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## Harmonization of Road Signs for Electric Vehicle Charging Stations

Prepared for:  
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## 1 BACKGROUND

The expansion of the availability of electric vehicles<sup>1</sup> (EVs) on a global basis has resulted in new requirements for a wide variety of standards and regulations. For plug-in EVs that require special charging “points” or “stations,” one of the needs is to assist EV drivers in identifying where they can recharge their cars. Until September 2012, however, there has been no recognizable, international road signage standard for EV charging stations like there is for gasoline and diesel fuel stations. Even with a United Nations standard, there is no single, internationally harmonized EV signage.

Many countries where the EV market is growing have created their own pictogram or symbol representing EVs and EV charging stations. The United States has developed a specific road sign for EV charging stations that looks like a standard liquid fuel pump with the letters “EV” and with an electric cord and plug replacing the typical liquid fuel nozzle. Sweden has adopted signage showing a silhouette of a car with an electric cord pointed to a device showing an electric bolt. Belgium has advocated EV charging signage based on other existing international signage for alternative fuels that shows a black silhouette of a fuel pump with an electric cord and plug in front of a blue “shadow” fuel pump that represents other fuel availability. France is using a stylized car logo with an electric plug trailing away from the body of the car. These and other signs are also being used to identify designated public parking places designed for EV plug-in charging. Some cities use symbols, while others — such as London (UK) — have longer descriptive statements about allowed times and conditions for using dedicated EV parking places with recharging capability.

Proper road signage is not just a matter of making it easier for EV drivers to find a convenient charging station. It also relates to safety — what voltage is available for which vehicle types — and consumer awareness that EVs are available and are beginning to enter mainstream vehicle markets. Issues about dedicated parking for EVs need to be addressed, and proper signage will be required to regulate EV driver access to charging in the public domain. The issue of slow and fast charge stations presents an additional challenge in terms of EV signage, because motorists need to have the proper guidance in finding an appropriate charging location suitable for specific EV-charging requirements.

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<sup>1</sup> The term “electric vehicle” (EV) refers to all types of vehicles with electric drive or combination of electric drive and other fueled auto-motion but — for the purpose of this report — relates specifically to those EVs that require recharging via connection to the electricity grid.

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## 2 PURPOSE

This report details the development of international road signage for EVs, including the background and status of the creation of international on-road signage for EV charging stations by the United Nations (UN), where international legal recognition of signage is regulated. Legal recognition for EV charging stations is established within the UN Working Party on Road Traffic and Safety (WP1)<sup>2</sup>, which functions within the broader umbrella of the Inland Transport Committee at the UN in Geneva, Switzerland. WP1 creates Consolidated Resolutions that provide de facto recognition and acceptance of road signage that is recommended for use by signatories to the 1968 Convention on Traffic Safety and Road Signage. This process has been used to recognize other alternative fuel signage. Once vehicle signage has obtained legal recognition, then a further request can be made to move this into a full treaty, making specific signage part of the harmonized mandate for road signs representing alternative fuel stations.

In mid-2012, this report surveyed what is being done for EV signage in the United States and internationally to determine the potential of engaging the appropriate parties (and countries) to be part of the process within the UN to create a single, harmonized, recognizable pictogram or sign for EV charging stations. During the period of this research, however, other European countries have moved forward in the same direction. Decisions made by WP1 in September 2012 to adopt a variety of EV signage proposed by several different countries now confirms that adoption of a universally accepted road sign for EV charging or dedicated charge-parking places will not soon be possible.

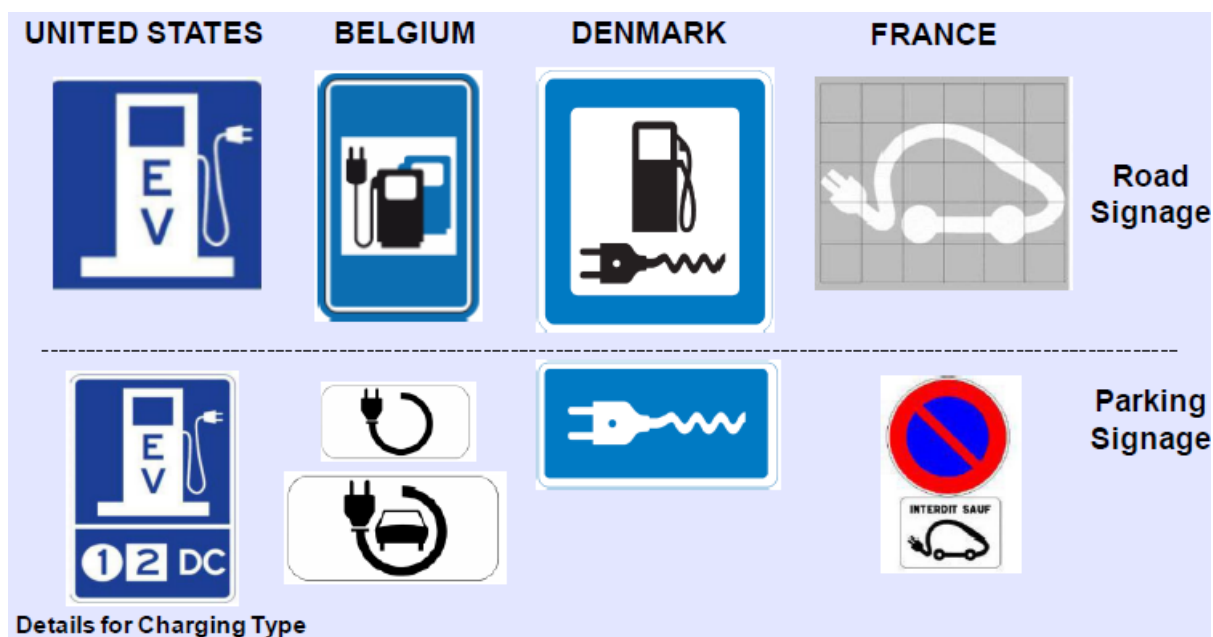


Figure 1. A sample of the wide range of EV road signage and EV parking signs currently in use

<sup>2</sup> <http://www.unece.org/trans/roadsafe/rsrec.html>.

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### 3 EV ROAD SIGNAGE IN THE UNITED STATES

#### 3.1 Current Status

A number of different signs for EV charging stations and “charge-parking” have been available from commercial vendors in the United States (Figure 2). These are “unofficial” signs that have not been officially sanctioned by any specific jurisdiction (local, state, or federal).



Figure 2. Commercial EV signs in the United States<sup>3</sup>

The U.S. Department of Transportation and state departments of transportation regulate signage that is allowed on federal and state highways. States may develop their own variety of road signage, but frequently state signage is based upon federal standards and guidelines.

#### 3.2 Historical Federal Sign Evolution, 2002–2012

In 2002, the U.S. Department of Transportation, Federal Highway Administration, published its first version of a road sign for EV charging stations (Figure 3).<sup>4</sup>



Figure 3. First U.S. government guidance on EV road signage

<sup>3</sup> Source: <http://www.stopsignsandmore.com/c-114-alternative-fuel-hybrid-parking-signs.aspx>.

<sup>4</sup> U.S. Department of Transportation, Federal Highway Administration, <http://mutcd.fhwa.dot.gov/services/publications/fhwaop02084/index.htm>.

