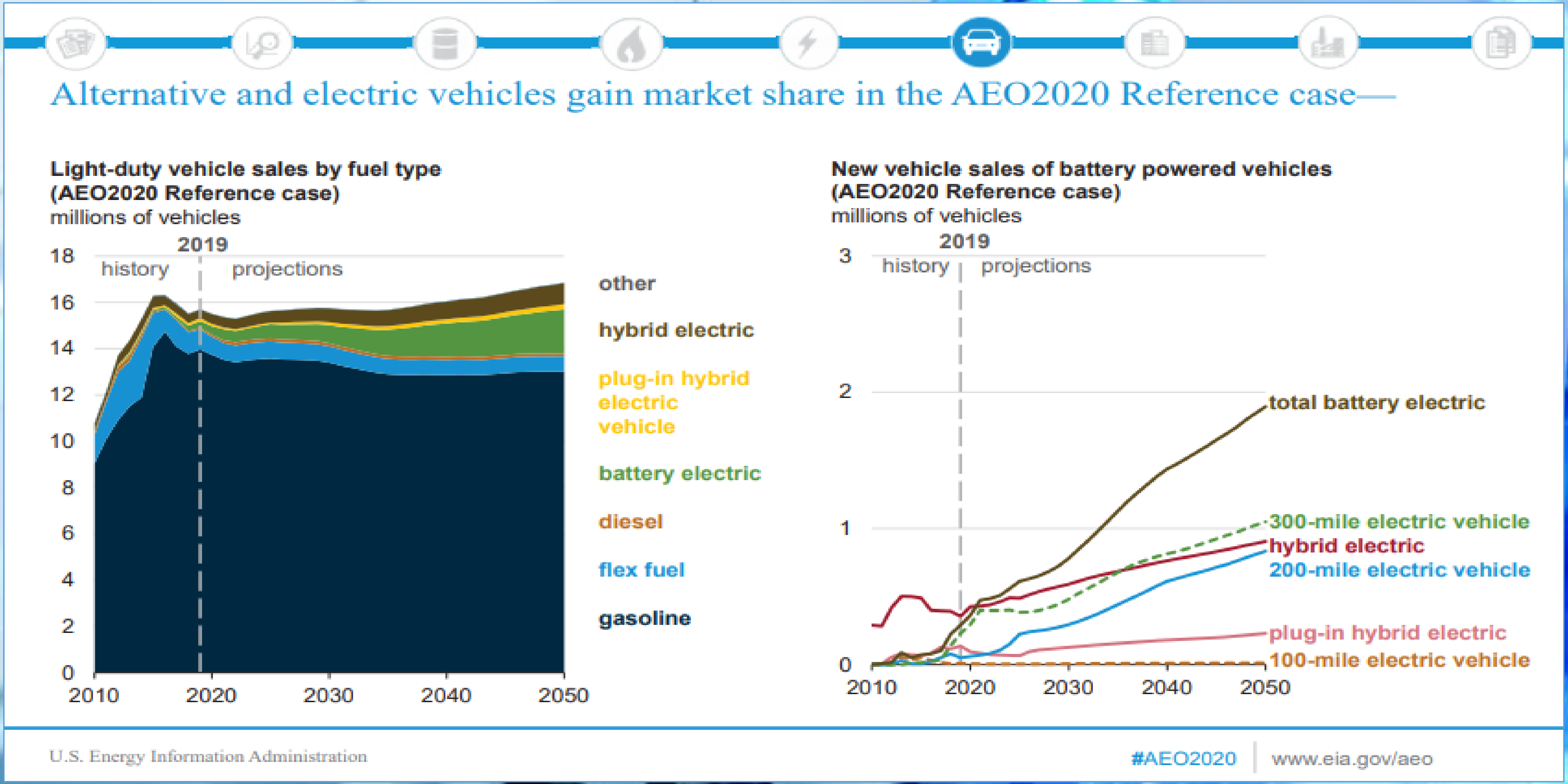
V2G (Vehicle-to-Grid)

Tendências dos veículos elétricos plug-ins conectados à rede elétrica das concessionárias.

Marcos Paulo Brito Gomes

Doutorando em Engenharia Elétrica – UFMG
Supervisor do Sistema Elétrico de Potência de Alta Tensão - CEMIG

Projeções para o Mercado de PEVs:



Projeções para o Mercado de PEVs:

Proibição de venda de ICE (Internal Combustion Engine), movidos à gasolina e diesel :

- ❖ França: 2040.
- ❖ Reino Unido: 2040.
- ❖ Noruega: 2025.
- ❖ Holanda: 2025.
- ❖ Alemanha: 2030


VAGA EXCLUSIVA
VEÍCULO ELÉTRICO
conect ME
CARRO
ÔNIBUS
SCOOTER
BICICLETA
CEMIG

Carros Elétricos
e Híbridos
Gessy

SAÍDA
SAÍDA


M EV 332E

MIRAI




FP 5235



$35.000

$28.375

$34.995

$69.420

$26.000

$37.620

$ 49.900

$29.990

45.800

Conceito V2G (Vehicle-to-Grid) , como funciona?

- ❖A recarga de VEs ou PEVs, PHEVs são comumente One-way.
- ❖One-way = Grid-to-vehicle = V1G.
- ❖A bateria dos VEes usada exclusivamente para tração do veículo.
- ❖ Bi-Direcional = V2G (Vehicle-to-Grid), a energia retorna para a rede proporcionando benefícios mútuos entre concessionária e dono do VE.

Conceito V2G (Vehicle-to-Grid) , como funciona?

- ❖ Bi-Direcional = V2G (Vehicle-to-Grid) + G2V (Vehicle to-Grid).
- ❖ A energia retorna para a rede proporcionando benefícios mútuos entre concessionária e dono do VE.
- ❖ VEs elétricos ainda possuem alto custo.
- ❖ Os proprietários dos VEs ganham, reembolso, retorno sobre investimento.
- ❖ Abre fronteiras para a Smart-Grid e Mercados de Energia.

Projetos já implementados

- ❖ System Applications.
- ❖ Customer application.

Intelligent Electric Vehicle Integration (INVENT)

State of California Energy Commission
UCSD
Mitsubishi Motors
Nissan
BMW
Honda
Hitachi Inspire the Next
SDGE
PG&E
Strategen Consulting
The City of San Diego

