ENERGY STAR Market and Industry Scoping Report
Electric Vehicle Supply Equipment (EVSE)
September 2013

The U.S. Environmental Protection Agency (EPA) consistently looks for new opportunities to expand ENERGY STAR to new product categories that will deliver significant benefits to consumers and the environment in the form of energy and dollar savings plus greenhouse gas reductions. A key step in this evaluation is the development of a scoping report that provides a snapshot of the product market, energy use, and savings potential associated with an ENERGY STAR program for the scoped product type. EPA uses scoping findings to prioritize product specification development work. While scoping reports are drafted primarily for internal evaluation purposes, and are not intended to be exhaustive but rather a guidepost for the ENERGY STAR program, EPA makes the reports available with the interest of benefiting other efficiency programs evaluating similar opportunities. For more information about the ENERGY STAR specification development process, go to: www.energystar.gov/productdevelopment.

1. Introduction

In 2012, sales of hybrid and electric vehicles exceeded 470,000 units—a gain of 64% over the previous year. By 2017 sales could reach 850,000.[1] The Electric Power Research Institute projects that 62% of the entire U.S. vehicle fleet will consist of plug-in hybrid-electric vehicles (PHEVs) or plug-in electric vehicles (PEVs) by 2050 using a moderate projection scenario.[2] Electric Vehicle Supply Equipment (EVSE) provides for the safe transfer of energy between the electric utility power and the EV. EVSE includes EV charge cords, charge stands (residential or public), attachment plugs, vehicle connectors, and protection. Adoption of EVSE is critical to the success of electric vehicles in the U.S.

2. EVSE Product Type Overview

Level 1 and Level 2 EVSE convert the utility's ac power into dc power through the EV's on-board charger. EV manufacturers provide the Level 1 EVSE consisting of a power supply cable with a standard 3-prong plug (NEMA 5-15P/20P, limited to 20 amps) and a charge current interrupting device (CCID) located in the cable within 12 inches of the plug. Level 2 EVSE typically operate with a peak current of 32 amps ac with a branch circuit breaker rated at 40 amps. The vehicle charger communicates with the EVSE to identify the circuit rating (voltage and current) and adjust the charge to the battery accordingly. Level 3 provides electricity through an off-board charger, delivering dc power directly to the vehicle.

[1] Mintel International Group Ltd., "Hybrid and Electric Cars – US – November 2012," http://www.marketresearch.com/Mintel-International-Group-Ltd-v614/Hybrid-Electric-Cars-November-7280067/view-toc/.
[2] M. Chow, W. Su, H. Rahimi-Eichi, and W. Zeng, "A Survey on the Electrification of Transportation in a Smart Grid Environment," *IEEE Transactions on Industrial Informatics*, Vol. 8, No. 1, February 2012.

The Society of Automotive Engineers (SAE) J1772 North American (and Japanese) standards for electric vehicle charge connectors for electric vehicles are listed below.

Table 1: Charging Power Levels Based in Part on SAE Standard J1772[3]

Power Level Types	Charger Location	Typical Use	Energy Supply Interface	Expected Power Level	Charging Time	Vehicle Technology
Level 1 (Opportunity) 120 Vac (US) 230 Vac (EU)	On-board 1-phase	Charging at home or office	Convenience outlet (NEMA 5-15R/20R)	1.4kW (12A) 1.9kW (20A)	4-11 hours 11-36 hours	PHEVs (5-15kWh) EVs (16-50kWh)
Level 2 (Primary) 240 Vac (US) 400 Vac (EU)	On-board 1- or 3-phase	Charging at private or public outlets	Dedicated EVSE	4kW (17A) 8kW (32A) 19.2 kW (80A)	1-4 hours 2-6 hours 2-3 hours	PHEVs (5-15kWh) EVs (16-30kWh) EVs (3-50kWh)
Level 3 (Fast) (208-600 Vdc)	Off-Board 3-phase	Commercial, analogous to a filling station	Dedicated EVSE	50kW 100kW	0.4-1 hour 0.2-0.5 hour	EVs (20-50kWh)

The figures below illustrate typical charging configurations and products available on the market today.

Figure 1: Level Charging Diagram and Representative Product[4]

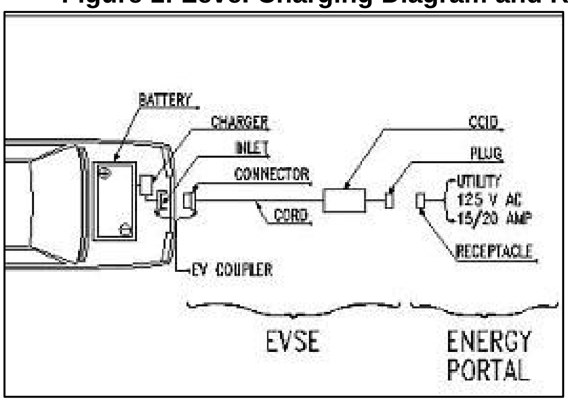
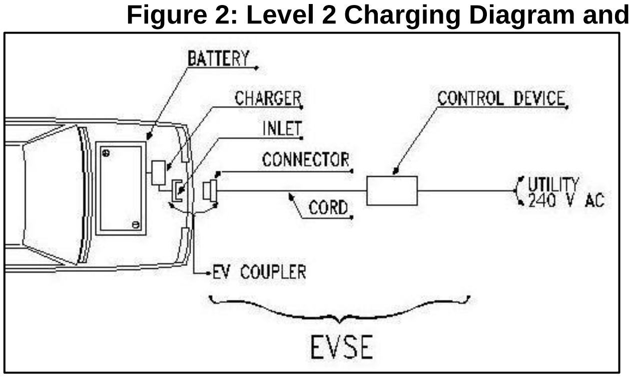
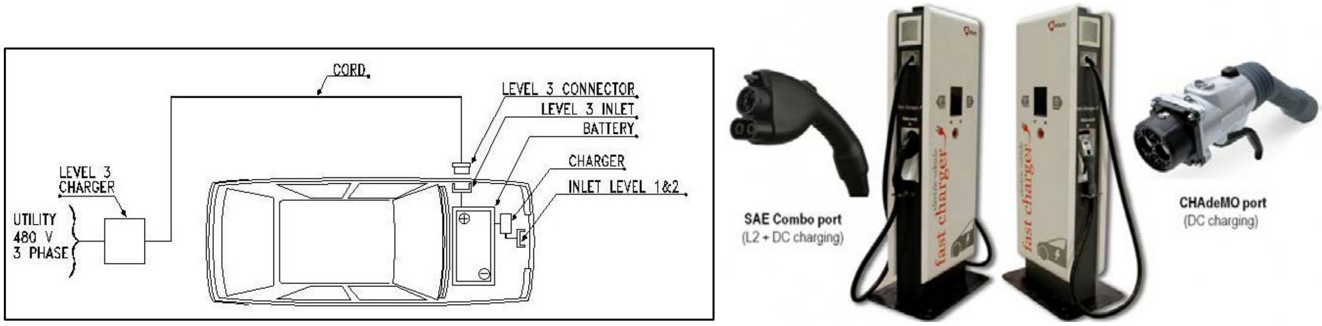


