehension must be front and center. The sign also has to be legible while viewed from a vehicle in MoTIion. It was noted during the research for design options that most high-voltage charging stations do indeed look like a gas pump. The actual SAE J1772 plug also looks very much like a gas pump nozzle.

Figure 5: FHWA 2009 EV charging pictogram (source: FHWA) and two charging stations (source: Eaton)

On the language level, the FHWA uses "EV" on its sign, which would be "VE" in French (for "*Véhicule Électrique*"). However, given the identical layout and reverse use of the letters, one might assume that both French and English speaking drivers will easily recognize either version of signs carrying the words "VE" or "EV". In the context of emerging technology, public awareness is still building on electric vehicles and the increased use of "VE" and "EV" by stakeholders is gradually building a "brand" around these acronyms. Initially, the PSC sought to replace the "EV" letters by a lighting bolt symbol to suit the needs of drivers independent of language, as per usual practice at TOMSC, but in FHWA comprehension testing responses to the lighting bolt option were mitigated.

Jurisdictional survey

At the time of the initiation of Project 319, Canada had four Electric Vehicle Charging Sign options: the existing TAC sign from 2008 (Figure 2), Quebec's MRN sign (Figure 1) and both EMC options (Figure 4). In the US, a group of eight states was involved in an early effort to expand consumer awareness and demand for zero-emission vehicles. Amongst the group's objectives was the need to develop common standards for roadway signs and charging networks. At the end of a thorough design and comprehension testing process, the FHWA granted interim approval to a revised D9-11b sign on April 1st 2011, giving those states a strong foundation for EV signage. The revised sign replaced the fuel pump nozzle with an electrical plug. The catalyst in creating updated EV signage was the elaborate "Electric Highway" project that covers the West coast from North to South. In FHWA comprehension testing, more than 92% of participants associated the electrical plug on this version of the sign to the availability of electricity.

Figure 6: Updated FHWA D9-11b sign (source: FHWA)

At the top of the American West Coast is British Columbia (BC). As part of the Electric Highway, the BC Ministry of Transportation and Infrastructure (MoTI) officially endorsed its version of the FHWA sign, and that sign is now used on public roads and public facilities in BC.

Figure 7: British Columbia Transportation sign Zi-128 (Source: BC MoTI)

Study Findings

The comprehension testing for this sign was integrated into an online survey by Transport Québec (MTQ) for the comprehension testing of various proposed traffic control devices. Accessible online via the MTQ/Quebec 511 portal, the survey generated 1433 responses, of which 677 were rejected as they came from MTQ employees. This still left 756 valid completed surveys, 652 from Quebec and 104 from other provinces. The survey was available in both French and English. MTQ did not include the exact FHWA pictogram as an option in the survey, but used one similar in concept built around the standard MTQ gas pump symbol, featuring a lighting bolt and an electrical plug in place of the pump nozzle (Fig. 8). The two other options tested were the EMC (Fig. 4) and MRN (Fig. 1) signs.

MTQ wanted to test the EV charging pictograms in a parking regulation application, and to that end the signs were shown in context installed next to a charging station. The picture used in the survey clearly showed the charging station, giving a strong hint to survey takers as to the meaning of the pictogram, but in a parking context; that approach was in accordance with the *TAC Guidelines for Traffic Control Device Comprehension Testing* methodology. Still, the basic pictograms tested are the same or nearly the same as our three options for the directional sign within Project 319. Due to the considerable work behind this online comprehension test and the similar context and use of the tested sign, results were extrapolated for our intended use, as we are only comparing pictograms, all three options being white-on-blue signs of the same size and shape.

Comprehension testing results

MTQ felt that it was critical to first develop a regulatory sign which will give authorities the ability to enforce parking at charging stations. As parking signs, the tested options need a 75% score to pass comprehension testing. The signs were shown in context in the survey, along a charging station but with no EV visible. All three pictograms were shown on the same parking sign template shown in Figure 8.

Figure 8: Pictogram developed by MTQ (source: MTQ) for survey

1) MRN sign option

The sum of correct and partly correct answers was 88.4% in QC, but only 60.5% in other provinces. The use of a well-publicized logo in this sign might explain the higher score in the QC-based responses. The MRN logo is frequently featured in newsletters sent with the utility bills that every Hydro Quebec customer receives, and has been advertized for a few years. The out of province answers are telling, as a result of only 42.1% fully correct answers shows that without prior exposure to this logo, comprehension is very low.