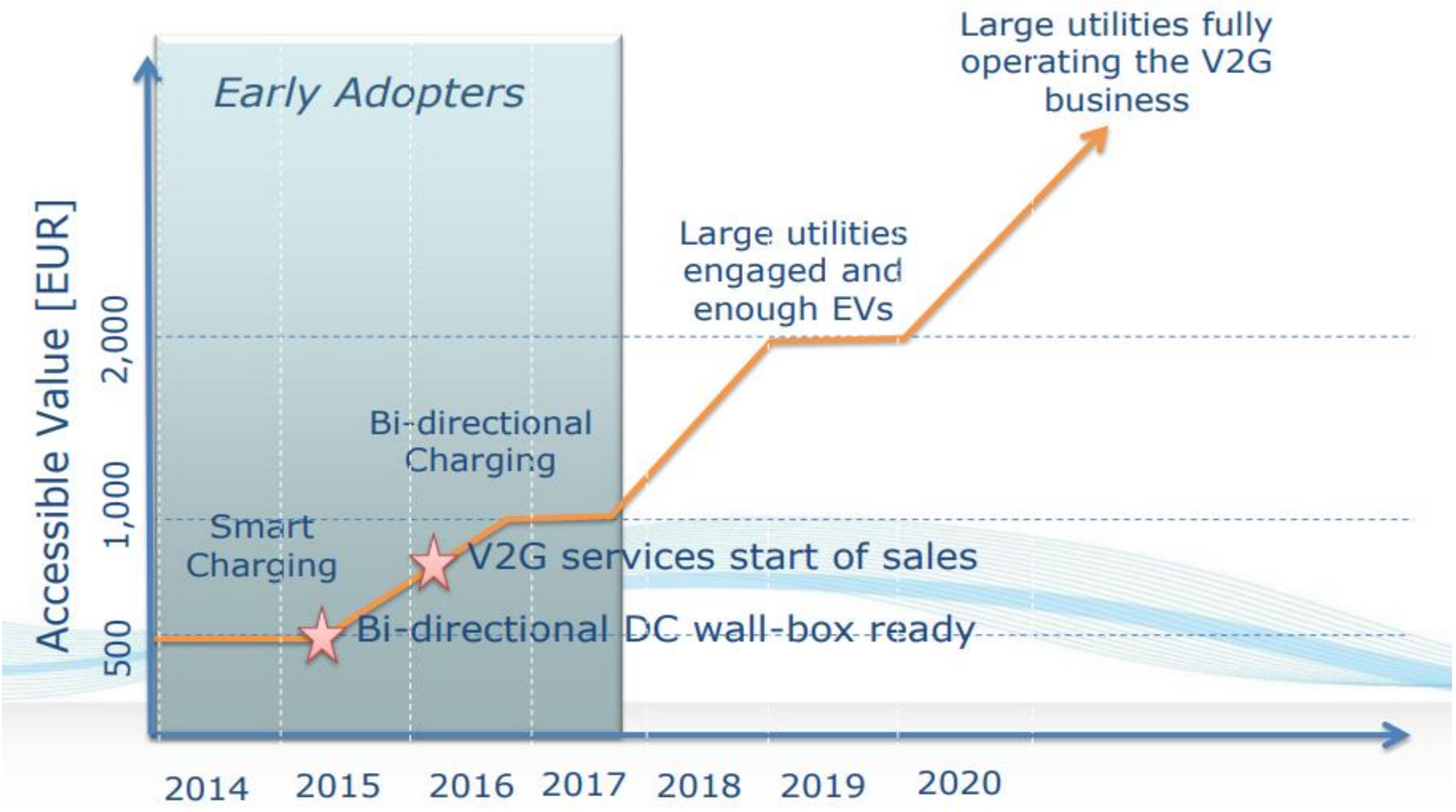
About Nuvve

- The world's only platform enabling profitable deployment of EV fleets globally
- Working on V2G since 1996
  - University of Delaware Prof. Kempton spin off – patented technology
- Headquarters in San Diego, CA
- Offices in Copenhagen, London, Newark (DE), Paris
- World's most experienced:
  - Only V2G firm to complete TSO/DNO qualification in multiple countries
  - Operating on 5 continents
  - Over 3.5 million hours kW of commercial V2G operation (by end 2018*)
- Scaling through partnerships, e.g. EDF using Nuvve for all e-mobility
- Corporate investors
  - EDF Renewable EDF
  - Toyota Tsusho

The main challenge is to reduce / eliminate barriers for feeding energy back to the grid

Influencing Groups	Influencers	Area of influence
Regulators	French Energy Regulatory Commission (CRE) Ofgem Bundesnetzagentur ACM	• Approval to **feed electricity back to the grid** (similar to PV) • Metering and high voltage safety rules
Transmission System Operators	Le réseau de l'intelligence électrique (RtE) National Grid Tennet, Amprion, 50Hertz, Transnet BW Tennet	• Stationary assets prequalification • Rules on reserve power – the market to bid with vehicle swarms
Distribution System Operators	Competitive market (e.g. 900+ DSOs in Germany)	• Balance group management, metering and special grid tariffs for EVs

V2G development roadmap




1
TAXI

Operado do Sistema da Transmissão

❖Resposta de frequência.

❖Controle de Tensão.


Operador do sistema de distribuição:
❖ Adiamento de upgrade de transformadores.
❖ Gestão de contingências.
❖ Integração com a Energia renovável, BESS.
❖ Back up de energia.
❖ EV load shifting.
❖ Peak -Shaving

Benefícios para o Proprietário do VE:

- Retorno sobre investimento.
- Tarifa otimizada com redução de custos.

Conceito V2G (Vehicle-to-Grid) ,
Sistemas de Controle, hardware, projetos, protocolos?

TESLA

SUPERCHARGING STATION

MADISON

WI009_MADISON
3801 E WASHINGTON AVE
MADISON, WI 53704

SITE INFORMATION

PROPOSED TESLA EV SITE ADDRESS:
3829 E WASHINGTON AVE
MADISON, WI 53704

EXISTING SITE ADDRESS:
3801 E WASHINGTON AVE
MADISON, WI 53704

PROPERTY OWNER:
HY-VEE, INC.
5820 WESTOWN PARKWAY
WEST DES MOINES, IW 50266
(515) 453-2795

EQUIPMENT SUPPLIER:
TESLA MOTORS, INC.
3500 DEER CREEK RD
PALO ALTO, CA 94304
(650) 681-5000

POWER COMPANY:
MADISON GAS & ELECTRIC
CONTACT: KEITH VANDEN WYMELENBERG
(608) 235-0284

COUNTY:
DANE

LATITUDE (NAD83):
43° 7' 9.30" N
43.11925°

LONGITUDE (NAD83):
89° 19' 9.36" W
-89.31927°

CONTACT ENGINEER:
RUSSELL POLLOM
(913) 458-6274
POLLOMRE@BV.COM

FLOOD HAZARD AREA NOTE

THIS SITE IS LOCATED IN FLOOD ZONE "X". NO BASE FLOOD ELEVATION. AREA DETERMINED TO BE OUTSIDE 500-YEAR FLOOD PLAIN.

CONTRACTOR NOTE

CONTRACTOR SHALL COMPLETE INSTALL PER THE SIGNED AND SEALED SET OF DRAWINGS. ANY NECESSARY DEVIATIONS FROM THE DRAWINGS MUST BE SUBMITTED THROUGH AN RFI REQUEST PROCESS WITH ENGINEERING FOR AN APPROVAL PRIOR TO CONTRACTOR PROCEEDING WITH A DEVIATION OF THE SIGNED AND SEALED SET OF DRAWINGS.