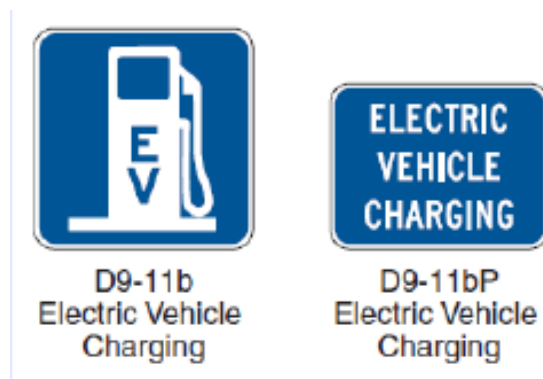
The design and use of road signage is specified in the Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways. The MUTCD specifies that “All General Service signs and supplemental sign panels shall have white letters, symbols, arrows and borders on a blue background.” The manual provides guidance on the use of signage as follows<sup>5</sup>:

- “General Service signs should be installed at a suitable distance in advance of the turn-off point or intersecting highway.
- States that elect to provide General Service signing should establish a statewide policy or warrant for its use, and criteria for the availability of services. Local jurisdictions electing to use such signing should follow State policy for the sake of uniformity.

Option:

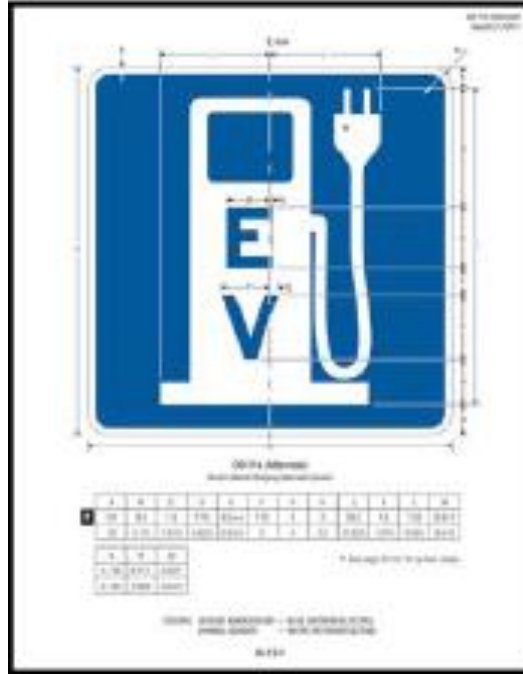
- Individual States may sign for whatever alternative fuels are available at appropriate locations.”

In 2009, two EV signage designs (D9-11b and D9-11bP) were provided to supersede the 2002 design (Figure 4). Extensive human factors research was done to improve the sign. In 2011, the fueling hose was replaced by an electric cord and plug to avoid confusion with a typical liquid fuel pump. Letter spacing and base dimensions were also revised and base dimensions and pedestal location were precisely specified (Figure 5).



**Figure 4. U.S. FHWA (Federal Highway Administration) modified EV signage, 2009**

<sup>5</sup> Manual on Uniform Traffic Control Devices for Streets and Highways, U.S. General Service Signs, Section 21.02, December 2009.



**Figure 5. 2011 signage showing an electric cord and plug**

The improved design can be used under the provisions of Interim Approval No. IA-13, issued April 1, 2011,<sup>6</sup> and summarized below (see Annex 1, last page, for full-size version):

- “The design of the EV charging symbol sign is not proprietary and can be used in any jurisdiction that requests and obtains interim approval from the FHWA to use the sign
- The Interim Approval does not create a new mandate compelling the use of this new sign, but will allow agencies to install this sign, pending official MUTCD rulemaking, to provide direction to road users to EV charging stations
- Agencies may also continue to use the EV Charging plaque (D9-11bP) as an educational message mounted below the alternative Electric Vehicle Charging symbol in a Directional Assembly.”

If the U.S. EV public charging network begins to develop and charging stations provide different charging speeds or voltage, there are provisions in the regulations for additional explanatory symbols, letters, or numbers in specified sizes to clarify for motorists the different types of charging services available. Such signage using the 2011 EV “plug” signage as a basis could be implemented. If revised signage is implemented, however, additional public education

<sup>6</sup> Memorandum from Jeffrey A. Lindley, Associate Administrator for Operations, to Federal Lands Highway Division Engineers Division Administrators, 1 April 2011. The provisions of the Interim Approval can be accessed at: [http://mutcd.fhwa.dot.gov/resources/interim\\_approval/ia13/ia13evcalt.pdf](http://mutcd.fhwa.dot.gov/resources/interim_approval/ia13/ia13evcalt.pdf).

would be necessary so that motorists could understand the differentiations (1 or 2 for speed of charge; DC or AC for voltage type). Figure 6 provides an example of how the EV signage could be adapted to accommodate different charging times and voltage, although this sign shows the plug pointing to the right as opposed to the approved sign with a vertical-pointing plug. Other details also vary. Annex 1 of this report shows the prescribed MUTCD size requirements for signage, also indicating “service” signs that would include EV road signs.



**Figure 6. Adaption of EV signage to reflect availability of specific alternating current (AC) charge levels (1 and/or 2) or direct current (DC) fast charging**

The complexity of charging infrastructure possibilities exceeds the three labels illustrated on the sign in Figure 6. The U.S. manufacturer Tesla and Japanese manufacturers Nissan and Mitsubishi are both installing “DC” fast charging equipment, but the two systems are incompatible. In the meantime, a group of U.S. and European manufacturers has agreed to introduce another DC fast charging technology. Thus, the label “DC” alone is inadequate to inform EV owners whether or not the charging station can serve their specific brand of vehicle. Further, most, but not all, plug-in electric vehicles are equipped with a standard on-board charger that can connect to “level 2” electric vehicle supply equipment (EVSE), which is rated at 3.3 kW power. However, the Ford Focus electric is able to charge at 6.6 kW if the level 2 EVSE is capable of providing that level of power. The SAE level 2 standard allows even higher kilowatt levels, up to about 19 kW. If this type of sign is to be used to inform travelers using Interstates and state highways, another question is how valuable the level 1 label will be, considering the very long time needed for a charge when level 1 EVSE is used. Thus, determination of the most useful sign information will need to await evolution of charging equipment technology and demonstration of customer needs.

Nevertheless, this sign option does illustrate one possible way of providing needed detail. By creating a space below the EV charge location standard symbol, an opportunity would be created to allow an evolution of needed additional signage information as charging technology and consumer preferences evolve.

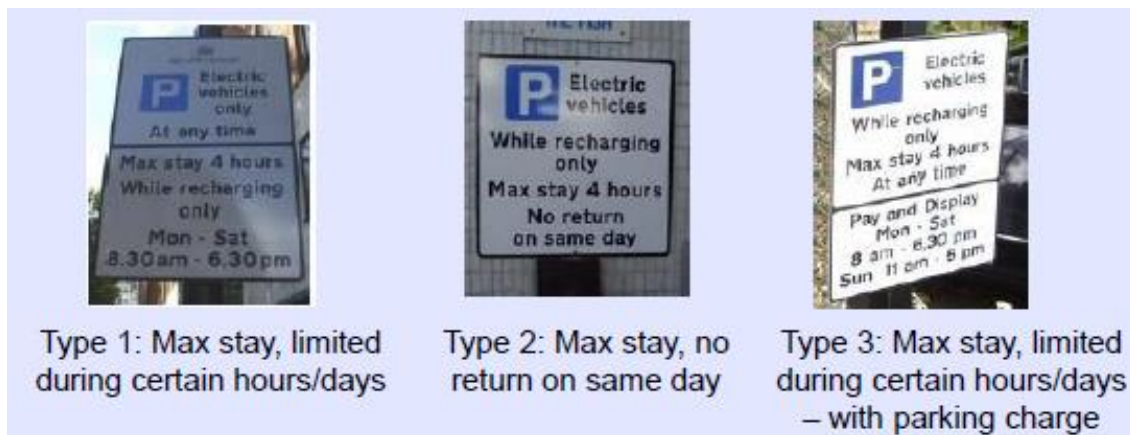
## 4 INTERNATIONAL EV ROAD SIGNAGE

### 4.1 The European Union: European Commission

In 2010, the European Commission mandated a collaborative effort to create EV charging standardization that included three principle standardization bodies: the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENLEC), and the European Telecommunications Standards Initiative (ETSI). “The collaborative development of such standards would not only simplify the charging process by being the same independently of vehicle brand or type, but would also increase safety.” The results were to be anticipated by mid-2011 and to become operable in 2017. However, EV road signage for charging stations or designated parking spaces was not addressed in the body of the mandate.<sup>7</sup>

#### 4.1.1 London, England

A standard sign layout has been adopted by London boroughs that operate electric vehicle charging points (EVCPs). The Department for Transport must approve sign typology before sign production and use. Signage requirements are specified in “Traffic Signs (Amendment) Regulations & General Directions (TSRGD) 2012” consultation document September 2009 (Figure 7).<sup>8</sup>



**Figure 7. London Borough EV signage for dedicated “charge-parking” spaces (Source: TSRGD 2012)**

In addition, a specific typology for public and private EV charge-parking spaces has been developed (Figure 8). This typology includes details about specific locations, restricted or open access to EVs, and the type of electric plugs to be used.