2) FHWA-style option

The sum of correct and partly correct answers was 96.8% in QC, and 83.8% in other provinces. The fully correct answers have a high share in the overall results, being at 75.9% in Quebec and 62.2% in other provinces.

3) EMC option

The sum of correct and partly correct answers was 99.0% in QC, and 96.6% in other provinces. Again, we have here a logo that, while not as well-publicized as that of the MRN logo, might have benefited from prior exposure, and this time in all Canadian provinces. Looking at the detailed numbers, fully correct answers are only at 63.9% in Quebec, and at a low 41.4% in other provinces, the worst score amongst all three options.

Analysis of results

When looking at the combined correct / partly correct scores, the EMC logo came out ahead. However, a significant portion of its score comes from the partially correct answers. Also, the EMC option received a significant amount of comments to the effect that survey takers only understood the meaning of the pictogram because of the charging station in the picture. This option also had the worst fully correct scores outside of Quebec. Both the EMC and MRN logos are in widespread use already in Quebec, while the EMC logo is also used in other provinces. That may well have influenced their results. The FHWA-style logo was created for this survey, so survey takers had no prior viewing of it, yet hundreds of participants easily understood what it meant. It can be safely said that the sign based on the MRN logo failed comprehension testing because out-of-province survey takers did not comprehend it and had no prior exposure to it, offering unbiased comprehension results.

Project 319 Conclusions and Recommendations

Harmony of standards between the US and Canada is always a valid objective when designing a new traffic control device. Here we had a case where an updated EV charging sign was included in the MUTCD by the FHWA after a design review and comprehension testing, and that a revised sign was in turn reviewed, adapted and included by BC's MoTI into its own standards. Even our country's need for bilingual signs can easily be worked into the existing FHWA / BC signs as only two letters are involved, and these letters are becoming popular acronyms in the community. We have also reviewed the results of MTQ comprehension testing of a similar pictogram, using a standard MTQ fuel pump symbol but featuring an electrical plug instead of a pump nozzle and an electrical bolt in place of letters (Fig. 8). The FHWA pictogram is also based on the agency's standard fuel pump symbol, offering a more contemporary shape that is more easily associated with a charging station, as shown in Figure 5.

Most high-voltage charging stations do look like a gas pump, basically a rectangular box with a screen display and an attached cable that ends with the SAE J1772 standard plug. The resemblance to the FHWA pictogram is strong, and in American tests an average of 94% of participants associated the electric plug in all sign options to the availability of electricity. Electric vehicle enthusiasts have shown a strong dislike to having electric mobility associated with fossil-fuel symbols, and although this qualitative appreciation has no effect on comprehension testing results, the shape used in the

FHWA pictogram is more neutral in that aspect and might offer better acceptance in the EV community. From these observations and based on available comprehension testing we concluded that an EV Charging Station sign based on the FHWA design would be an effective traffic control device for use to direct drivers to charging facilities, the very objective of this project. The simple conclusion to Project 319 was for TAC to adopt the Electric Vehicle Charging Station Sign Zi-128 that BC Transportation in turn adapted from the FHWA D9-11b sign and include said sign in the MUTCDC.

Based on successful comprehension testing results, the PSC recommended that sign Zi-128 from BC MoTI be adopted for inclusion in the MUTCDC. To be consistent with other signs in the MUTCDC, the size of this sign would be 600 mm x 600 mm and new numbering will be required. A French version of the sign was developed, reversing the "EV" letters to "VE". Both signs were approved by TOMSC and the Chief Engineer's Council and are now part of the MUTCDC.

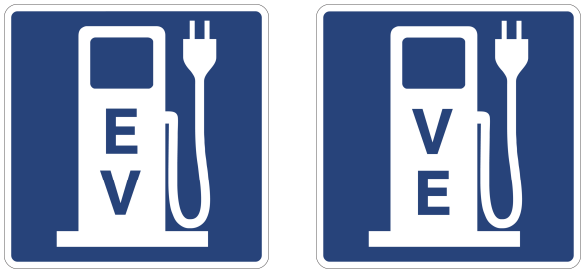


Figure 9: Approved IC-30 Electric Vehicle Charging Sign ("EV", same as fig. 8) and IC-30F ("VE", French version)

2- Electric Vehicle Charging Tab Signs (TOMSC Project 334)

The scope of this TOMSC volunteer project was to design a family of tab signs to supplement information given by the new IC-30 / IC-30F Electrical Vehicle Charging Station sign. The objective of the tab signs will be to indicate the charging levels offered at the facility. Tab signs could be changed as service evolves at facilities, while keeping the main sign current. A new project steering committee set out to design Electric Vehicle Charging tab signs that will meet the project's objectives as well as the ever changing technological context in which they will be used.

