SAE International standards work, including communication protocols and connectors, fast charge, batteries

Jack Pokrzywa
Director
SAE Ground Vehicle Standards






SAE History

1910 Baker Model V Electric Victoria

1996 EV1 – General Motors

CitiCar - 1970's Electric Car

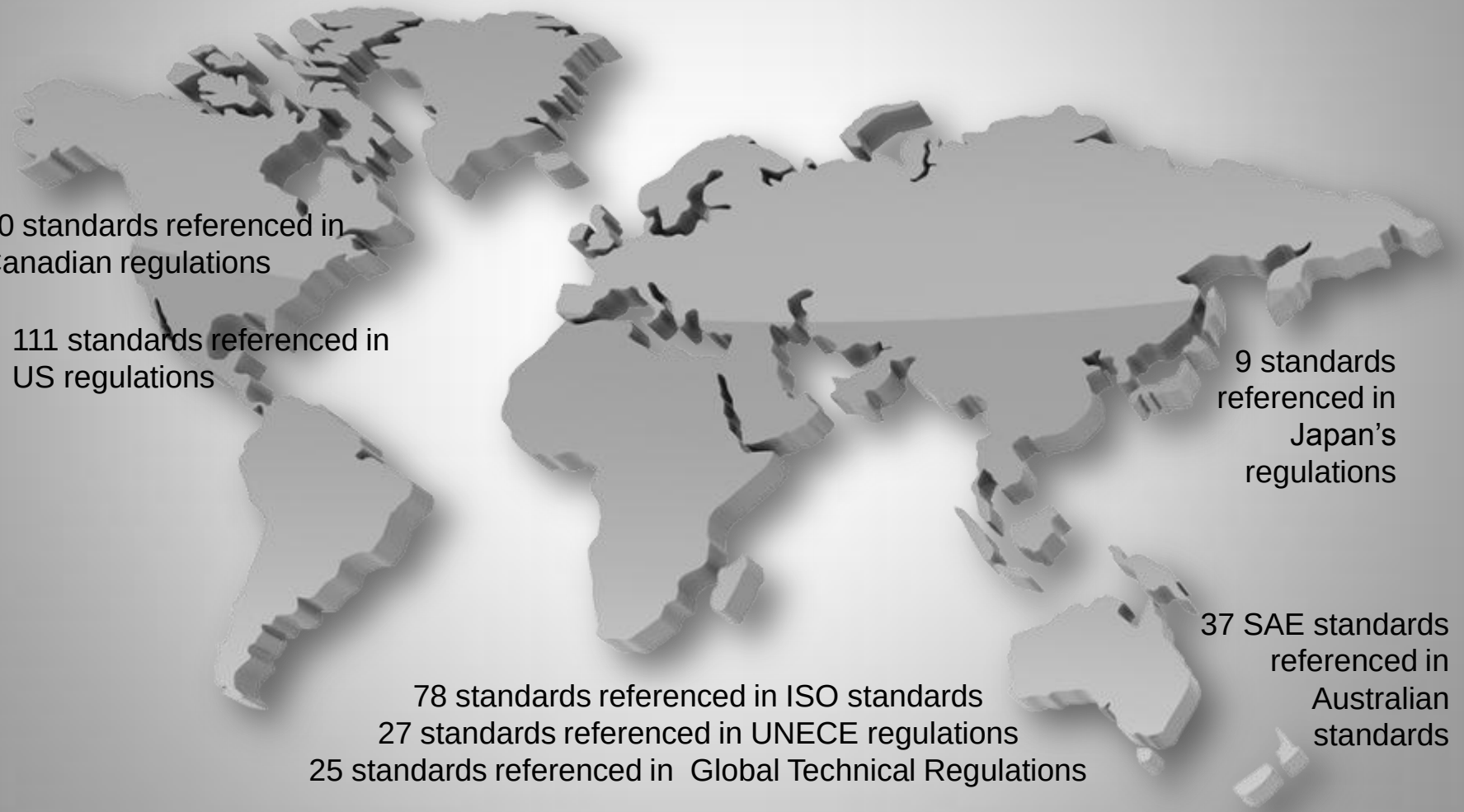
2011 Chevrolet PHEV Volt

Established in 1905
First President – Andrew Riker
First VP – Henry Ford
Initial Membership – 30 Engineers

Today SAE is the largest producer of consensus based ground mobility standards in the world.