APPLICABLE CODES

ALL WORK SHALL COMPLY WITH THE FOLLOWING APPLICABLE CODES:

2011 WISCONSIN COMMERCIAL BUILDING CODE
IBC 2009 WISCONSIN MECHANICAL CODE
NEC 2008 WISCONSIN ELECTRICAL CODE
IBC 2009 WISCONSIN STRUCTURAL CODE
IBC 2009 MFPA-1 WISCONSIN FIRE/LIFE SAFETY CODE
WISCONSIN COMMERCIAL BUILDING CODE
ADA STANDARDS (WISCONSIN COMMERCIAL BUILDING CODE)

IN THE EVENT OF CONFLICT, THE MOST RESTRICTIVE CODE SHALL PREVAIL

PROJECT DESCRIPTION

- INSTALL (4) TESLA SUPERCHARGER CABINETS
- INSTALL (8) TESLA CHARGING STATIONS
- INSTALL (1) QED SWITCHGEAR ASSEMBLY
- INSTALL (1) UTILITY TRANSFORMER
- INSTALL (1) PEDESTRIAN LIGHT POLE AND FIXTURE

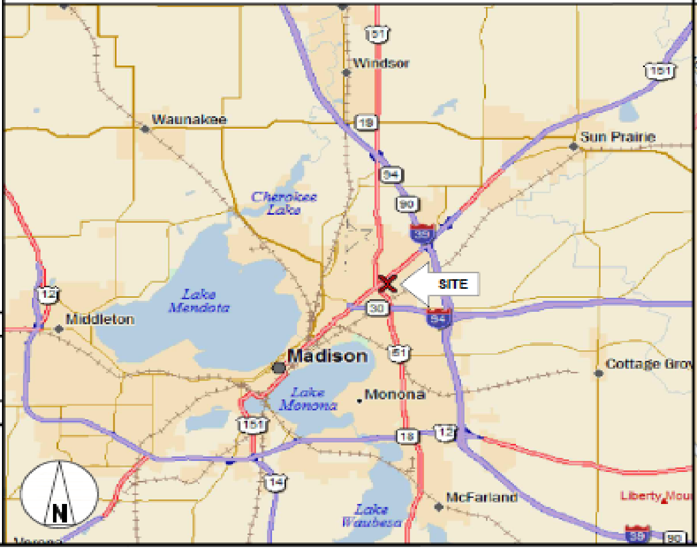
ZONING INFORMATION

PERMITTING JURISDICTION: CITY OF MADISON
ZONING CLASS: SS-1

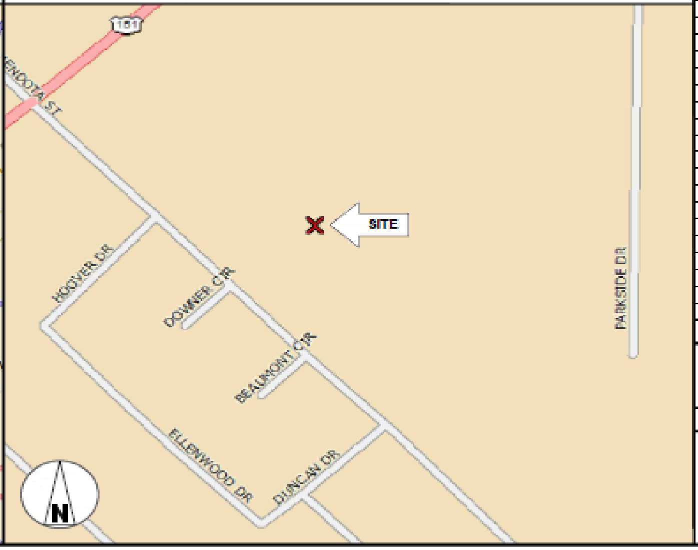
DO NOT SCALE DRAWINGS

CONTRACTOR SHALL VERIFY ALL PLANS, EXISTING DIMENSIONS & CONDITIONS ON THE JOB SITE & SHALL IMMEDIATELY NOTIFY THE ENGINEER IN WRITING OF ANY DISCREPANCIES BEFORE PROCEEDING WITH THE WORK.

AREA MAP



LOCATION MAP



DRAWING INDEX

SHEET NO:	SHEET TITLE	REV NO:
T-1	TITLE SHEET & PROJECT DATA	E
GN-1	GENERAL NOTES 1	E
GN-2	GENERAL NOTES 2	E
GN-3	GENERAL NOTES 3	E
A-1	OVERALL SITE PLAN	E
A-2	DEMOLITION SITE PLAN	E
A-3	PROPOSED SITE PLAN	E
A-4	ENLARGED PROPOSED EQUIPMENT LAYOUT	E
A-5	SITE ELEVATIONS	E
A-6	SIGNAGE DETAILS	E
A-7	EQUIPMENT DETAILS	E
A-8	FENCE DETAILS	E
E-1	UTILITY PLAN	E
E-2	ELECTRICAL PLAN	E
E-3	ELECTRICAL DETAILS	E
E-4	ELECTRICAL DETAILS	E
E-5	ELECTRICAL DETAILS	E
E-6	ELECTRICAL DETAILS	E
G-1	GROUNDING DETAILS	E
G-2	GROUNDING DETAILS	E
S-1	STRUCTURAL DETAILS	E
S-2	STRUCTURAL DETAILS	E
LS-1	LANDSCAPING PLAN	E
LS-2	LANDSCAPING DETAILS AND PLANT SCHEDULE	E
	FOR REFERENCE ONLY	
	PROPERTY SURVEY	

ENGINEER OF RECORD

ROBLEY A. EVANS
PE # 37439-006
BLACK & VEATCH CORPORATION

CALL BEFORE YOU DIG

UNDERGROUND SERVICE ALERT
UTILITY NOTIFICATION CENTER OF WISCONSIN
811 OR 1-800-242-8511

3 WORKING DAYS UTILITY NOTIFICATION PRIOR TO CONSTRUCTION

TESLA MOTORS, INC.
3500 DEER CREEK RD
PALO ALTO, CA 94304
(650) 681-5000

BLACK & VEATCH
6800 W 115th St, Suite 2292
OVERLAND PARK, KS 66211
(913) 458-2000

PROJECT NO:	192745
DRAWN BY:	AKJ
CHECKED BY:	CNS

REV	DATE	DESCRIPTION
E	06/07/17	RE-ISSUED FOR 100% REVIEW
D	06/02/17	RE-ISSUED FOR 100% REVIEW
C	05/09/17	RE-ISSUED FOR 50% REVIEW
B	03/24/17	RE-ISSUED FOR 50% REVIEW
A	12/07/16	ISSUED FOR 50% REVIEW

NOT TO BE USED FOR CONSTRUCTION

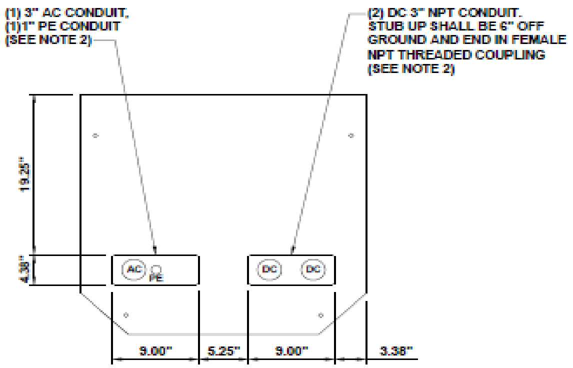
IT IS A VIOLATION OF LAW FOR ANY PERSON, UNLESS THEY ARE ACTING UNDER THE DIRECTION OF A LICENSED PROFESSIONAL ENGINEER, TO ALTER THIS DOCUMENT.