An overview of available charging levels

Motorists are familiar with the terminology used to grade fossil fuels. Basically, nearly all internal-combustion vehicles on the market will use either regular, premium or diesel fuels. Apart from that designation, all non-diesel fuels come with supplementary information in the form of the octane rating, usually 87 for regular and 91 or more for premium. The higher the number, the more "high performance" the fuel is. Some cars require premium fuel, others can benefit from it while most won't produce anything more than added costs while running the more expensive fuel option. Thus, Motorists must know what their vehicle needs in order to make the optimal fuel choice.

For EVs, things are somewhat different. Charging stations may offer different voltages, and while there are no "premium" electrons, a higher voltage at the charging stations will reduce the time needed to replenish the EV's battery. A higher-grade charging station will give out more kilometers (of range) per hour of charge, not more vehicle performance. As with premium gasoline, the caveat is that not all EVs are able to take advantage of high-speed charging stations. Their on-board components will limit the speed at which the battery is replenished. The added twist here is that three different plug standards limit which EV may hook up to any given charging station.

A popular terminology has been adopted for charging speed, in effect the voltage that a charging station offers. The higher the voltage, the quicker the "fill-up":

Level 1	120V AC	
Level 2	240V AC	
DC	440V DC	(where "DC" alone is not exact, as discussed further down)

Level 1: just plug it in

One of the main advantages of electric vehicles is that they are able to charge off a domestic electrical outlet. A standard, grounded 120V plug can provide a slow trickle of electrons to a depleted battery. This basic way of charging up is called "Level 1". It's far from ideal, as it may take up to a full day to fully recharge an EV through voltage this low, but it's better than being stranded. All EVs currently available on the market are compatible with household plug charging, so there are no restrictions to offering Level 1 to EV drivers. A Level 1 charge point supplies AC current at 120 volts / 12-16 amps to the EV's on-board charger.

Level 2: Moving EVs towards mainstream use

A few home appliances run on 240V: kitchen ranges, clothes dryers, heat pumps and such. These are either specially wired or use a specific plug as not to fry a 120V device. This higher voltage enables electric vehicles to recharge at a much faster rate, typically 4-6 hours to fully replenish a depleted battery. All domestic charging stations offered in the marketplace are 240V Level 2 types, as are most public units currently signed by signs like IC-30. Level 2 charging stations use the standard SAE J1772 plug. All electric or plug-in hybrid electric vehicles available on the market come with an SAE socket or adaptor. A Level 2 charge point supplies AC current at 208-240 volts / 12-80 amps to the EV's on-board charger.

Figure 10: SAE J1772 charging plug and portal (source: SAE)

DC : dueling standards for rapid charging

How EVs manage a high-voltage charge is a delicate affair involving many electronic processes, and how to achieve that can be done through different approaches, which in turn led to different standards. In the world of electronics, history repeats itself and many "standard wars" happened in the marketplace before one rose to universal acclaim. Think Beta vs VHS, Plasma vs LCD or Blu-Ray vs HD DVD. At the time of this writing, three DC standards dominate the North-American EV marketplace: CHAdeMO, CCS Combo and Tesla's Supercharger network.

CHAdeMO, an acronym for "Move by Charge", took an early lead in the EV industry. Born in Japan, the standard was created by a consortium of manufacturers and utility companies, mainly Nissan, Mitsubishi and Toyota. With the Nissan Leaf becoming the first mass-market purely electric vehicle, CHAdeMo facilities started popping out all over North-America. It requires a separate charging portal on the car and a different cable than used by the SAE plug for Level 2.

The SAE CCS Combo plug is also an acronym, for "Combined Charging System". As shown in Figure 11 below, it effectively combines the industry-standard SAE J1772 Level 2 port with an additional one set below it. Without going into a complex analysis of electrical engineering, it offers the advantage of using the same Level 2 plug, with the DC port capped off when not in use. In effect, this takes less room in a charge portal and allows more components sharing between Level 2 and DC for equipment suppliers.