Figure 2: Level 2 Charging Diagram and Connectors[5]



[3] P. Krein and M. Yilmaz, “Review of Battery Charger Topologies, Charging Power Levels, and Infrastructure for Plug-In Electric and Hybrid Vehicles,” *IEEE Transactions on Power Electronics,* Vol. 28, No. 5, May 2013.
[4] Electric Transportation Engineering Company, “Electric Vehicle Charging Infrastructure Deployment Guidelines for The Oregon I-5 Metro Areas of Portland, Salem, Corvallis, and Eugene,” Draft Version 1.0, January 2010, http://www.rmi.org/Content/Files/Oregon%20EV%20Infrastructure%20%20Guidelines.pdf.
[5] *Ibid*.

Figure 3: Level 3 Charging Diagram and Connectors[6]



Level 3 DC fast-charging stations can be modified to serve both the CHAdeMO connector standard backed by Japanese automakers like Mitsubishi and Nissan and the SAE Combo connector standard backed by U.S. and German automakers.[7] The competing connectors are shown in Figure 3, above. Refer to Appendix A for a comprehensive list of EVSE industry standards.

3. Market: Sales, Usage Cases, and Installation

EVSE are used in the following settings:

- Residential (Level 1 and Level 2):
  - Individual homes – garages, carports
- Commercial (Level 2 and Level 3):
  - Townhouses, condominiums, apartments
  - Workplaces, schools, hospitals, hotels, parking lots, garages, retail facilities
- Public Use (Level 2 and Level 3)
  - Train stations
  - Government buildings

Most EV owners living in detached houses will purchase Level 2 EVSE through the vehicle manufacturer or retail channels to use as the primary or preferred charging method. With about half of the vehicles in the United States parked at overnight locations with access to plugs,[8] approximately 2/3 of charging occurs in a residential setting and 1/3 of charging occurs in a commercial setting.[9]

For purposes of this report, the simplified assumption is that most EV owners will recharge the battery in the evening or overnight following the work day. The U.S. Department of Transportation (DOT) Federal Highway Administration estimates that the average U.S. driver averages 37 miles per day over the course of the year.[10] Electric vehicle ranges can meet the average driver's needs with the 2012 Chevrolet Volt storing up to 40 miles per charge and the 2012 Nissan Leaf storing up to 100 miles per charge.[11]

Global sales of EVSE will rise from under 200,000 units in 2012 to almost 2.4 million units in 2020 (about 500,000 in the US). By 2020, 11.4 million EV charging stations will be in operation worldwide (stock). Navigant Research

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[6] Electric Transportation Engineering Company, "Electric Vehicle Charging Infrastructure Deployment Guidelines for The Oregon I-5 Metro Areas of Portland, Salem, Corvallis, and Eugene," Draft Version 1.0, January 2010, http://www.rmi.org/Content/Files/Oregon%20EV%20Infrastructure%20%20Guidelines.pdf.

[7] D. King, "Sacramento getting first DC fast chargers," http://green.autoblog.com/2013/08/30/sacramento-first-with-dc-fast-chargers-with-sae-combo-chademo/.

[8] U.S. Department of Energy, "EV Everywhere Workplace Charging Challenge," http://www1.eere.energy.gov/vehiclesandfuels/electric_vehicles/workplace_charging.html.

[9] T. Bahn, "Codes and Standards Support for Vehicle Electrification," Argonne National Laboratory. 2013 DOE Hydrogen and Vehicle Technologies Annual Merit Review. Presented on May 14, 2013.

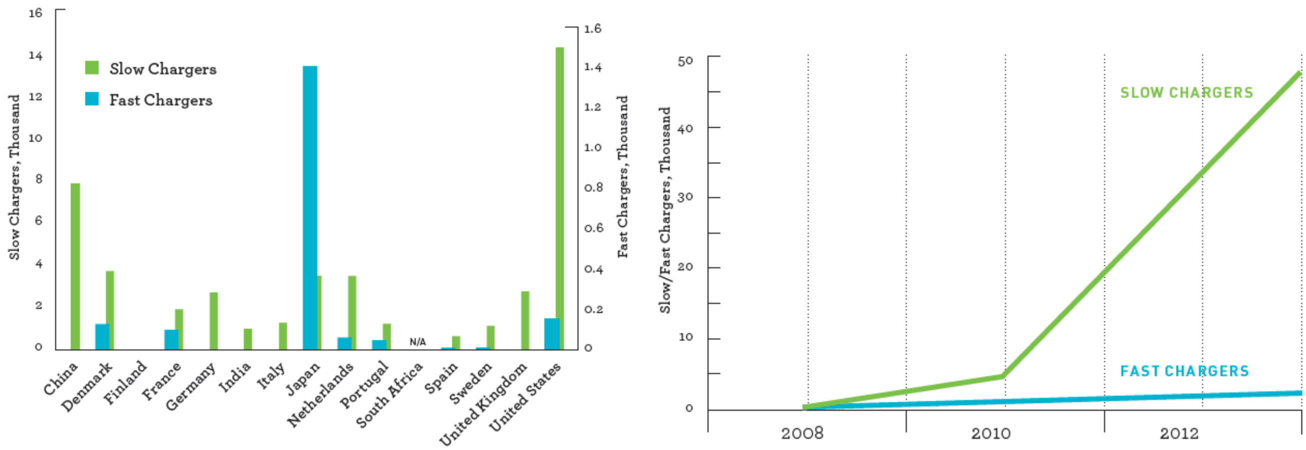
[10] U.S. Department of Transportation Federal Highway Administration, http://www.fhwa.dot.gov/policyinformation/statistics/2010/rc1c.cfm .

[11] D. Change, D. Erstad, E. Lin, A. Rice, C. Goh, " Financial Viability Of Non-Residential Electric Vehicle Charging Stations," University of California, Los Angeles, http://luskin.ucla.edu/sites/default/files/Non-Residential%20Charging%20Stations.pdf.

forecasts that the global EVSE market will grow from $713 million in 2013 to $3.8 billion by 2020, a compound annual growth rate (CAGR) of 27.1%.[12] These estimates are used to calculate the EVSE Level 2 savings potential in Section 4.