SAE International Today

128,000 Members From Over 100 Nations



40 standards referenced in Canadian regulations

111 standards referenced in US regulations

9 standards referenced in Japan's regulations

37 SAE standards referenced in Australian standards

78 standards referenced in ISO standards
27 standards referenced in UNECE regulations
25 standards referenced in Global Technical Regulations

SAE International






SAE Standards Development

Volunteer, consensus based standards development process

- Total Committees: 580
- Total Committee Members: 8,064
- Total Standards Published : 10,077 (Ground Vehicle 2,081)
- Active Standards: 8,635 (Ground Vehicle 1,681)
- Standards In Development /Review: 657

Vehicle Electrification

- EV, PHEV's
- Batteries
- Smart Grid
- J1772™ Connector

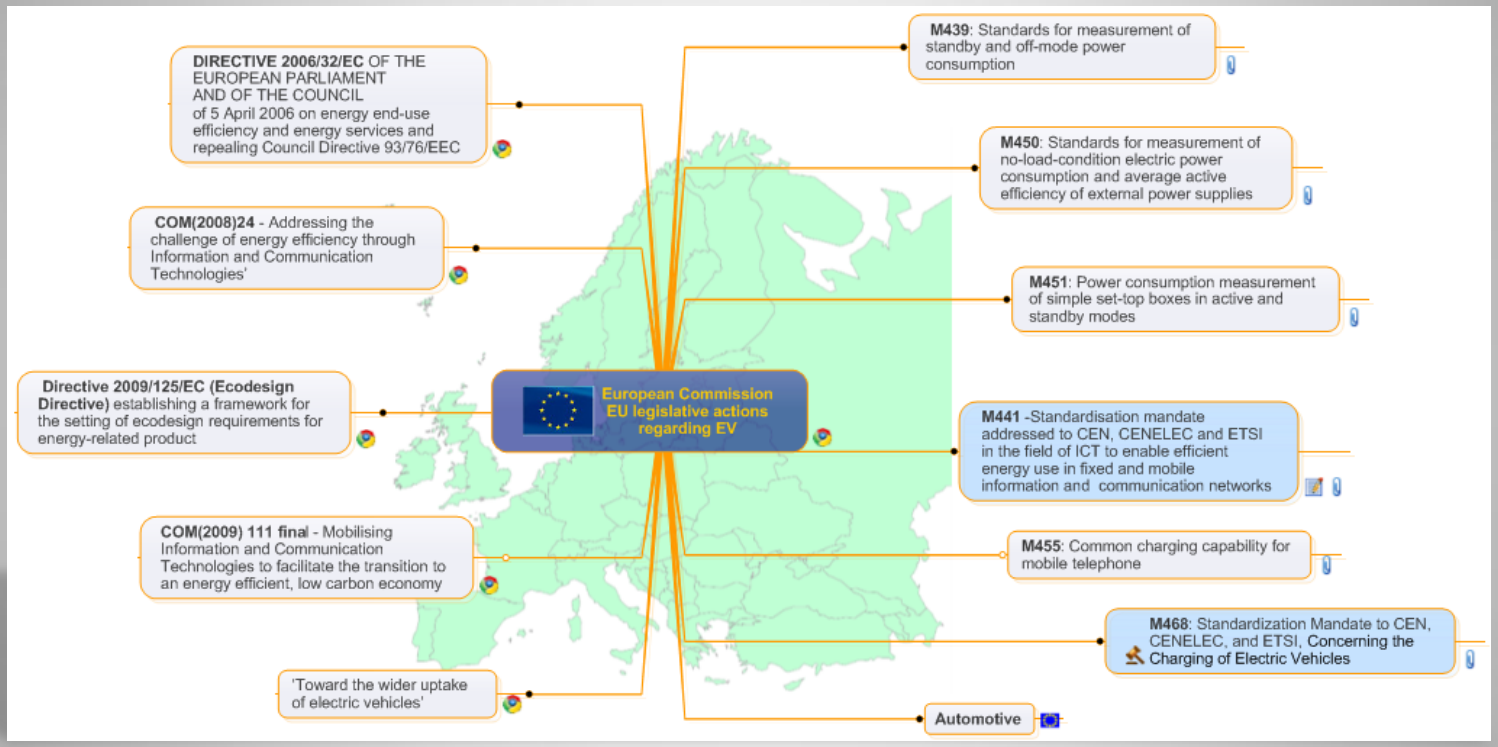
Leading SDO in NIST Roadmap for Smart Grid interoperability