Figure 11: SAE CCS Combo plug and portal (source: SAE)

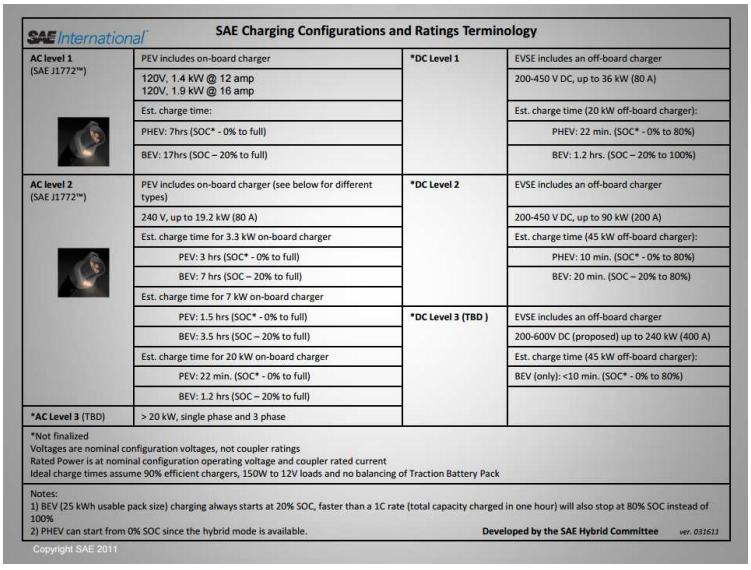
No matter what plug standard is used, "DC" is fundamentally different as the charger is outside the car and supplies DC energy as high as 600 volts and 240 watts. Electrical currents are very high, up to hundreds of amps. The exact term really is "DC Level 2", as the SAE has set aside other DC charging options for the future. Your mileage will vary, but the promise behind DC is recharging an EV's battery to 80% capacity in 30 minutes. The larger the battery, the more time it will take to "fill".

Official SAE standards for North-America

Typically, in the field of electric vehicle charging, AC means on-board chargers manage "fueling", while the faster DC chargers need bulky off-board chargers. Why off-board? The DC chargers generate a lot of heat due to their high voltage operation, requiring active cooling equipment. This explains why fast chargers often present themselves in enclosures that are in effect as large or even larger than a gasoline pump.

Figure 12 shows all current SAE charging standards. In effect, both AC and DC feature a standard called "Level 1", "Level 2" and "Level 3". Of those, AC Level 3 is only in use in Europe at this moment. DC Level 1 is not in use and DC Level 3 is to be developed.

The popular "Level 1" and "Level 2" expressions should really be called "AC Level 1" and "AC Level 2", but with AC being more the norm than the exception when looking at charging facilities, it's not a major mistake to omit the "AC" portion on signage to simplify the message. Both "Level 1" and "Level 2" can then be used as they are right now at many facilities. However, the popular "Level 3" expression is seriously flawed as it offers no correspondence at all to the DC Level 2 standard it actually designates. "Level 3" should thus not be used by itself on official signage as it has the potential to create confusion with upcoming AC Level 3 and DC Level 3 standards. Even worse, "Level 3 DC" is sometimes used for signaling a Level 2 DC facility. The correct expression to use then at current fast-charging facilities is "DC". At this deployment stage, using the full "DC Level 2" designation may create confusion.



SAE International — SAE Charging Configurations and Ratings Terminology

AC level 1 (SAE J1772™)	PEV includes on-board charger	***DC Level 1**	EVSE includes an off-board charger
	120V, 1.4 kW @ 12 amp 120V, 1.9 kW @ 16 amp		200-450 V DC, up to 36 kW (80 A)
	Est. charge time:		Est. charge time (20 kW off-board charger):
	PHEV: 7hrs (SOC* - 0% to full)		PHEV: 22 min. (SOC* - 0% to 80%)
	BEV: 17hrs (SOC – 20% to full)		BEV: 1.2 hrs. (SOC – 20% to 100%)
AC level 2 (SAE J1772™)	PEV includes on-board charger (see below for different types)	***DC Level 2**	EVSE includes an off-board charger
	240 V, up to 19.2 kW (80 A)		200-450 V DC, up to 90 kW (200 A)
	Est. charge time for 3.3 kW on-board charger		Est. charge time (45 kW off-board charger):
	PEV: 3 hrs (SOC* - 0% to full)		PHEV: 10 min. (SOC* - 0% to 80%)
	BEV: 7 hrs (SOC – 20% to full)		BEV: 20 min. (SOC – 20% to 80%)
	Est. charge time for 7 kW on-board charger		
	PEV: 1.5 hrs (SOC* - 0% to full)	***DC Level 3 (TBD)**	EVSE includes an off-board charger
	BEV: 3.5 hrs (SOC – 20% to full)		200-600V DC (proposed) up to 240 kW (400 A)
	Est. charge time for 20 kW on-board charger		Est. charge time (45 kW off-board charger):
	PEV: 22 min. (SOC* - 0% to full)		BEV (only): <10 min. (SOC* - 0% to 80%)
	BEV: 1.2 hrs (SOC – 20% to full)		
***AC Level 3** (TBD)	> 20 kW, single phase and 3 phase		