Due to more reliance on home charging and the prevalence of PHEVs, Level 2 chargers are more common than dc fast chargers in the U.S. According to the EIA, "early estimates of adequate non-residential EVSE/EV ratios range from 0.08 to 0.3.[13] While fast charging ratios in the U.S. are much lower, it is also possible that fast chargers are not as widely needed as previously thought. In one U.S. study, 100-200 fast charging locations were deemed sufficient for good initial geographic coverage for the majority of drivers in California. [14]

Figure 4: Non-Residential EVSE Stock and Growth by Slow (Levels 1 and 2) /Fast (Level 3), 2012[15]



Features

Most EVSE is sold with basic features such as auto-restart and LED status indicators. Additional features include programming and timers to manually schedule delayed starts. EVSE may also provide network connectivity and bi-directional data flow between the utility and vehicle.

Pricing

According to Wired.com electric vehicle prices are coming down, but the cost of chargers has always hovered in the $1,000-$2,000 range. This trend could change as more manufacturers and new products enter the market. Bosch has a $950 charger, the Power Xpress on sale, but the company has distilled that same technology into a more affordable package with its 2013 Power Max system retailing for under $800.[16] This Power Max charger, however, does not come with a network connection or other additional features.

Installation

In addition to the actual EVSE product cost, Level 2 and Level 3 typically have additional installation costs to hard-wire the EVSE to the utility supply. For a Level 2 installation, a branch circuit and appropriate breakers, conductors, and receptacles are needed, warranting or requiring a professional electrician.

Below are some example costs related to the installation of EVSE. Level 3 chargers require significantly more capital and planning and thus make Level 2 EVSE deployment options more appealing despite longer charge times. In addition to the cost aspect, the installation process can often be complex, requiring permits and

[12] Green Car Congress, "Navigant Research forecasts EV charger global market to grow to $3.8B by 2020; 27.1% CAGR from 2013",Electric 11 April 2013, http://www.greencarcongress.com/2013/04/nav-evse-20130411.html.
[13] International Energy Agency, "Global EV Outlook: Understanding the Electric Vehicle Landscape to 2010," April 2013. http://www.iea.org/topics/transport/electricvehiclesinitiative/EVI_GEO_2013_FullReport.pdf.
[14] *Ibid*.
[15] *Ibid*.
[16] D. Lavrinc, "At Long Last, an Affordable Electric-Vehicle Charger," Wired.com, http://www.wired.com/autopia/2013/05/bosch-power-max/.

discussions with the utility. Process diagrams for the installation are shown in Appendix B. Consumers could potentially benefit from additional resources guiding them through this process.

Table 2: Installation Costs for Residential and Publicly Available EVSE/Charge Stations[17]

	Residential Level 2 (Qty 1)	Publicly Available Charge Station Level 2 (Qty 2)	Publicly Available Charge Station Level 3 (Qty 2)
Labor	$1,050	$4,670	$7,020
Materials (EVSE, panels, breakers, signage, etc.)	$1,137	$6,840	$56,863
Permit	$85	$85	$85
Trenching and Repair	N/A	$4,500	$1,500
Concrete Work	N/A	N/A	$1,500
Total	**$2,272**	**$16,095**	**$66,968**

Utility and Commercial Payment Options

In both residential and commercial settings the following mechanisms for utilities to control EV load may be implemented:[18]

- Time-of-use (TOU) – Owner charges at off-peak times when demand on the utility electrical grid is at its lowest point;
- Dual Metering – Some utilities provide a special rate for EV charging and require the installation of a second meter;
- Demand Response – EVs may participate in programs where the utility enters into contract with EV owners to allow the utility to maintain more control on EV chagrining via smart meters;
- Real-Time Pricing (RTP) – Price signals are sent to a customer through a number of communication mediums that allows the customer to charge their EV during the most cost effective period. Smart meters would need to be in place at the charging location and the technology built into EVSE to enable charging to occur without customer intervention via RTP signaling; and
- Vehicle-to-Grid (V2G) – Allows the energy stored in the vehicle battery to supplement home electrical requirements. To support this concept (still years away from implementation), a bidirectional on-board charger is necessary.

Commercial operators of EVSE need to work with software/payment service providers (eVgo, ChargePoint) or consider the following point-of-sale options[19]

1. Card Readers: credit/debit card readers and smart card readers – communication system from the read to a terminal for off-site approval and data recording is require;
2. Parking Area Meters – integrated into existing parking meter infrastructure; and
3. Radio-Frequency Identification (RFID) Subscription Service – RFID fob can be programmed with user information. Monthly subscription keeps the fob active.

4. Stakeholders and Existing Federal Government Initiatives

[17] Electric Transportation Engineering Company.
[18] *Ibid*.
[19] *Ibid*.

Table 3: Relevant Industry Organizations

Organization
Society of Automotive Engineers (SAE)
Institute of Electrical and Electronics Engineers (IEEE)
Electric Power Research Institute (EPRI)
ZigBee Alliance
National Electric Code (NEC)
American National Standards Institute (ANSI)
HomePlug Power Alliance
EV Plug Alliance
National Electrical Manufacturers Association (NEMA)
Underwriters Laboratory (UL)
International Electrotechnical Commission (IEC)

Table 4: EVSE Manufacturers and Their Vehicle Partners

EVSE Manufacturers	Vehicle Partners
AeroVironment	Nissan, BMW, Mitsubishi, Fiat, Ford
Bosch	
ChargePoint	
ClipperCreek	
Eaton	
Ecotality	Nissan Leaf
GE	
Hubbell	
Leviton	
NEC - Takasago Ltd.	
Schneider Electric	
Siemens	
SPX	Chevrolet Volt
Voltec	

The payment and service models for EVSE are continuing to evolve and diversify as indicated by the following providers, in Table 5, which offer stationary and mobile options and annual and monthly plans to commercial operators and consumers.