WI009_MADISON
MADISON
3801 E WASHINGTON AVE
MADISON, WI 53704

SHEET TITLE
TITLE SHEET & PROJECT DATA

SHEET NUMBER
T-1

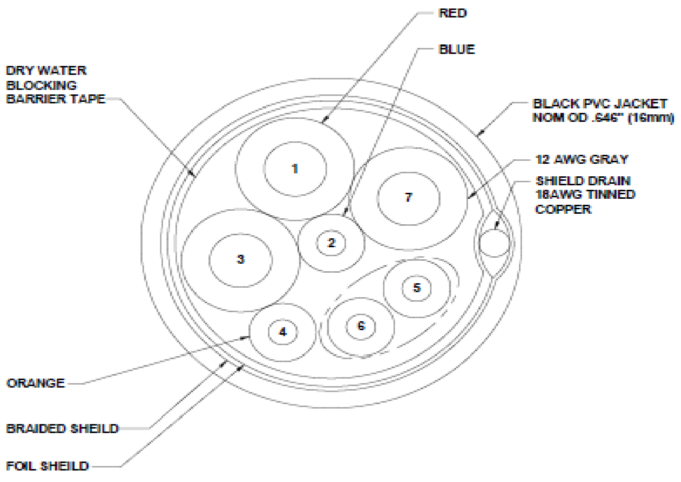
TO BE PROVIDED BY TESLA



NOTES

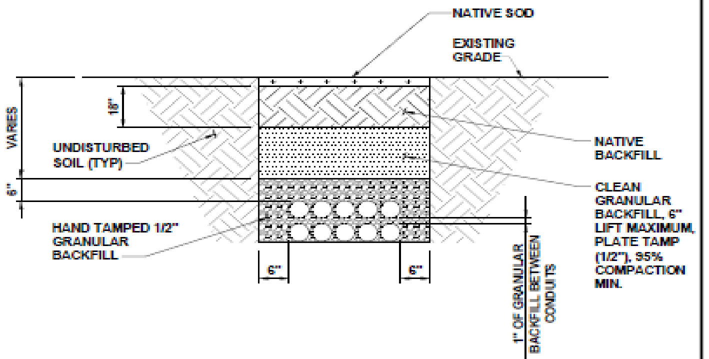
1. BOLT HOLES FOR REFERENCE ONLY.
2. USE DOTTIE DUCT SEAL COMPOUND PC 6130 (CAT NO LHD1) TO SEAL ENDS OF CONDUIT (TYP. ALL CONDUITS FOR SUPERCHARGERS AND CHARGE STATIONS)
3. USE BELL FITTINGS ON ALL AC AND DC CONDUIT STUBS.

TESLA SUPERCHARGER CONDUIT ENTRY DETAIL | NO SCALE | A



E73202 3/C 18AWG(.824MM2)+1/PR 18 AWG(.824MM2)+1/C 12 AWG(3.31MM2)+1/C 10 AWG(5.26MM2) (UL) TYPE TC-ER 90C DRY 75C WET 600V SUN RES DIR BUR OIL RES II UL 1277 OR c(UL) CIC-TC FT4 — LL41103 CSA AWM I/II A/B 90C 600V FT4 — CE ROHS

COMMUNICATION CABLE DETAIL | NO SCALE | B



NOTES

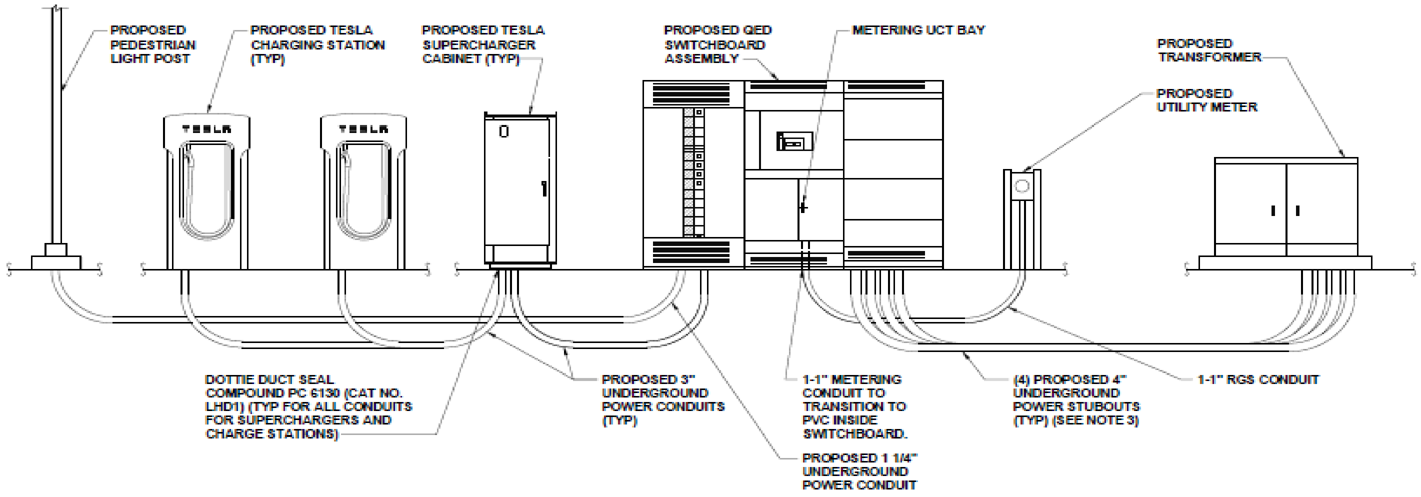
1. ANY EXCAVATION LEFT OPEN SHOULD BE SECURELY FENCED OFF.
2. ANY PAVEMENT DAMAGE DURING CONSTRUCTION SHALL BE REPAIRED OR REPLACED BY THE CONTRACTOR TO PRE CONSTRUCTION CONDITIONS OR BETTER.

TYPICAL NON-UTILITY CONDUIT UNDER SOIL TRENCH DETAIL | NO SCALE | C

DETAIL NOT USED | NO SCALE | D

NOTES

1. CONDUITS SHALL BE BURIED BELOW FROST LINE AND IN COMPLIANCE WITH LOCAL AND NATIONAL CODE REQUIREMENTS.
2. REFER TO SHEET E-3 FOR CONDUCTOR REQUIREMENTS WITHIN CONDUITS.
3. REFERENCE SHEET E-1 AND E-2 FOR ADDITIONAL DETAIL.



CAR CHARGER CONDUIT ELEVATION | NO SCALE | E

TESLA MOTORS, INC.
3500 DEER CREEK RD
PALO ALTO, CA 94304
(650) 681-5000

BLACK & VEATCH
6800 W 115th St, Suite 2292
OVERLAND PARK, KS 66211
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PROJECT NO:	192745
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CHECKED BY:	CNS

REV	DATE	DESCRIPTION
E	06/07/17	RE-ISSUED FOR 100% REVIEW
D	06/02/17	RE-ISSUED FOR 100% REVIEW
C	05/09/17	RE-ISSUED FOR 90% REVIEW
B	03/24/17	RE-ISSUED FOR 90% REVIEW
A	12/07/16	ISSUED FOR 90% REVIEW