*Not finalized
Voltages are nominal configuration voltages, not coupler ratings
Rated Power is at nominal configuration operating voltage and coupler rated current
Ideal charge times assume 90% efficient chargers, 150W to 12V loads and no balancing of Traction Battery Pack

Notes:
1) BEV (25 kWh usable pack size) charging always starts at 20% SOC, faster than a 1C rate (total capacity charged in one hour) will also stop at 80% SOC instead of 100%
2) PHEV can start from 0% SOC since the hybrid mode is available.

Developed by the SAE Hybrid Committee ver. 031611

Figure 12: SAE Charging Configurations and Rating Terminology (source: SAE.org)

How does all this relate to a tab sign project?

Why all the electric discussion? Short answer: to establish that not all EVs can charge at every DC Level 2 facility. For example, stop in Surrey at BC's first DC charging station

with a depleted BMW i3 and you will need a tow truck. That charging facility only offers CHAdeMO connection, while the electric BMW only offers CCS Combo compatibility.

That's the twist. Not all charging facilities offer all possible combinations of AC Level 1, AC Level 2 or DC Level 2. A tab sign is thus needed below sign IC-30 to indicate what charge levels are offered at a facility, and what type in the case of DC Level 2. Thanks to recent agreements and initiatives in the supplier's field, most new fast chargers being installed now support both CCS and CHAdeMO, but there are still exceptions, in legacy facilities or even in new ones.

Jurisdictional survey

When discussions around the EV Charging Station sign project began, some jurisdictions in the US were showing charging levels either in the main sign or through the use of tabs. AC Levels 1 and 2 were shown as numbers, while DC Level 2 was simply shown as "DC", given that only one standard was in use at the time (CHAdeMO).

Figure 13: all-level charging indication (source: unknown US initiative)

As is always the case with electric vehicle signage, there are also plenty of private initiatives that include charging levels available, as seen in Figure 14.

Figure 14: Family of private EV charging signs available for sale in the US (sources: unknown US initiatives)

In Canada, BC's MoTI developed its EV signage with interest in keeping a strong harmony with what the Americans are using along the West coast's Electric Highway program. Initially, BC came up with tab sign options to indicate the availability of Level 1, Level 2 or DC (quick charge) charging facilities. However, the tabs shown in Figure 15 are now obsolete.

Figure 15: Now obsolete family of EV charging tab signs from BC Transportation (source: BC MoTI)

In 2014, BC MoTI eliminated the redundant Level 1 and Level 2 tabs and only kept a "Fast" tab sign, to indicate the availability of DC fast charging, again following American practices. As demonstrated by the facility in Surrey, this limited information is not ideal as not all "Fast" stations are able to provide a charge to all EVs.

Figure 16: BC MoTI "Fast" charging tab sign (current) (source: BC MoTI)

The "Fast" tab from BC features the right colors, size and layout for Project 334, however it lacks:

- distinction between CHAdeMO or CCS Combo standards;
- presents a worded message that needs to be translated to French;
- does not cover provinces that require bilingual messages;
- does not allow provisions for upcoming charging standards.

Study findings and considerations

The tab approach to indicating what charging levels are offered leaves room open for further research and development for new tabs as the technology evolves and facilities are improved. Economies of scale are to be realized by using tabs for the part of the message that will have to be updated frequently, while leaving the main sign (IC-30) untouched. Some examples as to why these updates will happen:

- services available at each charging point ("levels") will vary from one facility to another;
- these services may vary in time as facilities expand, upgrade or new tech is deployed;
- EV technology and the way it is labelled will have a shorter life cycle than fossil-fuel products, thus requiring frequent updates of signage.