Table 5: EVSE Service Providers

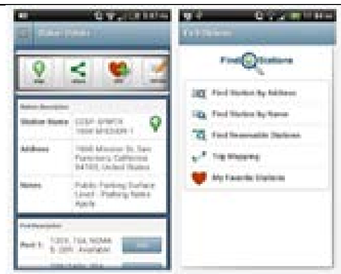
Company Name	Highlights
eVgo (ee-vee-go) (part of NRG) 	Deploys chargers to homes and public spaces and charges subscription fees – basic for home installation of charger. Higher plan that covers electricity as well for home charger and network of chargers. See: http://www.nrgevgo.com/
ChargePoint (part of Coulomb technologies) (Illustration of phone app) 	Nearly 13,000 ChargePoints are in operation. The ChargePoint annual subscription service plans work with stations from ChargePoint and from other manufacturers who have built compatible stations. The ChargePoint solution also supports APIs to integrate billing or other charging operations with existing systems. See: http://www.chargepoint.com/
Ubitricity (Germany)  	A mobile meter attached to the charging cable closes the circuit and allows charging. The meter keeps track of how much electricity is used and communicates that to the relevant utility via cellular connection. Less expensive than fixed electric car charging stations. See: https://ubitricity.com/en/

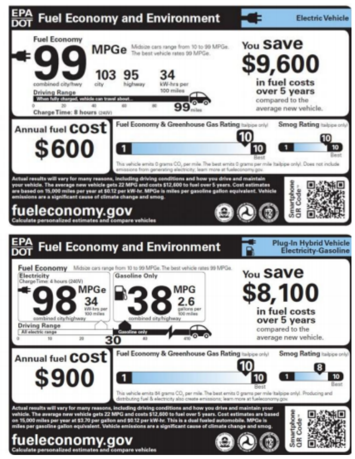
Table 6: Existing U.S. Federal Government Programs and Initiatives

Department	Program	Description
U.S. Department of Energy	The EV Project http://www.theevproject.com/	"Collects and analyzes data on vehicle use in diverse topographic and climatic conditions, evaluates the effectiveness of charge infrastructure, and conducts trials of various revenue systems for commercial and public charge infrastructures. The ultimate goal of The EV Project is to take the lessons learned from the deployment of the first thousands of EVs, and the charging infrastructure supporting them, to enable the streamlined deployment of the next generation of EVs to come."
U.S. Department of Energy	EV Everywhere Workplace Charging Challenge http://www1.eere.energy.gov/vehiclesandfuels/electric_vehicles/workplace_charging.html	"Calls on America's employers to sign the Workplace Charging Challenge Pledge as "Partners" to make a bold commitment to provide PEV charging access to their workforce. The Pledge also enlists stakeholder organizations as "Ambassadors" to promote and facilitate workplace charging. Nearly 50 major companies have pledged (Verizon, Samsung, Cisco, Coca-Cola)"
U.S. Environmental Protection Agency and U.S. Department of Transportation	Fuel Economy and Environment Label for Electric Vehicles http://www.fueleconomy.gov/feg/label/learn-more-electric-label.shtml	The label provides over a dozen pieces of information to consumers purchasing a new hybrid or electric vehicle (see Figure 5, below). It does not provide efficiency data for the on-board charger.
Internal Revenue Service (IRS)	Plug-In Electric Drive Vehicle Credit http://fueleconomy.gov/feg/taxcenter.shtml	Provides up to USD 7,500 tax credit for vehicles, based on battery capacity. Phased out after 200,000 vehicles from qualified manufacturers.
Internal Revenue Service (IRS)	EVSE Installation Tax Credit http://fueleconomy.gov/feg/taxcenter.shtml	Provides a tax credit of 30% of the cost, not to exceed USD 30,000, for commercial EVSE installation; a tax credit of up to USD 1,000 for consumers who purchase qualified residential EVSE. Provides a total of USD 360 million for infrastructure demonstration projects.

The majority of the above Federal initiatives focus on R&D and financial incentives. There is currently no vehicle or EVSE label for on-board charger and EVSE efficiency, and third-party online resources and information about EVSE are not prevalent. The below figure is the Fuel Economy and Environment Label illustrating the large amount of information consumers already encounter when purchasing an EV. The label does not include data on the on-board charging efficiency.

Figure 5: Ecologic Institute Analysis of Existing U.S. Federal Electric and Hybrid Car Labels[20]

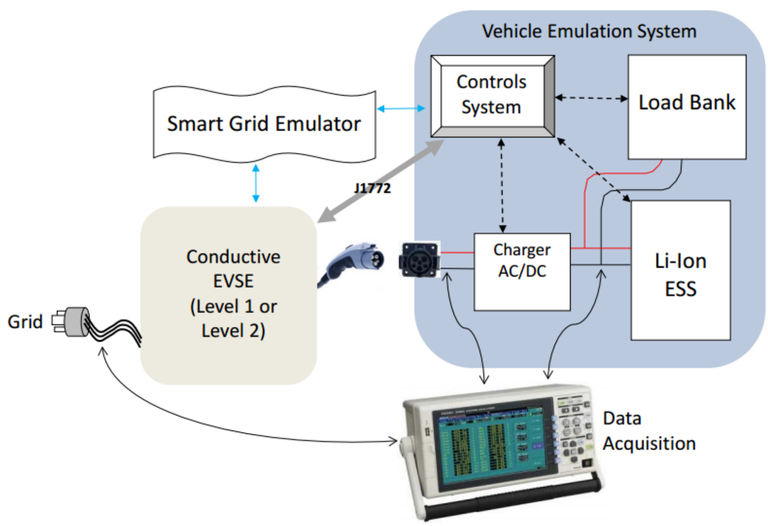
Label Attribute	
	Separate label for electric and hybrid vehicles
Format	**Absolute:** same scale as other passenger vehicles **Static**
Additional Information	Charge time, driving range, fuel economy by electricity and gasoline
Assessment	Focus on costs Potential information overload



5. *Testing, Efficiency Data, and Savings Potential*

Idaho National Laboratory (INL) has measured EVSE power usage with the test set-up below. INL charged a Chevrolet Volt using Level 1 and Level 2 EVSE. No on-board vehicle components were included in the power usage measurements.

Figure 6: INL Conductive EVSE Test Set-up[21]



[20] M. Grünig, "Car Labeling: A Comparison of Case Studies." Ecologic Institute Presentation, http://www.ecologic.eu/files/presentations/2013/Car%20Labeling%20Presentation_English_Gruenig.pdf.
[21] J. Francfort, "INL Efficiency and Security Testing of EVSE, DC Fast Chargers, and Wireless Charging Systems," Idaho National Laboratory. Presented on May 14, 2013, http://www4.eere.energy.gov/vehiclesandfuels/resources/merit-review/content/inl-efficiency-and-security-testing-evse-dc-fast-chargers-and-wireless-charging-systems.

INL tested the efficiency and standby power usage (just before and after charging) of one Level 1 EVSE model, 12 Level 2 models, and one Level 3 model (analyzed separately in Figure 9). INL measured the steady-state charge power which is the most common power level dictated by the vehicle during charge. During the steady-state charge, most EVSE had losses under 30 W. The measured standby power ranged from 1.3 W to 13.4 W and roughly correlates with the amount of features offered by the EVSE including timers, flashlights, and network connectivity.