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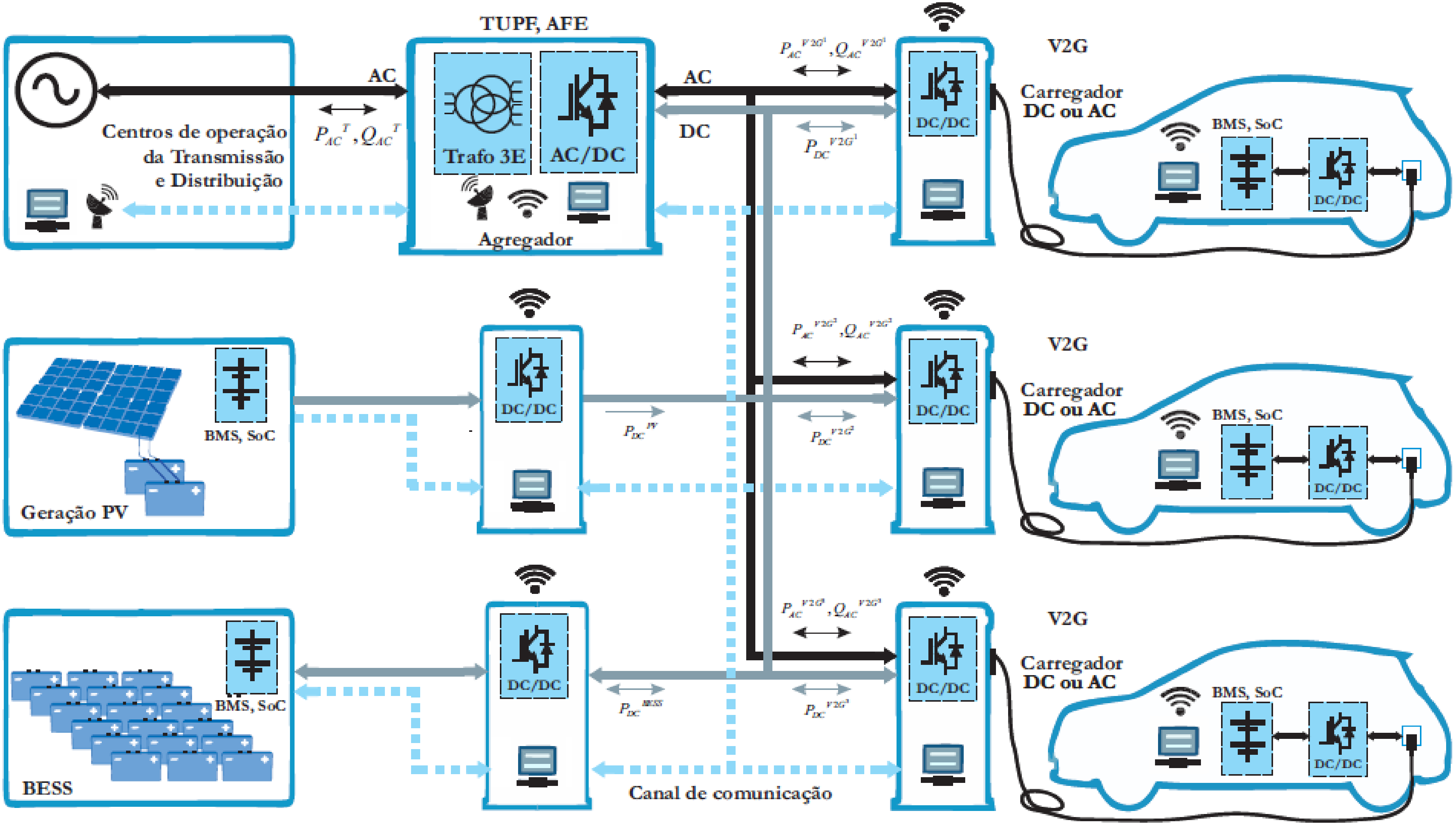
MADISON, WI 53704

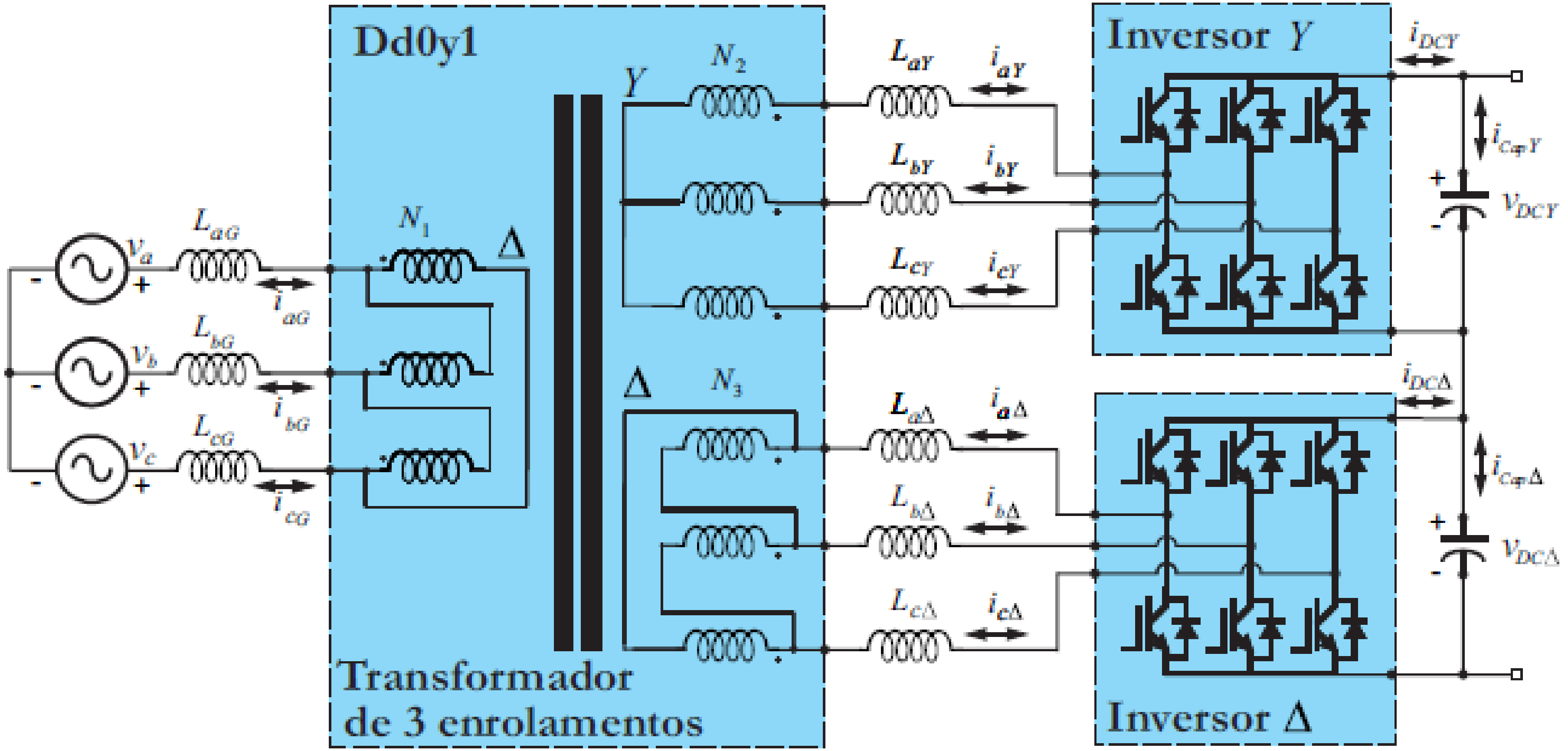
SHEET TITLE
ELECTRICAL DETAILS

SHEET NUMBER
E-5

Modelo V2G em estudo:



Conversor TUPF:



$h = 6 \times k \pm 1, \{k \in \mathbb{N}^*\}$

cancelamento das ordens harmônicas

5^a, 7^a, 17^a, 19^a, 29^a, 31^a, 41^a e 43^a.