<sup>7</sup> DG Enterprise and Industry, M/468 EN, 4 June 2010.

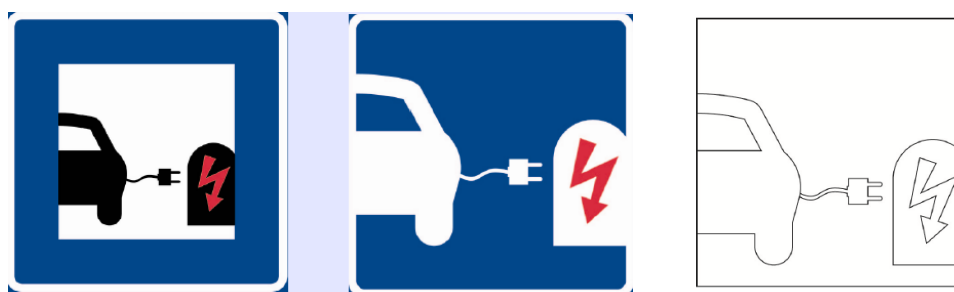
<sup>8</sup> Transport for London, Guidance for implementation of EV charging infrastructure, April 2010.

| Type | On-street/<br>off-street | Public/<br>private | Locations  | Shared | Restricted access<br>(RA) / Open<br>access (OA) | Plug type              |
|------|--------------------------|--------------------|--|--------|---|------------------------|
| A    | On-street                | Public             | All (high streets, residential areas<br>etc)                                   | Yes    | RA  | 3-pin                  |
| B    | Off-street               | Public             | Car parks – leisure & retail centres,<br>community facilities, stations, parks | Yes    | RA/OA   | 3-pin/blue<br>commando |
| C    | Off-street               | Private            | Car parks – workplaces, residential<br>apartments                              | Yes    | RA/OA   | 3-pin/blue<br>commando |
| D    | Off-street               | Private            | Residential  | No     | OA  | 3-pin/blue<br>commando |

**Figure 8. London Borough typology of public and private EV charge-parking**  
(Source: TSRGD 2012)

#### 4.1.2 Sweden

Sweden adopted signage for EV charging stations as of June 2009 (Figure 9).



**Figure 9. Swedish EV signage for charging stations<sup>9</sup>**

#### 4.1.3 Norway

Signage for EV charging stations was developed, and Norway co-submitted the Swedish EV charging station signage at the UN for adoption, indicating that Norway would share this signage as its approved versions (see below, United Nations).

<sup>9</sup> See: [http://archive-se.com/se/t/transportstyrelsen.se/2012-05-14\\_5901\\_131/Tung\\_lastbil\\_med\\_tillkopplad\\_sl%C3%A4pvagn\\_Transportstyrelsen/](http://archive-se.com/se/t/transportstyrelsen.se/2012-05-14_5901_131/Tung_lastbil_med_tillkopplad_sl%C3%A4pvagn_Transportstyrelsen/).



#### 4.1.4 Belgium

The Belgian Ministry of Transportation has prepared EV signage for charging stations and reserved parking places. The design for the road signage (Figure 10) is in keeping with the design approach taken on the already-adopted UN signage for CNG, LNG, hydrogen and LPG (liquefied petroleum gas), fueling stations. Signage for reserved EV charge-parking spaces is in Dutch and French, which are two of the official Belgian languages. The design also leaves open the possibility to indicate different types of vehicles to be charged (Figure 11).

Belgium's signage was proposed as part of the UN proposal that was adopted for international EV road signs.



Figure 10. Belgian road signage for EV charging stations

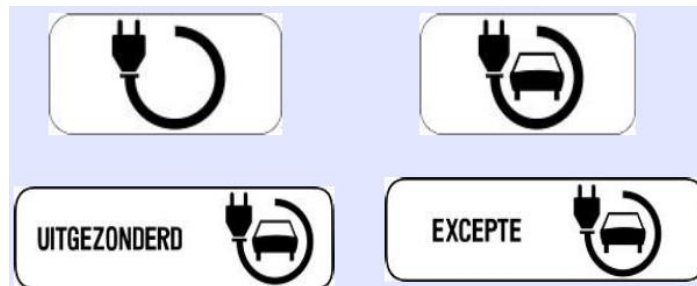


Figure 11. Signage for charge-parking spaces (Dutch-uitgezonderd = saved-for; French-excepte = apart/only for)

## 4.2 THE UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE (UNECE)

The Inland Transport Committee (ITC) that operates within the overall framework of the UNECE is the highest policy-making body of the UNECE in the field of transport. The ITC provides a pan-European, intergovernmental forum where UNECE member countries come together to create, negotiate, and adopt international legal instruments — laws and regulations — on a wide range of issues, technologies, and practices related to inland transport.<sup>10</sup> The ITC deals with 13 “theme” areas of transportation, including vehicle regulations, security, infrastructure development, and safety. The WP1, Road Traffic Safety within the ITC, deals explicitly with issues from the 1949 Convention on Road Traffic, the 1968 Convention on Road Traffic, and the 1968 Convention on Road Signs and Signals. These Conventions are subject to continual amendment by WP1 members and interested parties, such as non-governmental organizations that bring various issues to the attention of WP1.

When it comes to issues regarding road signage, WP1 does not always formally “vote” on proposed amendments and prefers to gain acceptance by consensus. A vote can be taken, in which case a two-thirds majority is required for an amendment to move to the next phase, a Consolidated Resolution (CR). The CRs are distributed worldwide for consideration and observation by all of the contracting parties to the 1968 Vienna Convention on Road Signs and Signals. The more countries that begin adopting the signage *de facto* and using it in advance of the final acceptance as an amendment to the Treaty, the more strength it has for easier passage in the Treaties of Contracting Parties (*de jure*). Following adoption of a CR, countries can use — at their own discretion — the signage. The CRs then can be packaged together and submitted to the UN in New York to be distributed to all contracting parties (i.e., country signatories of the Treaty), who have 12 months to consider the amendments, followed by an additional 6 months for the amendments to enter into force and thereby become legally binding. If the amendments are accepted by two-thirds of the contracting parties, they become binding for all contracting parties thereafter.

### 4.2.1 Road Signage for Alternative Fuels

WP1 began dealing with fueling station signage for alternative fuels in March 2003 when the European Natural Gas Vehicle Association (ENGVA), in conjunction with the International Association for Natural Gas Vehicles (IANGV, now NGV Global), requested adoption of a Consolidated Resolution for compressed natural gas (CNG) fuel stations, and that was later joined by the European Association for Liquefied Petroleum Gas (AEGPL) to introduce signage for LPG stations. Road signage for CNG and LPG was adopted in 2005. In 2009, NGV Global advocated for fuel station signage for liquefied natural gas (LNG). At the same time, Norway introduced signage for hydrogen fueling stations, both of which were adopted as a CR in 2010 (Figure 12).<sup>11</sup> Road signage for alternative fuels adopted in a CR by the UNECE now has recognized international “legal status” but is not (yet) a finalized amendment adopted in the 1968 Convention on Road Signs and Signals.