Figure 6: AC Energy Consumption at Rest and During Chevy Volt Charging[22]

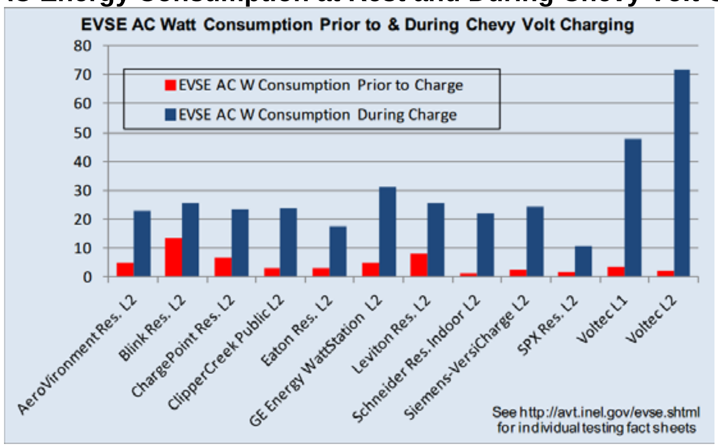
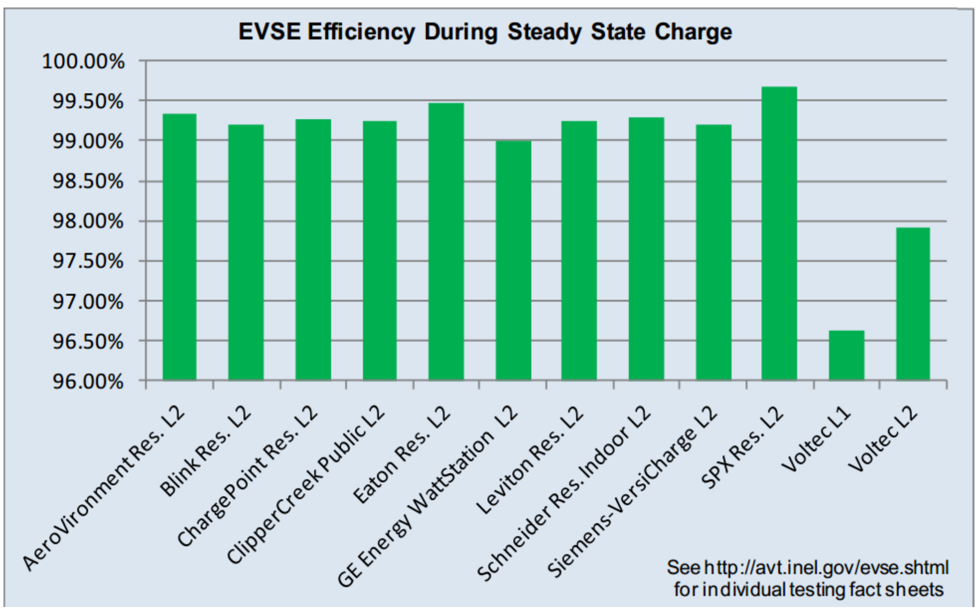


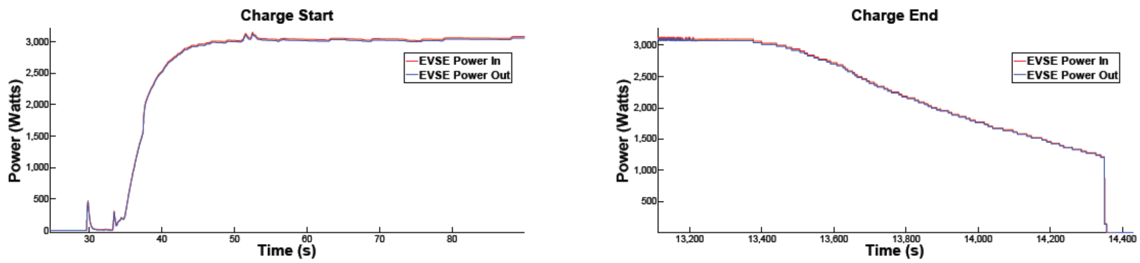
Figure 7: Conductive EVSE Charging Efficiency[23]



As shown in the Figure 7, above, most Level 2 EVSE models are over 99% efficient during steady-state charge per INL's tests. Charging efficiency can be difficult to quantify with a single number for all conditions; however, steady-state charge accounts for the overwhelming amount of time that the charger is in active use: in one case, 3.7 of the 4 hours spent charging, as shown in Figure 8, below.

[22] J. Francfort, "INL Efficiency and Security Testing of EVSE, DC Fast Chargers, and Wireless Charging Systems," Idaho National Laboratory. Presented on May 14, 2013, http://www4.eere.energy.gov/vehiclesandfuels/resources/merit-review/content/inl-efficiency-and-security-testing-evse-dc-fast-chargers-and-wireless-charging-systems.
[23] *Ibid.*

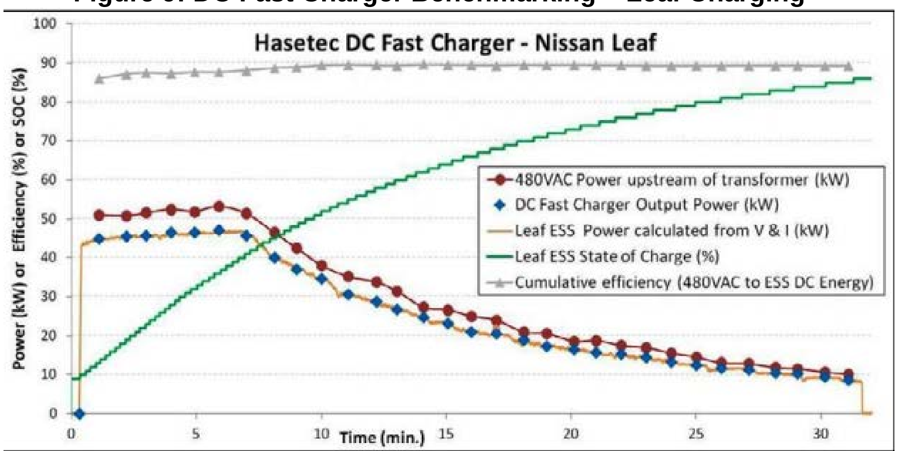
Figure 8: Schneider Electric EV2430WS Test Data[24]



NOTE: Charge start and charge end power demand curves are dependent upon the vehicle

Although the above graphs show high efficiency among chargers, INL also tested a Hasetec DC Fast Charger (Level 3) with the Nissan Leaf and found it had an overall charge efficiency of 88.7%.