$h = 12 \times k \pm 1, \{k \in \mathbb{N}^*\}$

cancelamento das ordens harmônicas

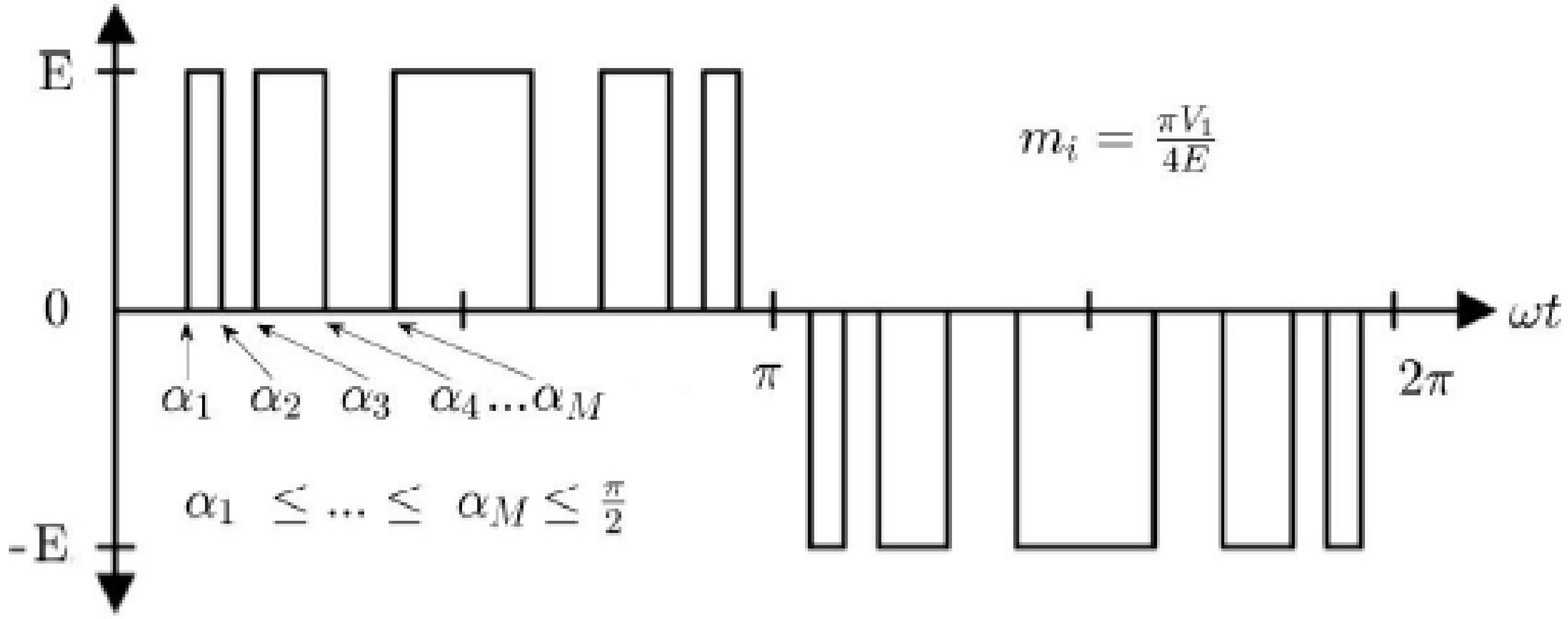
11^a, 13^a, 23^a, 25^a, 35^a, 37^a, 47^a e 49^a.

$$f_{Pv} = \cos(\theta_v - \theta_i) \cdot \frac{1}{\sqrt{1 + (\frac{THD_v}{100})^2} \cdot \sqrt{1 + (\frac{THD_i}{100})^2}}$$

$$f_{Pd} = \frac{P}{S} = \frac{P}{{V_{RMS}}^1 \cdot {I_{RMS}}^1} = \cos(\theta_v - \theta_i)$$

$$f_{Ph} = \frac{1}{\sqrt{1 + (\frac{THD_v}{100})^2} \cdot \sqrt{1 + (\frac{THD_i}{100})^2}}$$

Modulação SHEPWM



Assessment of a NPC frequency inverter with low switching frequency modulation for a high speed rating operation of an induction motor

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Electrical Engineering Department - Federal University of Minas Gerais, Belo Horizonte, Brazil [2]
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gabrielvilkn@gmail.com, iap@ufmg.br

***Abstract* - This paper brings an assessment of a three level NPC inverter with low frequency modulation commands for high speed operation of induction motors. The work is mainly devoted to medium voltage and high power and high-speed systems. It will be approached a very low switching frequencies, reducing the incidence of dv/dt on electric motors and eliminating the 5^{th} and 7^{th} harmonics. It is possible reach good sinusoidal waveforms, with semiconductors switching at 360 Hz, which is very low frequency, being able to preserve motors and semiconductor elements. The 5^{th} and 7^{th} have high amplitude and low frequency, and can cause high losses to the drive. The dv/dts in its turn, damage the electric motors and loads and its reduction contributes to minimizing problems on motors windings, damaged insulation and electrostatic currents on bearings that cause motors degradation. These problems tend to increase for the motor operation in field weakening. Another concern is currents asymmetries that can induce pulsating torques on motors, undesired DC voltages per phase and displacement of neutral voltage of three-phase loads, which in turn can influence common-mode current flows. Considering low frequency modulations, PD-PWM, POD-PWM and the selective harmonic elimination, SHE-PWM, will be studied through simulation and compared with experimental results.**

Keywords — *SHE-PWM, POD-PWM, PD-PWM, selective harmonic elimination, dv/dts reduction, motor drives, field weakening, NPC.*

I. Introduction

A large number of power converters and frequency inverters are found in industry. In steel, mining and metallurgical industries, equipment such as rollers, conveyors, excavator, and traction, pressurizing, lifting and drilling systems, can operate in better power quality with power electronic fed machines. In a large power range, from tens of kVA to tens of MVA power converters with reduced harmonic content and dv/dt incidence can be achieved. Electric utilities demand regularity of power factor, decrease in operating power for unbalanced potentials, reactive power consumption limitation, and low harmonic distortion rates, which may even degrade the power factor of the drives. Harmonic distortion is a concern in the power quality scenario and power electronics projects, and regulated for several standards. The IEEE 1459-2010 standard indicates procedures for non-sinusoidal regime measurements and demonstrates that THD interfere with power factor measurement and harmonics drain active and reactive power from electrical systems.

From the grid side, individual consumer harmonics diversity implies in cancellation phenomena in the point of common coupling, which is beneficial. In addition each consumer can use filtering systems or phase shifting transformers that mitigate harmonics of industrial power systems individually, [1,2]. IEEE 519-2014 indicates a concern to include higher order harmonics for THD calculation, defining standard procedures for measurement and sampling signals degraded by harmonics in accordance with the European standard IEC 61000-4-7. This standard also indicates maximum distortion in voltage and current in the grid, limiting $THDv$ and $THDi$ in the point of common coupling. It also includes a requirement to limit individual current harmonics because they are more harmful.