<sup>10</sup> Adapted from the UNECE, ITC home page: <http://www.unece.org/trans/main/itc/itc.html>.

<sup>11</sup> Based on the ENGVA/IANGV proposals Germany and Switzerland recommended signage (as adopted) for CNG in TRANS/WP.1/2005/7 30 December 2004. LNG, LPG, and H2 signage is indicated in ECE/TRANS/WP.1/2009/4 and all alternative fuel signage adopted by WP1 as a consolidated resolution (RE.2) is enumerated in ECE/Trans/WP.1/119/Rev.2, 27 May 2010.



Figure 12. Alternative fuel road signage adopted by the United Nations

#### 4.2.2 Road Signage for EV Charging Stations and Charge-Parking

Discussions of road signage for EVs first began at the UN WP1 in June 2010 for a collaborative effort to standardize the European EV fueling infrastructure.

- Belgium discussed secure parking spaces for EV charging (Figures 10 and 11).
- Sweden introduced its new EV road sign and EV parking sign (Figure 13).
- ISO EV road signage was introduced and discussed (Figure 14).



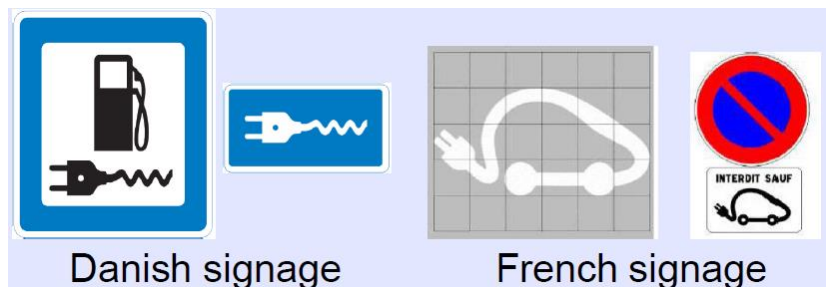
Figure 13. Sweden EV road signage and charge-parking signage



Figure 14. ISO EV road signage concept

The WP1 Secretariat asked to continue the discussion and consolidate the Belgian, Swedish, and Danish signage for the 62nd session of WP1 held on 26–29 September 2011. At that session, an informal document from Belgium, Denmark, and France was presented with their “consolidated concepts” for EV signage (ECE-TRANS-WP1-2011-2e). (See Belgian signage in Figures 10 and 11 and Denmark’s and France’s signage in Figure 15). Norway and

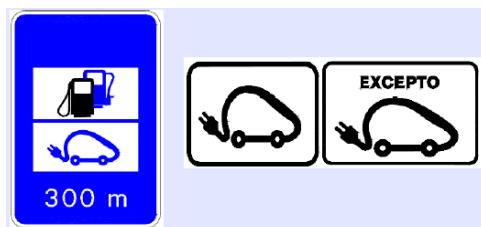
Sweden separately presented their EV road signage concepts (ECE-TRANS-WP1-2011-10e) (Figure 9). Signage and secure charge-parking concepts were discussed without resolution, and the chairwoman requested that any other countries interested in forwarding their EV signage submit designs for the 63rd session of the WP1.



**Figure 15. Denmark EV charging station and charge-parking signage (left) and French charging station and charge-parking signage (right), also introduced with Belgian signage**

At the 63rd session of WP1, 19–23<sup>rd</sup> March 2012, the road signage concepts were discussed again.<sup>12</sup>

- WP1 considered consolidating all of the proposals into a single formal consolidated resolution [Consolidated Resolution on Road Signs and Signals (R.E. 2)].
- Belgium, Denmark, France, Norway, and Sweden were asked to submit detailed specifications for their concepts at the 64th WP1 session on 24–27 September 2012.
- Portugal requested to add its EV fuel station concept (Figure 16).
- Signage for secure EV parking was discussed at length (public vs. private entities) but without resolution.
- Belgium asked for a revised proposal for 64th WP1 session.



**Figure 16. Portugal EV road signage and sign for dedicated charge-parking<sup>13</sup>**

<sup>12</sup> ECE Trans/WP1/135, Working Party on Road Traffic Safety, sixty-third session, Geneva, 19–22 March 2012.

Working Party 1, at the 64th session, approved new road signage for EV charging stations,<sup>14</sup> which specified the EV signs from Belgium, Denmark, Portugal (based on the French design), and Sweden, leaving the choice to the Contracting Parties. The smaller sets of signs also were approved for use below a larger informational sign (F-Type signs, for charge-parking/fueling stations shown in Figures 11, 15, and 16). Note that initially the Swedish signage had a red lightning bolt, but that was rejected because red, versus blue, is an emergency sign color, and so it cannot be used for EV signs (see Figure 9).

Adoption by WP1 means that the signage is not legally binding but will go into the Consolidated Resolution on Road Signs and Signals, which is where the current range of fuel station signage for CNG, LNG, LPG, and hydrogen “resides.” As such, they are more-or-less de facto signage, but to obtain full legal status, the signs would have to be approved to go to the UN in New York, where they would be provided to Contracting Parties for consideration as an amendment in the 1968 Economic Commission for Europe Convention on Road Signs and Signals<sup>15</sup>. If adopted by two-thirds of the nations that are signatories to the treaty, the signs would become “legal.” That could be possible if one or more advocates of alternative fuel vehicles or Contracting Parties began such a process, starting at WP1.

#### 4.2.3 Worldwide Implications for EV Road Signage

The inability of the UNECE WP1 to decide on a single, harmonized standard for road signage and their choice to bundle several country signs into the same proposal indicates there will not soon be any formal or “legal” international harmonization of road signs for EV charging stations or public parking for EV charging. As such, nations may use one or more of the UN/WP1-approved designs (as approved in September 2012). Most likely, countries will develop their own EV road signage or borrow signage from another country if they do not create their own, including signs for dedicated charging stations at parking locations (public and/or private).

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<sup>13</sup> ECE Trans/WP1/2012/5.

<sup>14</sup> ECE Trans/WP1/2012/5.

<sup>15</sup> <http://www.unece.org/fileadmin/DAM/trans/conventn/signalse.pdf>.

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## APPENDIX A

### A.1 ANNEX 1

#### Selected Signage Size Tables from the U.S. Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD)

Relevant tables have been copied in their entirety to indicate coverage for all signage types related to federal requirements. Arrows are used to highlight the portion of the table that is relevant for EV signage. Tables without an arrow apply to federal road signage in general.

**Table 2J-1. Minimum Letter and Numeral Sizes for Specific Service Signs According to Sign Type**

| Type of Sign                                    | Freeway or Expressway | Conventional Road or Ramp |
|---|-----------------------|---------------------------|
| <b>A. Specific Service Signs</b>                |                       |                           |
| Service Categories                              | 10                    | 6                         |
| Exit Number Words                               | 10                    | —                         |
| Exit Number Numerals and Letters                | 10                    | —                         |
| Action Message Words                            | 10                    | 6                         |
| Distance Numerals                               | —                     | 6                         |
| Distance Fraction Numerals                      | —                     | 4                         |
| <b>B. Logo Sign Panels</b>                      |                       |                           |
| Logo Sign Panels                                | 60 x 36               | 30 x 18                   |
| Words and Numerals (Non-Trademark/Graphic Logo) | 8                     | 4                         |
| Trademark/Graphic Logo                          | Proportional          | Proportional              |
| Supplemental Message Words and Numerals         | 5                     | 2.5                       |

Note: Sizes are shown in inches and where applicable are shown as width x height

Source: Manual on Uniform Traffic Control Devices (U.S. Department of Transportation, Federal Highway Administration), 2009, page 316.