Given the limited exposure that the general public has to electric vehicle technology, comprehension testing does not seem warranted for the tabs, as these will evolve quickly and will "speak" only to well-informed users or EV enthusiasts for at least the next decade. A technological watch will have to be maintained, and EV industry input will be needed to keep the tab signs current beyond the proposals featured in this report.

Some questions can be raised on what messages should the tab signs convey at this writing:

- Do we need to indicate the availability of Level 1 charging, given the fact that it can take a whole day to charge a battery this way?
- With Level 2 the default for most public facilities, do we really need a tab sign for Level 2, or should the simple presence of the IC-30 sign convey the message that the facility offers at least Level 2 charging?

- If DC Level 2 is offered, as well as AC Level 2, should we then add an AC Level 2 designation, as not all plug-in vehicles are able to use high-voltage facilities?

The Tesla situation was discussed in the final report for Project 319. EVs made by the American manufacturer are able to use public DC Level 2 charging stations (thanks to a CHAdeMO adaptor cable), but all other EVs on the market are barred from Tesla's Supercharger facilities due to the different technology they use. Even Tesla owners have to pay a premium to unlock Supercharger access. Therefore, as with sign IC-30, the proposed tab signs will not be used to direct motorists to the single-make Tesla charging facilities.

Tab Sign Design Considerations

As is the case for all guide and information signs, the supplementary tab signs proposed here feature white markings on a blue background, matching with the main sign (IC-30). During the course of the project, the PSC established a list of tab signs that should be designed to indicate available charging levels at a given facility. Being trademarks or "brands", both "CCS Combo" and "CHAdeMO" are bilingual as-is while their respective logos don't register with end users. It was also found during research that a short version of the SAE acronym, either "CCS" or "Combo", is often used by itself. In the interest of keeping the tab sign messages simple and legible, the PSC opted to use "CCS" only on tabs, as well as keeping the capital letters in "CHAdeMO" to help comprehension.

Project 334 Conclusions and Recommendations

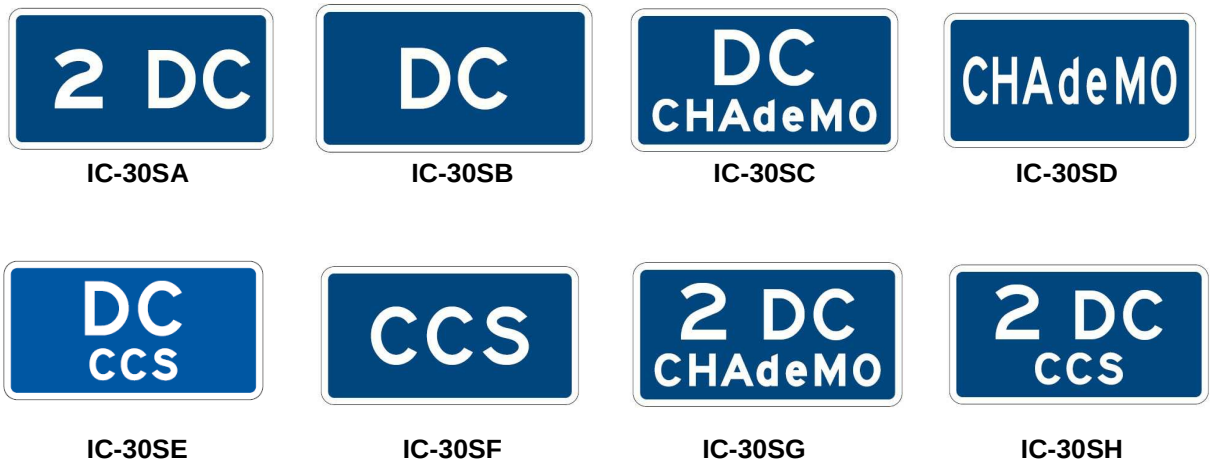
During the course of this project, after discussions and research, the PSC came to the conclusion that tab signs that indicate available charging levels are a necessary component of the message conveyed by the Electric Vehicle Charging sign IC-30.