Power electronics has provided the mining and steel industry with applications in wide ranges of speed and torque, as happens in iron and steel mills, but different techniques of PWM modulation imply in different harmonic intrinsic spectra of the process of power conversion in voltage and current source inverters, VSIs and CSIs. Harmonic distortion is a much discussed problem during power electronics projects. From the industrial loads side, harmonics are avoided because they cause decrease on efficiency, increase of heating, vibrations and sound noises in equipment and losses in ferromagnetic materials of transformers and electric motors, eddy currents and harmonics hysteresis sub-cycles. THD also becomes a preoccupation for high efficiency drives [3-6]. Recent works have indicated that the harmonic presence can also be harmful to control systems, especially those of trajectory tracking using observer techniques. Some controls require the machine parameters estimation and THD alter magnetization and leakage inductances, apparent rotor and stator resistances due to skin effect, and these problems tend to worse at high operating frequencies [7-10].

The problems caused by individual harmonics are difficult to establish, but it is expected that mainly the 5^{th}, 7^{th} and 11^{th} harmonics, are responsible for vibrations and pulsating torques on electric motors, especially at low speeds, when they are more noticeable, [3,11]. Modulation techniques like selective harmonic elimination, SHE-PWM, are able to eliminate specific harmonics in all modulation index range [12-14]. Furthermore, active and passive harmonic filters can be used to improve the quality of synthesized voltage, being quite effective, [14-16]. Classical

V. Experimental Results

The experimental results were developed in the laboratory stand tests, Fig. 13. POD-PWM with $m_f = 6$ and SHE-PWM with $M = 3$ were implemented on F28335 DSP which controls two gate drive boards, each commanding six IGBTs of Semikron SKM100GB121D package, resulting on 12 IGBTs of the three-level and three-phase NPC frequency inverter. Fig. 14 and Fig. 17 show experimental waveforms. Fig. 15 and Fig. 18 demonstrates harmonic spectrum, SHE-PWM has lower harmonic content and has 5^{th} and 7^{th} harmonic order reduced.

Fig. 13. Experimental Setup. Three-level and three-phase NPC frequency inverter and motor drive with POD-PWM and SHE-PWM techniques.

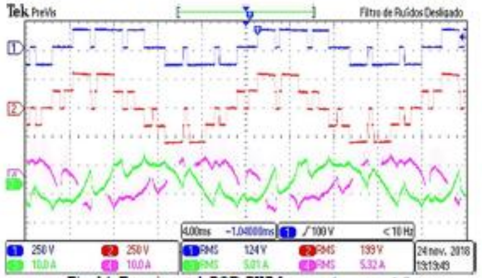


Fig. 14. Experimental POD-PWM, $m_f = 6$ e $m_i = 1.0$. V_a, V_{ab}, I_a e I_b $(T_L = 0)$, waveforms.

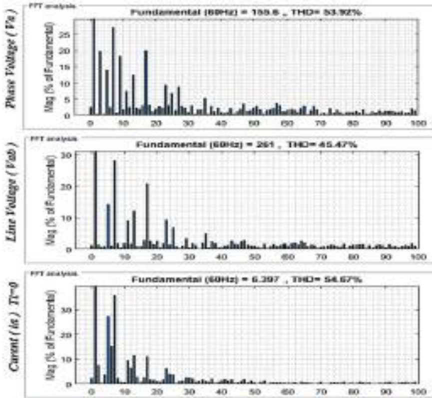


Fig. 15. Experimental POD-PWM, $m_f = 6$ e $m_i = 1.0$. V_a, V_{ab}, I_a e I_b $(T_L = 0)$, Harmonic spectrum.

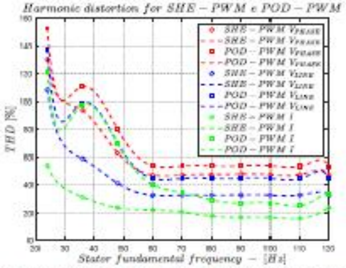


Fig. 16. THD for SHE-PWM and POD-PWM wavefors.

Fig. 16 shows that SHE-PWM has a lower THD than POD-PWM for all drive range. The application of an unconventional modulation with reduced dv/dt also raises concerns about motor overheating due to a possible increase in $THDi$. As describes in WEG W22 Premium 15 cv motor manual, the motor maximum temperature is 155 ° C at any point and work up to 3600 rpm in field weakening region. Fig. 19 shows that SHE-PWM has less noise than POD-PWM drive. Temperatures were measured with three Pt-100 in stator windings aiding insulation protection. It was also performed in the ferromagnetic core and bearings, as demonstrated in Fig. 20.

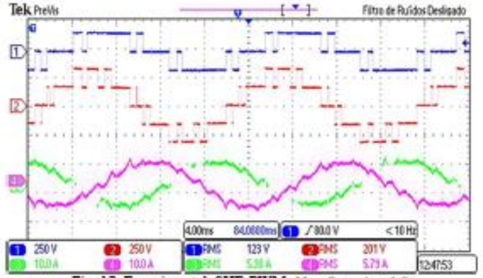


Fig. 17. Experimental SHE-PWM, $M = 3$ e $mi = 1.0$. V_a, V_{ab}, I_a e I_b $(T_L = 0)$, waveforms.

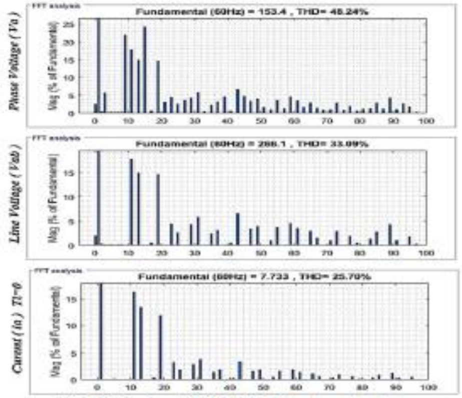


Fig. 18. Experimental SHE-PWM, $M = 3$ e $mi = 1.0$. V_a, V_{ab}, I_a $(T_L = 0)$, Harmonic spectrum.

$$\begin{bmatrix} \cos(\alpha_1) & -\cos(\alpha_2) & \cdots & (-1)^{M+1}\cos(\alpha_2) \\ \cos(5\alpha_1) & -\cos(5\alpha_2) & \cdots & (-1)^{M+1}\cos(5\alpha_2) \\ \vdots & \vdots & \ddots & \vdots \\ \cos(n_i\alpha_1) & \cos(n_i\alpha_2) & \cdots & (-1)^{M+1}\cos(n_i\alpha_1) \end{bmatrix} = \begin{bmatrix} f_{1k} \\ f_{2k} \\ f_{Mk} \end{bmatrix}$$