Figure 9: DC Fast Charger Benchmarking – Leaf Charging[25]



Ongoing Testing and Pilot Studies

INL is also continuing to conduct tests on EVSEs with a focus communications, cyber security, and smart grid functionality, working with EVSE operators and utilities. For example, INL has initiated data collection from ~500 Level 2 EVSEs as they are deployed throughout New York State in partnership with NYSERDA, NYPA, Port Authority of NY / NJ, and Energetics Existing Labeling and Incentive Programs.[26]

Efficiency Data and Savings Analysis

The efficiency data and savings analysis conducted for this report focus only on Level 2 EVSE (commercial and residential). Level 1 and Fast charging (Level 3) were excluded due to insufficient data and their limited expected use in the field: Level 1 provides a slower charge, while Level 2 requires significant capital investment and planning.

[24] J. Francfort, "INL Efficiency and Security Testing of EVSE, DC Fast Chargers, and Wireless Charging Systems," Idaho National Laboratory. Presented on May 14, 2013, http://www4.eere.energy.gov/vehiclesandfuels/resources/merit-review/content/inl-efficiency-and-security-testing-evse-dc-fast-chargers-and-wireless-charging-systems.

[25] *Ibid*.

[26] *Ibid.*

Table 7displays product data from INL's tests. Top performing models are designated as "efficient" with the rest of the models designated as "standard." Aside from the outlying Voltec model with 97.91% efficiency, there is little differentiation among products. Estimated annual energy use calculations in the subsequent tables use the power measurement "Prior to Charge" as the standby power (yellow highlighted cells). Models with network connectivity features are highlighted in purple.

Table 7: INL Level 1 and Level 2 EVSE Efficiency Data

Manufacturer	Model Number	EVSE Features - *purple indicates network functionality*	Prior to Charge (W)	Steady State Charge (W)	Post Charge (W)	Steady State Efficiency	Average Efficiency
Level 1 EVSE							
Voltec Level 1	2024191	Low and High Current Settings, Auto-restart, Integrated Flashlight	3.6	47.98	3.6	96.62%	N/A
Level 2 EVSE							
Voltec Level 2	22765700	Integrated Flashlight, 25ft coiled cable, Auto-reset	2.2	71.5	2.8	97.91%	99.0% (Standard Model)
GE Energy WattStation Wall-Mount Unit	Wall-Mount Unit	Power Button for Zero Consumption, Multi-Colored Charge Indicator, Auto-restart, LED power indicator	4.9	31.2	4.9	99.00%	
Blink Residential Wall-Mount Unit	Model No. we-30cire	Touch screen, Backlit screen, User charge scheduling via PDA, Internet, touch pad, PLC, Wi-Fi, cellular, LAN communications, Web-based bi-directional data flow	13.4	25.6	12.5	99.19%	
Siemens-VersiCharge	VC30BLKB	Power Limit Switch, LED Charge Indicator, LED Power Indicator	2.5	24.4	5.3	99.21%	
ClipperCreek Public EVSE	CS-40	LED Status Light	3.21	23.75	3.26	99.24%	
Leviton Residential Wall-Mount	EVB22-3PM	One-button interface, LED status indicator	8.18	25.72	7.48	99.24%	
ChargePoint Residential Wall-Mount Unit	CT503	Wi-Fi, cellular communications, vacuum florescent display, automated meter infrastructure, user charge scheduling	6.9	23.6	6.8	99.26%	
Schneider Electric	EV2430QWS	Charge Delay Option, Eight-segment process indicator, power light indicator, auto-restart	1.3	22.2	2.2	99.29%	
AeroVironment	EVSE-RS	LED Status Light	5.11	22.77	5	99.33%	99.5% (Efficient Model)
Eaton Residential Wall-Mount Unit	EVSE L2 30 C L B W	LED Status Features	3.2	17.4	2.8	99.48%	
SPX Residential Wall-Mount Unit	EV20M26318U	LED status, UART Interface	1.8	10.8	1.2	99.68%	

Table 8, below, presents calculations of the total annual energy needed to charge a typical EV for the average U.S. driver and the associated savings from using a potential "efficient" model compared to a representative "standard" model.

Table 8: Level 2 Unit Savings Potential for Steady State Charging

Average Annual Miles per U.S. Driver[27]	Fuel Economy (kWh/100 miles)[28]	Total Annual Energy (kWh/yr)	Standard Steady State Charge Efficiency	Efficient Steady State Charge Efficiency	Unit Savings (kWh/yr)
13,476	30	4043	99.0%	99.5%	18

Table 9, below, calculates the number of hours spent in standby mode and the power levels that could be representative of a standard model and an efficient model for both a basic model and a network connected model and the potential savings (21 kWh/yr for basic and 53 kWh/yr for network connected).

Table 9: Level 2 Unit Savings Potential for Standby Mode

EV On-Board Charger Capacity (kW)	Annual Level 2 Charging Hours (hr)	Annual Standby Hours (hr)	Efficient *Basic* EVSE (W)	Standard *Basic* EVSE (W)	Unit Savings *Basic* (kWh/yr)	ES *Network Connected* EVSE Standby Power (W)	Non-ES *Network Connected* EVSE Standby Power (W)	Unit Savings *Network Connected* (kWh/yr)
6.6	613	8147	1.55	4.2	22	6.9	13.4	53

Table 10, below, estimates the total unit savings by summing the savings during steady state charge and standby. The national savings estimate for the U.S. is calculated based on predicted annual unit shipments of EVSE.

Table 10: Level 2 Total Operation Unit and National Savings Potential

Unit Energy Savings Range (Charging and Standby Mode) (kWh/yr)	Average Unit Energy Savings (kWh)	Rough Estimate of U.S. EVSE Level 2 U.S. Shipments in 2015[29]	Total U.S. Savings for 2015 Shipments (MWh/yr)	GHG Equivalent (pounds CO2/yr)	Car Equivalent (car/yr)
40 (***basic***) to 71 (***network connected***)	56	85,551	4,791	7,377,924	640

Potential unit energy savings from choosing an "efficient" model over a "standard" model range from 39 kWh for basic products to 73 kWh for products with network connectivity. If applied to the predicted 2015 U.S. shipments, there is a potential for nationwide savings of 4,791 MWh/yr.