**Table 2I-1. General Service Sign and Plaque Sizes (Sheet 1 of 2)**

| Sign or Plaque                             | Sign Designation | Section | Conventional Road | Freeway or Expressway           |
|--|------------------|---------|-------------------|---------------------------------|
| Rest Area XX Miles                         | D5-1             | 2I.05   | 66 x 36*          | 96 x 54*                        |
| Rest Area Next Right                       | D5-1a            | 2I.05   | 78 x 36*          | 120 x 60* (F)<br>114 x 48* (E)  |
| Rest Area (with arrow)                     | D5-2             | 2I.05   | 66 x 36*          | 96 x 54*                        |
| Rest Area Gore                             | D5-2a            | 2I.05   | 42 x 48*          | 78 x 78* (F)<br>66 x 72* (E)    |
| Rest Area (with horizontal arrow)          | D5-5             | 2I.05   | 42 x 48*          | —                               |
| Next Rest Area XX Miles                    | D5-6             | 2I.05   | 60 x 48*          | 90 x 72*                        |
| Rest Area Tourist Info Center XX Miles     | D5-7             | 2I.08   | 90 x 72*          | 114 x 102* (F)<br>132 x 96* (E) |
| Rest Area Tourist Info Center (with arrow) | D5-8             | 2I.08   | 84 x 72*          | 120 x 102* (F)<br>120 x 96* (E) |
| Rest Area Tourist Info Center Next Right   | D5-11            | 2I.08   | 90 x 72*          | 144 x 102* (F)<br>132 x 96* (E) |
| Interstate Oasis                           | D5-12            | 2I.04   | —                 | 156 x 78                        |
| Interstate Oasis (plaque)                  | D5-12P           | 2I.04   | —                 | 114 x 48                        |
| Brake Check Area XX Miles                  | D5-13            | 2I.06   | 84 x 48           | 126 x 72                        |
| Brake Check Area (with arrow)              | D5-14            | 2I.06   | 78 x 60           | 96 x 72                         |
| Chain-Up Area XX Miles                     | D5-15            | 2I.07   | 66 x 48           | 96 x 72                         |
| Chain-Up Area (with arrow)                 | D5-16            | 2I.07   | 72 x 54           | 96 x 66                         |
| Telephone                                  | D9-1             | 2I.02   | 24 x 24           | 30 x 30                         |
| Hospital                                   | D9-2             | 2I.02   | 24 x 24           | 30 x 30                         |
| Camping                                    | D9-3             | 2I.02   | 24 x 24           | 30 x 30                         |
| Trailer Camping                            | D9-3a            | 2I.02   | 24 x 24           | 30 x 30                         |
| Litter Container                           | D9-4             | 2I.02   | 24 x 30           | 36 x 48                         |
| Handicapped                                | D9-6             | 2I.02   | 24 x 24           | 30 x 30                         |
| Van Accessible (plaque)                    | D9-6P            | 2I.02   | 18 x 9            | —                               |
| Gas  | D9-7             | 2I.02   | 24 x 24           | 30 x 30                         |
| Food                                       | D9-8             | 2I.02   | 24 x 24           | 30 x 30                         |
| Lodging                                    | D9-9             | 2I.02   | 24 x 24           | 30 x 30                         |
| Tourist Information                        | D9-10            | 2I.02   | 24 x 24           | 30 x 30                         |
| Diesel Fuel                                | D9-11            | 2I.02   | 24 x 24           | 30 x 30                         |
| Alternative Fuel - Compressed Natural Gas  | D9-11a           | 2I.02   | 24 x 24           | 30 x 30                         |
| Electric Vehicle Charging                  | D9-11b           | 2I.02   | 24 x 24           | 30 x 30                         |
| Electric Vehicle Charging (plaque)         | D9-11bP          | 2I.02   | 24 x 18           | 30 x 24                         |
| Alternative Fuel - Ethanol                 | D9-11c           | 2I.02   | 24 x 24           | 30 x 30                         |
| RV Sanitary Station                        | D9-12            | 2I.02   | 24 x 24           | 30 x 30                         |
| Emergency Medical Services                 | D9-13            | 2I.02   | 24 x 24           | 30 x 30                         |

Source: Manual on Uniform Traffic Control Devices (U.S. Department of Transportation, Federal Highway Administration), 2009, page 299.



## Section 2I.03 General Service Signs for Freeways and Expressways

Support:

- 01 General Service (D9-18 series) signs (see Figure 2I-3) are generally not appropriate at major interchanges (see definition in Section 2E.32) and in urban areas.

**Standard:**

- 02 **General Service signs shall have white letters, symbols, arrows, and borders on a blue background. Letter and numeral sizes shall comply with the minimum requirements of Tables 2E-2 through 2E-5. All approved symbols shall be permitted as alternatives to word messages, but symbols and word service messages shall not be intermixed. If the services are not visible from the ramp of a single-exit interchange, the service signing shall be repeated in smaller size at the intersection of the exit ramp and the crossroad. Such service signs shall use arrows to indicate the direction to the services.**

Option:

- 03 For numbered interchanges, the exit number may be incorporated within the sign legend (D9-18b) or displayed on an Exit Number (E1-5P) plaque (see Section 2E.31).

*Guidance:*

- 04 *Distance to services should be displayed on General Service signs where distances are more than 1 mile.*
- 05 *General Service signing should only be provided at locations where the road user can return to the freeway or expressway and continue in the same direction of travel.*
- 06 *Only services that fulfill the needs of the road user should be displayed on General Service signs. If State or local agencies elect to provide General Service signing, there should be a statewide policy for such signing and criteria for the availability of the various types of services. The criteria should consider the following:*

A. *Gas, Diesel, LP Gas, EV Charging, and/or other alternative fuels if all of the following are available:*

1. *Vehicle services such as gas, oil, and water;*
2. *Modern sanitary facilities and drinking water;*
3. *Continuous operations at least 16 hours per day, 7 days per week; and*
4. *Public telephone.*

B. *Food if all of the following are available:*

1. *Licensing or approval, where required;*
2. *Continuous operation to serve at least two meals per day, at least 6 days per week;*
3. *Public telephone; and*
4. *Modern sanitary facilities.*

C. *Lodging if all of the following are available:*

1. *Licensing or approval, where required;*
2. *Adequate sleeping accommodations;*
3. *Public telephone; and*
4. *Modern sanitary facilities.*

December 2009

Sect. 2I.02 to 2I.03

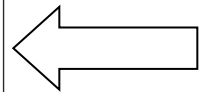
**Table 2E-1. Freeway or Expressway Guide Sign and Plaque Sizes (Sheet 1 of 2)**