The proposed tab signs shall be used in combination with the main Electric Vehicle Charging Station sign IC-30 in order to describe what services are available at a given facility:

IC-30 + no tab:	Facility offers at least AC Level 2, may offer AC Level 1
IC-30 + "DC" tab	Facility only offers CCS & CHAdeMO DC Level 2 charging standards (no AC Level 2)
IC-30 + "2 DC" tab	Facility offers AC Level 2 and CCS & CHAdeMO DC Level 2 charging standards
IC-30 + "DC CHAdeMO" tab	Facility only offers DC Level 2 charging for CHAdeMO equipped EVs

IC-30 + "DC CCS" tab	Facility only offers DC Level 2 charging for CCS Combo equipped EVs
IC-30 + "2 DC CHAdeMO" tab	Facility only offers AC Level 2 and DC Level 2 charging for CHAdeMO equipped EVs
IC-30 + "2 DC CCS" tab	Facility only offers AC Level 2 and DC Level 2 charging for CCS Combo equipped EVs

It was agreed by TOMSC that the tab sign options will not be comprehension tested, as these signs are not intended for the non-initiated. The intention is to include them as developed during the course of this project in the MUTCDC. The PSC developed interim numbering (to be finalized by the TOMSC Editing & Publication Subcommittee) and wording for each proposed tab sign, including revisions to the wording of main sign IC-30 to properly introduce the optional tabs and detail what sign/tab sign combinations should be used. Once approved by TOMSC, the tab sign family was subjected to letter ballot vote by TAC's Chief Engineer's Council (CEC) and formally approved for inclusion in the MUTCDC during the winter of 2017.



IC-30SA **IC-30SB** **IC-30SC** **IC-30SD**

IC-30SE **IC-30SF** **IC-30SG** **IC-30SH**

Figure 17: Electric Vehicle Charging Supplementary Tab Signs (IC-30SA through IC-30SH)

3- Electric Vehicle Parking Sign (TOMSC Project 335)

This ongoing TOMSC volunteer project's scope is to design a parking sign to regulate use at public charging facilities for electric vehicles, since no existing sign exists to regulate parking in front of charging stations, or to regulate time limits and other parking operational constraints at charging facilities. This creates everyday situations where motorists legally park in stalls equipped with a charging station, blocking access to electric vehicles that need recharging.

Once an EV driver reaches a charging facility, quite often the use of charging stations is not regulated and nothing ensures that they are effectively in use, becoming prime parking spots. Given the fact that recharging is essential to a stranded EV driver, parking regulations at EV charging facility must facilitate rotation and partial charging to offer renewed mobility to EV drivers, and not just parking per se. Depending on services offered at the facility and the technical aspects of the plug-in vehicle, a full charge can take as little as 30 minutes or as much as 24 hours. Having the option to regulate maximum charging time is thus desirable from an operations standpoint. This project's objective is thus to make sure charging facilities are used to charge up EVs, and not just provide a parking place for electric vehicles.

Jurisdictional survey results

There are multiple interpretations of what an EV parking sign should be in the public landscape. In the US, the National Committee on Uniform Traffic Control Devices (NCUTCD) had come up with a series of signs to regulate EV parking. Those signs have at their core the EV charging station logo from the traveler information sign, showing continuity in the message.

Figure 18: NCUTCD proposals for EV parking regulation

Memorandum HOTO-1, titled "Regulatory Signs for Electric Vehicle Charging and Parking Facilities" was published in June 2013 by the FHWA with the intention of promoting uniformity among the regulatory signing while allowing variations for local regulations. Tab signs are also offered to supplement the information given out in the main sign. This sign series uses color and language consistent with other FHWA parking signage and eschews the use of a pictogram in favor of a worded message. This of course would not work very well in the Canadian context, because of the need for translated or bilingual messages, plus the overall sign formatting that is different from TAC's.

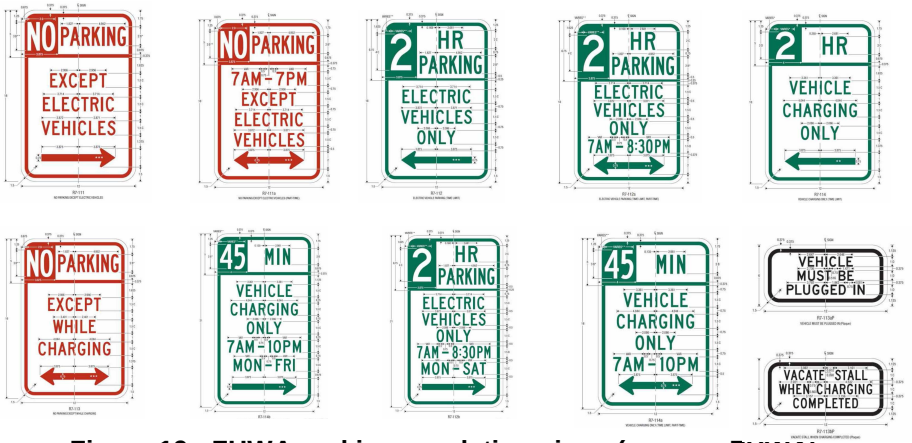


Figure 19 : FHWA parking regulation signs (source: FHWA)