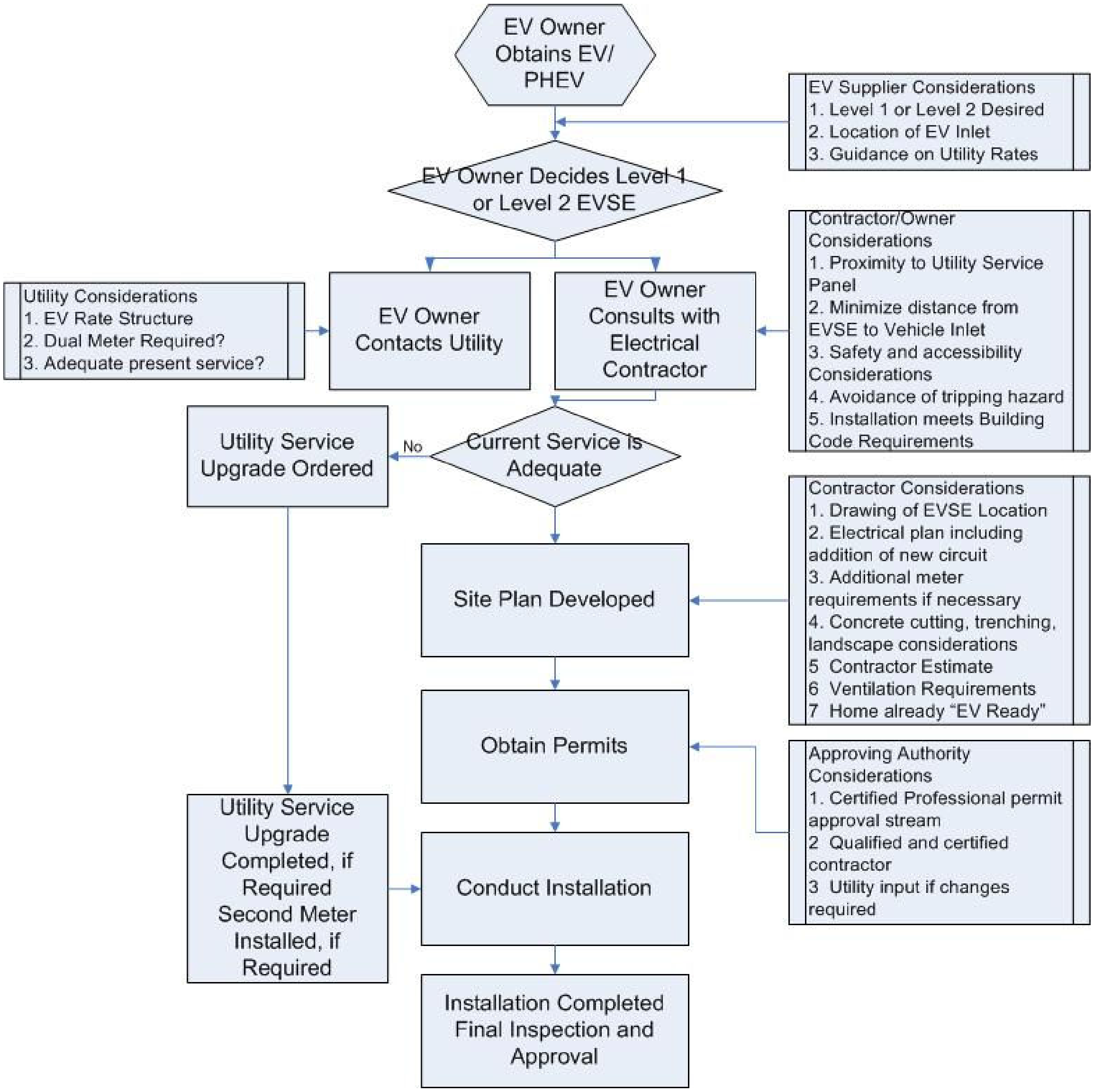
[27] U.S. Department of Transportation Federal Highway Administrationhttp://www.fhwa.dot.gov/policyinformation/statistics/2010/rc1c.cfm. ..
[28] U.S. Department of Energy, Fueleconomy.gov: The Official U.S. Government Source for Fuel Economy Information. http://www.fueleconomy.gov/feg/evsbs.shtml.
[29] Mintel International Group Ltd., "Hybrid and Electric Cars – US – November 2012," http://www.marketresearch.com/Mintel-International-Group-Ltd-v614/Hybrid-Electric-Cars-November-7280067/view-toc/.

APPENDIX A: Relevant Industry Standards

Standard	Title/Description
SAE J2293	Establishes the requirements for EV and off-board electric vehicle supply equipment used to transfer electrical energy to an EV from a utility in North America.
SAE J2847	Provides requirements and specifications on the necessary communication between PHEV and power grids.
SAE J2836	Supplies use cases for communication between PHEVs and power grids.
SAE J2894	Provides the charging equipment operational recommendations for power quality.
IEEE P2030.1	Guide for Electric-Sourced Transportation Infrastructure
NEMA (5EV)	Electric Vehicle Supply Equipment/Systems
UL 991	Standards for Tests for Safety-Related Controls Employing Solid-State Devices
UL 2231	Standards for Personnel Protection Systems for Electric Vehicle Supply Circuit
UL 1998	Standard for Software in Programmable Components
UL 2594	Outline of Investigation for Electric Vehicle Supply Equipment
SAE J1772	Electric Vehicle Conductive Charge Coupler Standard
NEC Article 625	Electric Vehicle Charging System Equipment
UL 2251	Standard for Plugs, Receptacles and Couplers for Electric Vehicles
CHAdeMO	Proposed as a global industry standard for quick charging high-voltage dc via a special electrical connector.