| Sign or Plaque  | Sign Designation | Section | Minimum Size  |
|---|------------------|---------|---------------|
| <b>Exit Number (plaque)</b>                             |                  |         |               |
| 1-, 2-Digit Exit Number                                 | E1-5P            | 2E.31   | 114 x 30      |
| 3-Digit Exit Number                                     | E1-5P            | 2E.31   | 132 x 30      |
| 1-, 2-Digit Exit Number (with single letter suffix)     | E1-5P            | 2E.31   | 138 x 30      |
| 3-Digit Exit Number (with single letter suffix)         | E1-5P            | 2E.31   | 156 x 30      |
| 1-, 2-Digit Exit Number (with dual letter suffix)       | E1-5P            | 2E.31   | 168 x 30      |
| 3-Digit Exit Number (with dual letter suffix)           | E1-5P            | 2E.31   | 186 x 30      |
| Left (plaque)   | E1-5aP           | 2E.33   | 72 x 30       |
| <b>Left Exit Number (plaque)</b>                        |                  |         |               |
| 1-, 2-Digit Exit Number                                 | E1-5bP           | 2E.31   | 114 x 54      |
| 3-Digit Exit Number                                     | E1-5bP           | 2E.31   | 132 x 54      |
| 1-, 2-Digit Exit Number (with single letter suffix)     | E1-5bP           | 2E.31   | 138 x 54      |
| 3-Digit Exit Number (with single letter suffix)         | E1-5bP           | 2E.31   | 156 x 54      |
| 1-, 2-Digit Exit Number (with dual letter suffix)       | E1-5bP           | 2E.31   | 168 x 54      |
| 3-Digit Exit Number (with dual letter suffix)           | E1-5bP           | 2E.31   | 186 x 54      |
| Next Exit XX Miles (1 line)                             | —                | 2E.34   | Varies x 24   |
| Next Exit XX Miles (2 lines)                            | —                | 2E.34   | Varies x 36   |
| Exit Gore (no exit number)                              | E5-1             | 2E.37   | 72 x 60       |
| <b>Exit Gore (with exit number)</b>                     |                  |         |               |
| 1-, 2-Digit Exit Number                                 | E5-1a            | 2E.37   | 78 x 60       |
| 3-Digit Exit Number                                     | E5-1a            | 2E.37   | 96 x 60       |
| 1-Digit Exit Number (with single letter suffix)         | E5-1a            | 2E.37   | 90 x 60       |
| 2-Digit Exit Number (with single letter suffix)         | E5-1a            | 2E.37   | 108 x 60      |
| 3-Digit Exit Number (with single letter suffix)         | E5-1a            | 2E.37   | 126 x 60      |
| 1-Digit Exit Number (with dual letter suffix)           | E5-1a            | 2E.37   | 120 x 60      |
| 2-Digit Exit Number (with dual letter suffix)           | E5-1a            | 2E.37   | 138 x 60      |
| 3-Digit Exit Number (with dual letter suffix)           | E5-1a            | 2E.37   | 156 x 60      |
| <b>Exit Number (plaque)</b>                             |                  |         |               |
| 1-, 2-Digit Exit Number                                 | E5-1bP           | 2E.37   | 42 x 30       |
| 3-Digit Exit Number                                     | E5-1bP           | 2E.37   | 60 x 30       |
| 1-Digit Exit Number (with single letter suffix)         | E5-1bP           | 2E.37   | 48 x 30       |
| 1-Digit Exit Number (with dual letter suffix)           | E5-1bP           | 2E.37   | 72 x 30       |
| 2-Digit Exit Number (with single or dual letter suffix) | E5-1bP           | 2E.37   | 72 x 30       |
| 3-Digit Exit Number (with single or dual letter suffix) | E5-1bP           | 2E.37   | 72 x 30       |
| Narrow Exit Gore  | E5-1c            | 2E.37   | 60 x 90*      |
| Pull-Through  | E6-2             | 2E.12   | Varies x 120* |
| Pull-Through  | E6-2a            | 2E.12   | Varies x 90*  |
| Exit Only (with arrow)                                  | E11-1,1d         | 2E.24   | 174** x 36    |
| Exit  | E11-1a           | 2E.24   | 66 x 18       |
| Only  | E11-1b           | 2E.24   | 66 x 18       |
| Exit Only   | E11-1c           | 2E.24   | 120 x 18      |
| Exit Only (with two arrows)                             | E11-1e,1f        | 2E.24   | 222** x 36    |
| Left  | E11-2            | 2E.40   | 60 x 18       |
| Exit Gore Advisory Speed (plaque)                       | E13-1P           | 2E.37   | 72 x 24       |
| Exit Direction Advisory Speed                           | E13-2            | 2E.36   | 162 x 24      |
| Interstate Route Sign (1 or 2 digits)                   | M1-1             | 2E.27   | 36 x 36       |
| Interstate Route Sign (3 digits)                        | M1-1             | 2E.27   | 45 x 36       |
| Off-Interstate Route Sign (1 or 2 digits)               | M1-2,3           | 2E.27   | 36 x 36       |
| Off-Interstate Route Sign (3 digits)                    | M1-2,3           | 2E.27   | 45 x 36       |
| U.S. Route Sign (1 or 2 digits)                         | M1-4             | 2E.27   | 36 x 36       |
| U.S. Route Sign (3 digits)                              | M1-4             | 2E.27   | 45 x 36       |
| State Route Sign (1 or 2 digits)                        | M1-5             | 2D.11   | 36 x 36       |

**Table 2E-3. Minimum Letter and Numeral Sizes for Expressway Guide Signs According to Sign Type**

| Type of Sign  | Minimum Size |
|---|--------------|
| <b>A. Pull-Through Signs</b>  |              |
| Destinations — Upper-Case Letters   | 13.33        |
| Destinations — Lower-Case Letters   | 10           |
| Route Signs   |              |
| 1- or 2-Digit Shields   | 36 x 36      |
| 3-Digit Shields   | 45 x 36      |
| Cardinal Directions — First Letters   | 12           |
| Cardinal Directions — Rest of Word  | 10           |
| <b>B. Supplemental Guide Signs</b>  |              |
| Exit Number — Words   | 8            |
| Exit Number — Numerals and Letters  | 12           |
| Place Names — Upper-Case Letters  | 10.67        |
| Place Names — Lower-Case Letters  | 8            |
| Action Messages   | 8            |
| Route Signs   |              |
| Numerals  | 12           |
| 1- or 2-Digit Shield  | 24 x 24      |
| 3-Digit Shield  | 30 x 24      |
| <b>C. Interchange Sequence or Community Interchanges Identification Signs</b> |              |
| Words — Upper-Case Letters  | 10.67        |
| Words — Lower-Case Letters  | 8            |
| Numerals  | 10.67        |
| Fraction Numerals   | 8            |
| Route Signs   |              |
| Numerals  | 12           |
| 1- or 2-Digit Shield  | 24 x 24      |
| 3-Digit Shield  | 30 x 24      |
| <b>D. Next XX Exits Sign</b>  |              |
| Place Names — Upper-Case Letters  | 10.67        |
| Place Names — Lower-Case Letters  | 8            |
| NEXT XX EXITS — Words   | 8            |
| NEXT XX EXITS — Number  | 12           |

| Type of Sign   | Minimum Size |
|--|--------------|
| <b>E. Distance Signs</b>   |              |
| Words — Upper-Case Letters   | 8            |
| Words — Lower-Case Letters   | 6            |
| Numerals   | 8            |
| Route Signs  |              |
| Numerals   | 9            |
| 1- or 2-Digit Shield   | 18 x 18      |
| 3-Digit Shield   | 22.5 x 18    |
| <b>F. General Services Signs (see Chapter 2I)</b>                          |              |
| Exit Number — Words  | 8            |
| Exit Number — Numerals and Letters   | 12           |
| Services   | 8            |
| <b>G. Rest Area, Scenic Area, and Roadside Area Signs (see Chapter 2I)</b> |              |
| Words  | 10           |
| Distance Numerals  | 12           |
| Distance Fraction Numerals   | 8            |
| Distance Words   | 8            |
| Action Message Words   | 10           |
| <b>H. Reference Location Signs (see Chapter 2H)</b>                        |              |
| Words  | 4            |
| Numerals   | 10           |
| <b>I. Boundary and Orientation Signs (see Chapter 2H)</b>                  |              |
| Words — Upper-Case Letters   | 8            |
| Words — Lower-Case Letters   | 6            |
| <b>J. Next Exit and Next Services Signs</b>                                |              |
| Words and Numerals   | 8            |
| <b>K. Exit Only Signs</b>  |              |
| Words  | 12           |
| <b>L. Overhead Arrow-Per-Lane and Diagrammatic Signs</b>                   |              |
| See Table 2E-5   |              |