$$f(\overline{a}_k) = \begin{bmatrix} 0 & 0 & \cdots & 0 \end{bmatrix}^T$$

$$\overline{a}_{k+1} = \overline{a}_k + \Delta\overline{a}_k$$

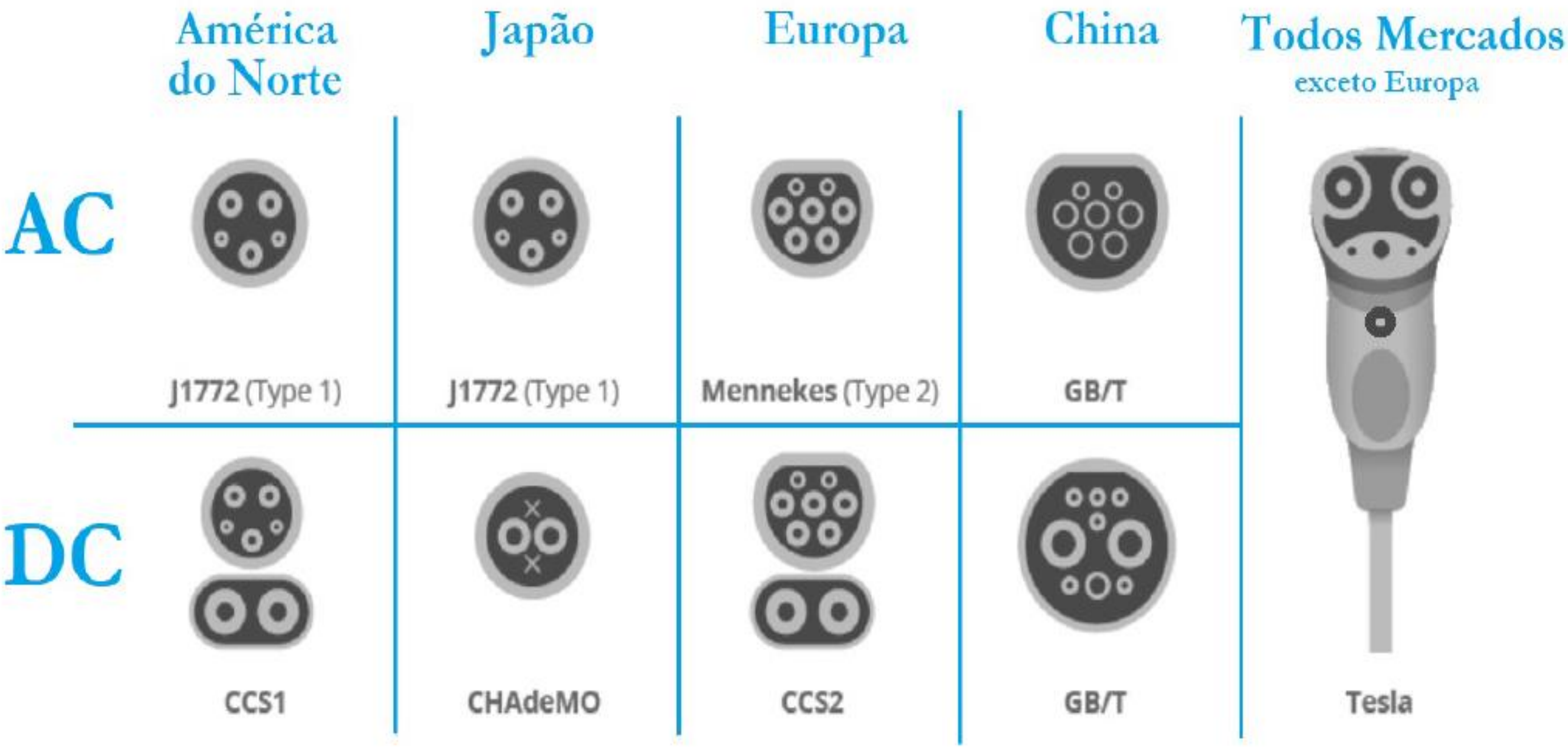
$$\overline{a}_k = \begin{bmatrix} \overline{a}_{1k} & \overline{a}_{2k} & \cdots & \overline{a}_{Mk} \end{bmatrix}^T$$

$$\Delta\overline{a}_k = -J^{-1}(\overline{a}_k) f(\overline{a}_k)$$

$$f(\overline{a}_k) = \begin{bmatrix} \overline{a}_{1k} & \overline{a}_{2k} & \cdots & \overline{a}_{Mk} \end{bmatrix}^T$$

$$\overline{a}_{k+1} = \overline{a}_k - J^{-1}(\overline{a}_k) f(\overline{a}_k)$$

$$\begin{bmatrix} J(\overline{a}_k) \end{bmatrix} = \frac{\partial f(\overline{\alpha_k}))}{\partial \overline{\alpha_k}} = \begin{bmatrix} \frac{\partial f_1}{\partial \alpha_1} & \frac{\partial f_1}{\partial \alpha_2} & \cdots & \frac{\partial f_1}{\partial \alpha_M} \\ \frac{\partial f_2}{\partial \alpha_1} & \frac{\partial f_2}{\partial \alpha_2} & \cdots & \frac{\partial f_2}{\partial \alpha_M} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial f_M}{\partial \alpha_1} & \frac{\partial f_M}{\partial \alpha_2} & \cdots & \frac{\partial f_M}{\partial \alpha_M} \end{bmatrix}$$


América do Norte
Japão
Europa
China
Todos Mercados
exceto Europa
AC
J1772 (Type 1)
J1772 (Type 1)
Mennekes (Type 2)
GB/T
DC
CCS1
CHAdeMO
CCS2
GB/T
Tesla

Visão geral dos padrões dos carregadoes PEVs:

	Convencional	**Carga Lenta**	**Carga Rápida**	
Nível **Corrente** **Potência**	**Nível 1** **AC** $\leq$ **3,7 kW**	**Nível 2** **AC** $>$**3,7 kW e** $\leq$ **22 kW**	**Nível 3** **AC Trifásico** $>$**22 kW e** $\leq$ **34,5 kW**	 **DC** $\leq$ **400kW** (Atualmente)
Australia	Tipo 1	IEC 62196-2 Tipo 2		CCS Combo 2 CHAdeMO (IEC 62196-3) Tesla possui o próprio
China	Tipo 1	GB/T 20234 AC		GB/T 20234 DC
Europa	Tipos C/F/G	IEC 62196-2 Tipo 2	IEC 62196-2 Tipo 2	CCS Combo 2 CHAdeMO (IEC 62196-3)
India	Tipos C/D/M	IEC 62196-2 Tipo 2 IEC 60309 AC/DC	IEC 62196-2 Tipo 2	CCS Combo 2 CHAdeMO (IEC 62196-3)
Japão	Tipo B	SAE J1772 Type 1 Tesla possui o próprio		CCS Combo 2 CHAdeMO (IEC 62196-3) Tesla possui o próprio

Korea	Tipo A/C	IEC 62196-2 Tipo 2		CCS Combo 1 CHAdeMO (IEC 62196-3) Tesla possui o próprio
Nova Zelânia	Tipo 1	IEC 62196-2 Tipo 2	IEC 62196-2 Tipo 2	CCS Combo 2 CHAdeMO (IEC 62196-3)
América do Note	Tipo B SAE J1772 Tipo 1	SAE J1772 Type 1 Tesla possui o próprio	SAE J3068	CCS Combo 1 (SAE J1772 e IEC 62196-3) CHAdeMO (IEC 62196-3) Tesla possui o próprio
Singapura	Tipo G	IEC 62196-2 Tipo 2	IEC 62196-2 Tipo 2	CCS Combo 2 (IEC 62196-3)
Tailâdia	Tipo A/B/C/F	IEC 62196-2 Tipo 2		CCS Combo 1 e 2 CHAdeMO (IEC 62196-3) Tesla possui o próprio

Perguntas

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