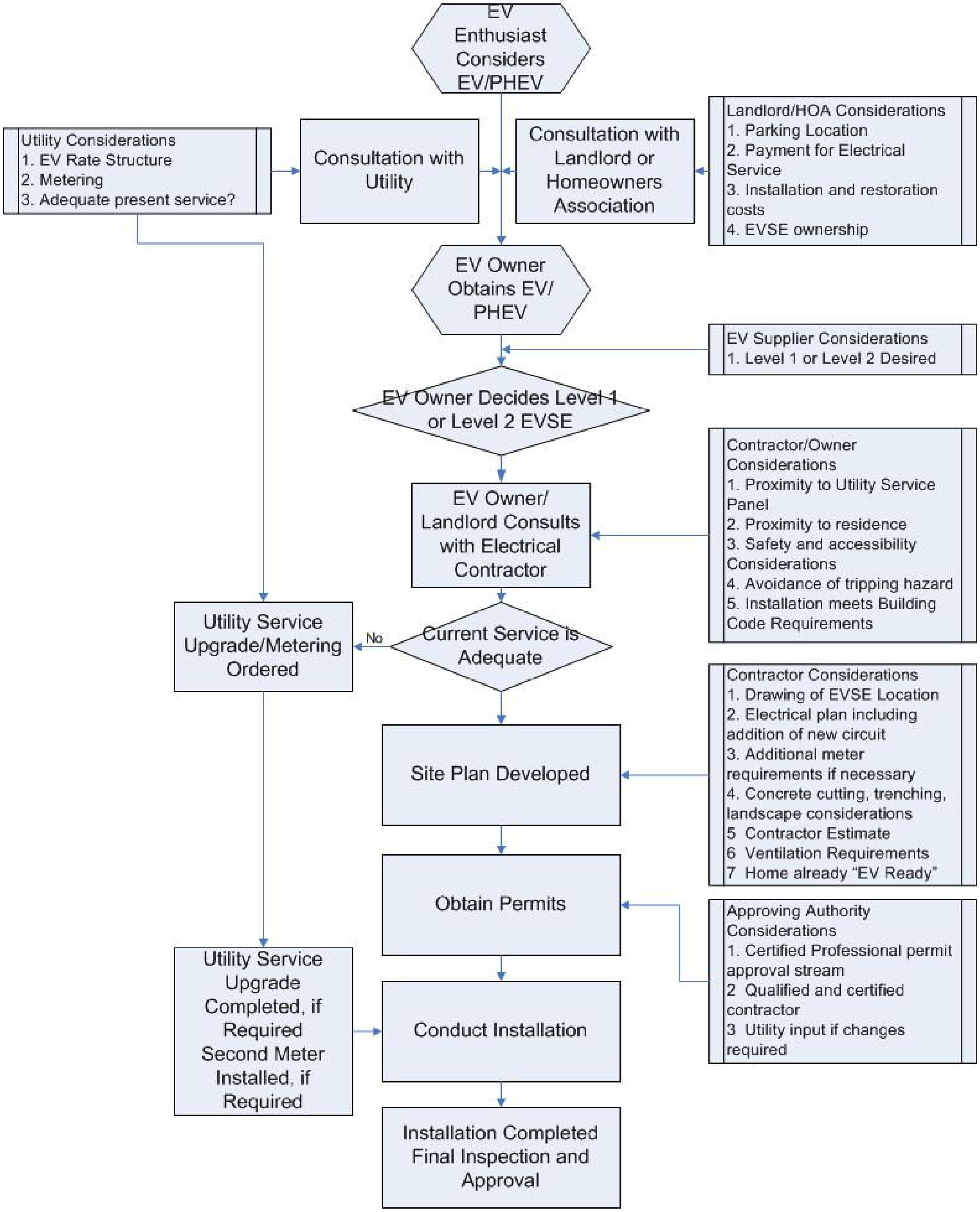
APPENDIX B: Example Installation Processes

Installation Process for Residential Garage/Car Port[30]



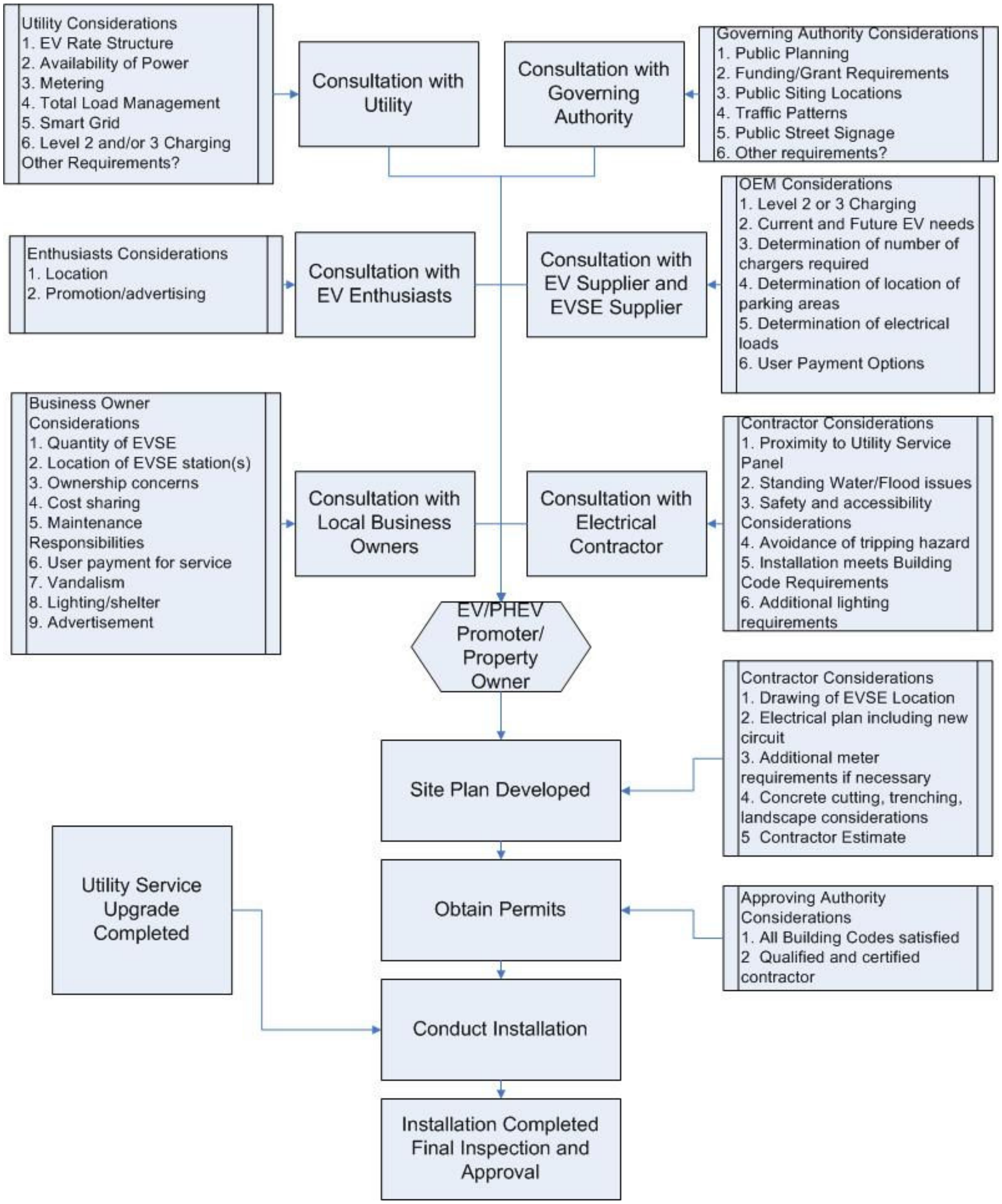
[30] Electric Transportation Engineering Company.

Installation Process for Multi-Family [31]



[31] *Ibid*.

Installation Flowchart for Public Charging [32]



[32] *Ibid*.