British Columbia's MoTI, as part of its tool kit for deployment of electric vehicle services, published a catalog of signs related to charging stations, either for way finding or to regulate use and parking. The charging station sign in that package became TAC sign IC-30 and is now part of the MUTCDC. For static use near charging stations, BC developed sign # Zi-129-LRD, combining the charging station logo, the familiar "no parking" sign, arrows (optional) and wording to convey the intended message.

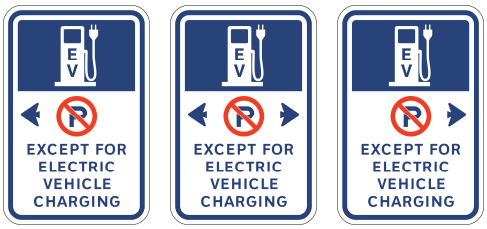


Figure 20: BC sign Zi-129-LRD with all arrow combinations shown (source: BC MoTI)

The same sign package also proposes an option to display the limited charging time, using a format similar to the FHWA signs. This sign allows a custom duration time in hours. Apart from that number, the sign is essentially worded. BC also designed a simple "no parking" sign in standard TAC colors to regulate parking when facing a charging station.

Figure 21: BC sign Zi-130 (where "x" is replaced by a number, left) and Zi-131 (right) (source: BC MoTI)

All three BC signs present issues when faced with translation or bilingual needs.

In the summer of 2014, Ville de Montréal had to come up with a sign to regulate parking at its first public curbside charging station. Given the work order only days before a press conference at the location, the city's practitioners had to think fast. Using the recently approved TAC loading zone sign options, Montréal used a standard TAC sign layout featuring the "no parking" logo on top, the EV charging station pictogram from TAC sign IC-30 and minimal wording. The result was sign R-VF as shown in figure 22.

Figure 22: Montréal's "R-VF" sign (source: Ville de Montréal)

Montréal's application has the added complexity of being a metered parking space. In other words, EV drivers need to pay for charging and pay for parking when using that curb side location. The parking post features a sticker to explain this (Fig. 23).

Figure 23: Parking meter sticker for EVs in Montreal (photo by author)

The City of Ottawa also came up with its own sign, using detailed bilingual wording to fully convey the intended message. In contrast with other applications, it uses a positive "parking allowed" message instead of the usual "no parking". The logo featured on the sign is not standardized however (Fig. 24).

Figure 24: City of Ottawa sign (source: City of Ottawa)

English version of Montreal sign

During the course of the EV Parking Sign project, an English version of the Montreal prototype sign has been developed, using the same language found in recent TAC parking restriction signs.

Figure 25: English version of Montréal sign R-VF (source: Ville de Montréal)

Study findings and considerations

The jurisdictional survey confirmed that there are many sign options out there to regulate use and parking at EV charging facilities, and while all of these options convey the proper message, the Canadian context brings added issues when too many words are

used on a single sign. With that in mind, the following considerations should be treated in the final design of the EV parking sign:

- the proposed sign should favour the use of pictograms over words, as per usual TAC practice;
- sign format (size, colors, layout, fonts) should follow current TAC standards;
- charging station pictogram from sign IC-30 (EV charging station) could be used to ensure visual consistency for all EV signage needs;
- minimum wording shall be used to convey the message.

Project 335 Conclusions and Recommendations

The proposed EV Parking Sign should feature the same pictogram as sign IC-30 to ensure a visual "EV" signature to what will become a family of signs in the MUTCDC. Given the fact that the English and French versions of Montréal's R-VF sign strictly follow the format created with the recent family of loading zone signs approved by TAC, the PSC proposes that the Montréal signs be comprehension tested to gauge the general public's understanding of the parking restriction message that the sign conveys.

Figure 26: Options to be tested

As opposed to charging technology, the parking restrictions are addressed to the non-initiated and all drivers must understand them. Therefore, TAC's regular comprehension testing process must be followed. To that effect, the development of a fully bilingual version should be completed in parallel to comprehension testing.

At the time of this writing (April 2017), the PSC is currently waiting for the completion of the online comprehension testing of the sign options. Results and recommendations will be presented during the 2017 TAC Annual Conference.