Note: Sizes are shown in inches and where applicable are shown as width x height

**Table 2E-4. Minimum Letter and Numeral Sizes for Freeway Guide Signs According to Interchange Classification**

| Type of Sign   | Type of Interchange (see Section 2E.32) |            |              |         | Overhead |
|--|---|------------|--------------|---------|----------|
|  | Major                                   |            | Intermediate | Minor   |          |
|  | Category a                              | Category b |              |         |          |
| <b>A. Advance Guide, Exit Direction, and Overhead Guide Signs</b>          |   |            |              |         |          |
| Exit Number Plaques  |   |            |              |         |          |
| Words  | 10                                      | 10         | 10           | 10      | 10       |
| Numerals & Letters   | 15                                      | 15         | 15           | 15      | 15       |
| Interstate Route Signs   |   |            |              |         |          |
| Numerals   | 24/18                                   | —          | —            | —       | 18       |
| 1- or 2-Digit Shields  | 48 x 48/<br>36 x 36                     | —          | —            | —       | 36 x 36  |
| 3-Digit Shields  | 60 x 48/<br>45 x 36                     | —          | —            | —       | 45 x 36  |
| U.S. or State Route Signs  |   |            |              |         |          |
| Numerals   | 24/18                                   | 18         | 18           | 12      | 18       |
| 1- or 2-Digit Shields  | 48 x 48/<br>36 x 36                     | 36 x 36    | 36 x 36      | 24 x 24 | 36 x 36  |
| 3-Digit Shields  | 60 x 48/<br>45 x 36                     | 45 x 36    | 45 x 36      | 30 x 24 | 45 x 36  |
| U.S. or State Route Text Identification (Example: US 56)                   |   |            |              |         |          |
| Numerals & Letters   | 18                                      | 18/15      | 15           | 12      | 15       |
| Cardinal Directions  |   |            |              |         |          |
| First Letters  | 18                                      | 15         | 15           | 10      | 15       |
| Rest of Words  | 15                                      | 12         | 12           | 8       | 12       |
| Auxiliary and Alternative Route Legends (Examples: JCT, TO, ALT, BUSINESS) |   |            |              |         |          |
| Words  | 15                                      | 12         | 12           | 8       | 12       |
| Names of Destinations  |   |            |              |         |          |
| Upper-Case Letters   | 20                                      | 20         | 16           | 13.33   | 16       |
| Lower-Case Letters   | 15                                      | 15         | 12           | 10      | 12       |
| Distance Numbers   | 18                                      | 18/15      | 15           | 12      | 15       |
| Distance Fraction Numerals   | 12                                      | 12/10      | 10           | 8       | 10       |
| Distance Words   | 12                                      | 12/10      | 10           | 8       | 10       |
| Action Message Words   | 12                                      | 12/10      | 10           | 8       | 10       |
| <b>B. Gore Signs</b>   |   |            |              |         |          |
| Words  | 12                                      | 12         | 12           | 8       | —        |
| Numeral & Letters  | 18                                      | 18         | 18           | 12      | —        |

Notes: 1. Sizes are shown in inches and where applicable are shown as width x height  
 2. Slanted line (/) signifies separation of desirable and minimum sizes

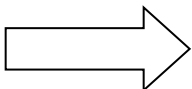
**Table 2E-5. Minimum Letter and Numeral Sizes for Freeway Guide Signs According to Sign Type**

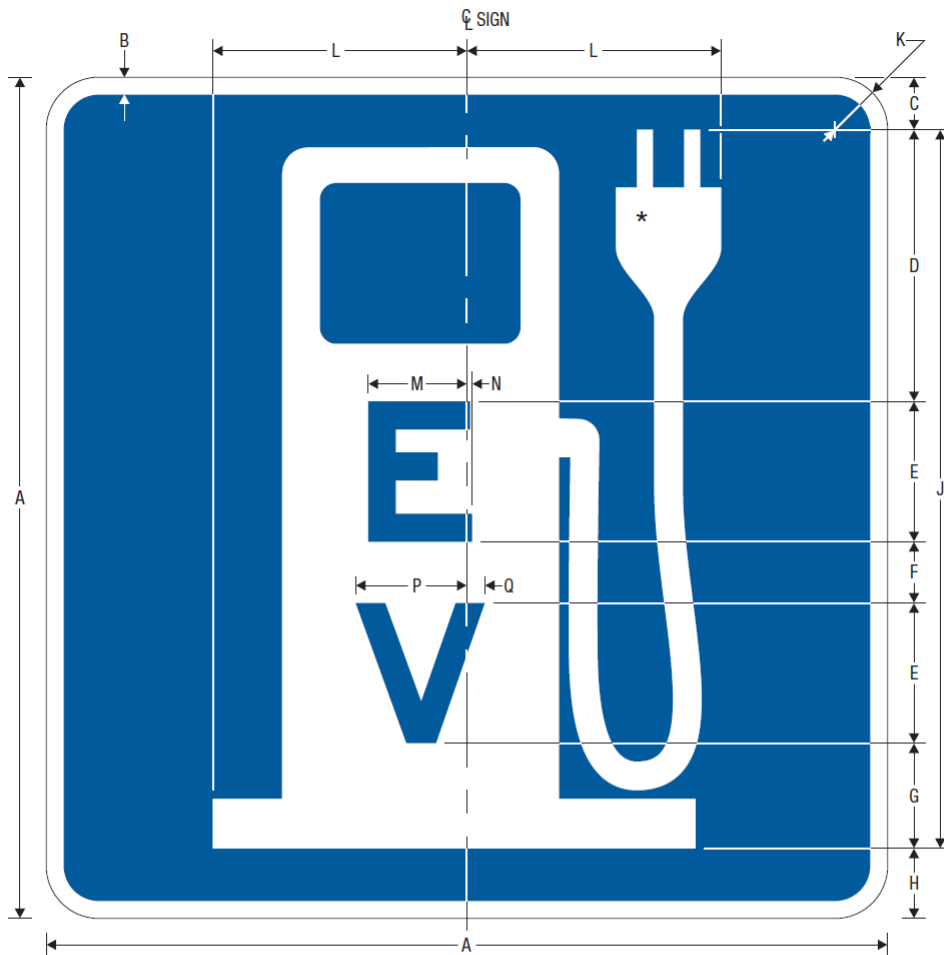
| Type of Sign  | Minimum Size |
|---|--------------|
| <b>A. Pull-Through Signs</b>  |              |
| Destinations — Upper-Case Letters   | 16           |
| Destinations — Lower-Case Letters   | 12           |
| Route Signs   |              |
| 1- or 2-Digit Shields   | 36 x 36      |
| 3-Digit Shields   | 45 x 36      |
| Cardinal Directions — First Letter  | 15           |
| Cardinal Directions — Rest of Word  | 12           |
| <b>B. Supplemental Guide Signs</b>  |              |
| Exit Number Words   | 10           |
| Exit Number Numerals and Letters  | 15           |
| Place Names — Upper-Case Letters  | 13.33        |
| Place Names — Lower-Case Letters  | 10           |
| Action Messages   | 8            |
| Route Signs   |              |
| Numerals  | 12           |
| 1- or 2-Digit Shield  | 24 x 24      |
| 3-Digit Shield  | 30 x 24      |
| <b>C. Interchange Sequence or Community Interchanges Identification Signs</b> |              |
| Words — Upper-Case Letters  | 13.33        |
| Words — Lower-Case Letters  | 10           |
| Numerals  | 13.33        |
| Fraction Numerals   | 10           |
| Route Signs   |              |
| Numerals  | 12           |
| 1- or 2-Digit Shield  | 24 x 24      |
| 3-Digit Shield  | 30 x 24      |
| <b>D. Next XX Exits Sign</b>  |              |
| Place Names — Upper-Case Letters  | 13.33        |
| Place Names — Lower-Case Letters  | 10           |
| NEXT XX EXITS — Words   | 10           |
| NEXT XX EXITS — Number  | 15           |
| <b>E. Distance Signs</b>  |              |
| Words — Upper-Case Letters  | 8            |
| Words — Lower-Case Letters  | 6            |
| Numerals  | 8            |
| Route Signs   |              |
| Numerals  | 9            |
| 1- or 2-Digit Shield  | 18 x 18      |
| 3-Digit Shield  | 22.5 x 18    |
| <b>F. General Services Signs (see Chapter 2I)</b>                             |              |
| Exit Number Words   | 10           |
| Exit Number Numerals and Letters  | 15           |
| Services  | 10           |

| Type of Sign   | Minimum Size |
|--|--------------|
| <b>G. Rest Area, Scenic Area, and Roadside Area Signs (see Chapter 2I)</b>   |              |
| Words  | 12           |
| Distance Numerals  | 15           |
| Distance Fraction Numerals   | 10           |
| Distance Words   | 10           |
| Action Message Words   | 12           |
| <b>H. Reference Location Signs (see Chapter 2H)</b>                          |              |
| Words  | 4            |
| Numerals   | 10           |
| <b>I. Boundary and Orientation Signs (see Chapter 2H)</b>                    |              |
| Words — Upper-Case Letters   | 8            |
| Words — Lower-Case Letters   | 6            |
| <b>J. Next Exit and Next Services Signs</b>                                  |              |
| Words and Numerals   | 8            |
| <b>K. Exit Only Signs</b>  |              |
| Words  | 12           |
| <b>L. Overhead Arrow-Per-Lane Signs</b>                                      |              |
| Arrowhead (Type D Directional Arrow)   | 21.625       |
| Arrow Shaft Width  | 8            |
| Arrow Height   |              |
| Through  | 72           |
| Left Only  | 48           |
| Right Only   | 48           |
| Optional-Diverge (Through with Left or Right)                                | 72           |
| Optional-Split (Left and Right)  | 66           |
| Vertical Separator Width   | 2            |
| Vertical Space between Vertical Separator and Top of Nearest Arrow           | 8            |
| Horizontal Space between Vertical Separator and Top of Nearest Through Arrow | 15           |
| Horizontal Space between Arrow Shaft and EXIT and ONLY plaques               | 10           |
| EXIT and ONLY Panels   | 60 x 18      |
| <b>M. Diagrammatic Signs</b>   |              |
| Arrowhead (Type D Directional Arrow)   | 13.5*        |
| Lane Widths  | 5            |
| Lane Line Segments   | 1 x 6        |
| Spacing between Lane Line Segments   | 6            |
| Stem Height to Upper Point of Departure                                      | 30           |
| Horizontal Space between Arrowhead and Route Shield or Destination           | 12           |

\* The size shown is the arrowhead width per lane depicted on the corresponding arrow shaft

Note: Sizes are shown in inches and where applicable are shown as width x height





D9-11b (Alternate)  
Electric Vehicle Charging (Alternate Symbol)

|          | A  | B    | C     | D     | E      | F    | G | H   | J      | K     | L     | M     |
|----------|----|------|-------|-------|--------|------|---|-----|--------|-------|-------|-------|
| <b>C</b> | 24 | 0.5  | 1.5   | 7.75  | 4 E(m) | 1.75 | 3 | 2   | 20.5   | 1.5   | 7.25  | 2.814 |
|          | 30 | 0.75 | 1.875 | 9.625 | 5 E(m) | 2    | 4 | 2.5 | 25.625 | 1.875 | 9.063 | 3.518 |

| N     | P     | Q     |
|-------|-------|-------|
| 0.148 | 3.174 | 0.507 |
| 0.185 | 3.968 | 0.635 |

\* See page IA-13-2 for symbol design

COLORS: LEGEND, BACKGROUND – BLUE (RETROREFLECTIVE)  
SYMBOL, BORDER – WHITE (RETROREFLECTIVE)

IA-13-1

Road signage adopted for EVs as it appears in detail in the Manual on Uniform Traffic Control Devices (U.S. Department of Transportation, Federal Highway Administration).

## A.2 ANNEX 2 UN Conventions on Road Traffic, Road Signs, and Signals

### Convention on Road Traffic

<http://www.unece.org/fileadmin/DAM/trans/conventn/crt1968e.pdf>

Vienna, 8 November 1968

Entered into force on 21 May 1977

<http://www.geocities.com/bkkridders/law/unc/>

**Contracting Parties:** Albania, Austria, Bahamas, Bahrain, Belarus, Belgium, Bosnia and Herzegovina (succession), Brazil, Bulgaria, Central African Republic, Cote d'Ivoire, Croatia (succession), Cuba, Czech Republic (succession), Democratic Republic of Congo, Denmark, Estonia, Finland, France, Georgia, [German Democratic Republic], Germany, Greece, Guyana, Hungary, Iran (Islamic Republic of), Israel, Italy, Kazakhstan, Kuwait, Latvia, Lithuania, Luxembourg, Monaco, Mongolia, Morocco, Niger, Norway, Pakistan, Philippines, Poland, Republic of Moldova, Romania, Russian Federation, San Marino, Senegal, Seychelles, Slovakia (succession), Slovenia (succession), South Africa, Sweden, Switzerland, Tajikistan, The former Yugoslav Republic of Macedonia (succession), Turkmenistan, Ukraine, Uruguay, Uzbekistan, Yugoslavia (succession), Zimbabwe.

**Countries which have signed the Convention but have not ratified it:** Chile, China, Costa Rica, Ecuador, Ghana, Holy See, Indonesia, Mexico, Portugal, Republic of Korea, Spain, **Thailand**, United Kingdom, Venezuela.

#### Declarations and Reservations

##### Thailand

"Thailand will not be bound by article 52 of this Convention.

"Thailand will consider mopeds as motor-cycles."

### [Convention on Road Signs and Signals](#) [PDF]

Vienna, 8 November 1968

Entered into force on 6 June 1978

**Contracting Parties:** Austria, Bahrain, Belarus, Belgium, Bosnia and Herzegovina (succession), Bulgaria, Central African Republic, Chile, Cote d'Ivoire, Croatia (succession), Cuba, Czech Republic (succession), Democratic Republic of Congo, Denmark, Estonia, Finland, France, Georgia, [German Democratic Republic], Germany, Greece, Hungary, India, Iran (Islamic Republic of), Iraq, Italy, Kazakhstan, Kuwait, Latvia, Lithuania, Luxembourg, Mongolia, Morocco, Norway, Pakistan, Philippines, Poland, Republic of Moldova, Romania, Russian Federation, San Marino, Senegal, Seychelles, Slovakia (succession), Slovenia (succession), Sweden, Switzerland, Tajikistan, The Former Yugoslav Republic of Macedonia (succession), Turkmenistan, Ukraine, Uzbekistan, Yugoslavia (succession).

**Countries which have signed the Convention but have not ratified it:** Brazil, China, Costa Rica, Ecuador, Ghana, Holy See, Indonesia, Mexico, Portugal, Republic of Korea, Spain, **Thailand**, United Kingdom, Venezuela.

**Contracting Parties of the 1971 European Complementary Agreement**  
EUROPEAN AGREEMENT SUPPLEMENTING THE CONVENTION ON ROAD TRAFFIC  
OPENED FOR SIGNATURE AT VIENNA ON 8 NOVEMBER 1968.

**THE CONTRACTING PARTIES, BEING ALSO PARTIES TO THE CONVENTION ON ROAD TRAFFIC OPENED FOR SIGNATURE AT VIENNA ON 8 NOVEMBER 1968**, DESIRING to achieve greater uniformity in the rules governing road traffic in Europe, HAVE AGREED as follows:

(Source: <http://www.unece.org/trans/conventn/11-E-ECE-813.pdf>)