24 active committees
774 committee members
33 standards developed or in process

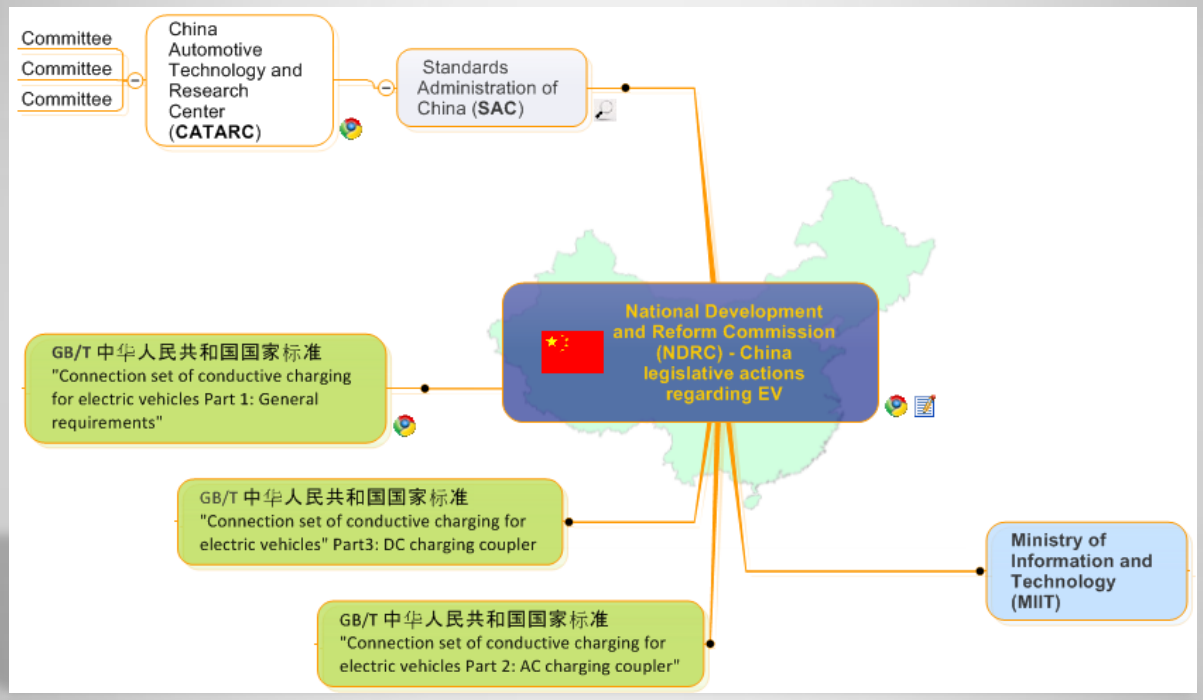
Formula for success

$$\frac{Policy + f(Infrastructure + Reliability + Affordability)}{(Standardization)} = Customer\ Acceptance + Market\ Demand$$

Regional regulations (EU)



Regional regulations (China)

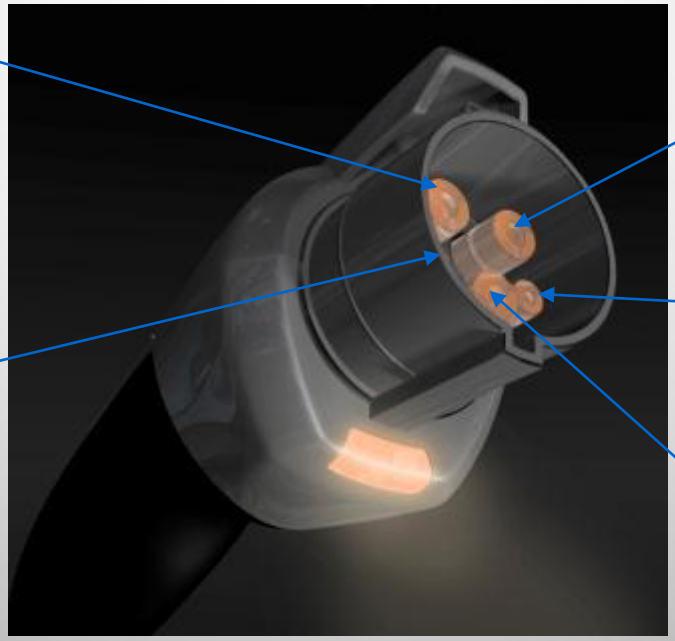


Vehicle to Grid SAE AC Coupler

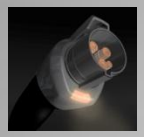
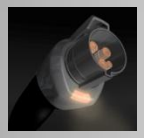
SAE J	Title	Scope	Status
SAE J1772™	SAE Electric Vehicle Conductive Charge Coupler	General requirements for the electric vehicle conductive charge system and coupler for use in North America. Define a common electric vehicle conductive charging system architecture including operational requirements and the functional and dimensional requirements for the vehicle inlet and mating connector.	Published January, 2010

Two charging levels:

- AC Level 1: 120 Volt single phase to 16 Amps
- AC Level 2: 240 Volt single phase to 80 Amps



SAE Charging Configurations and Ratings Terminology

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

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

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

Developed by the SAE Hybrid Committee *ver. 031611*

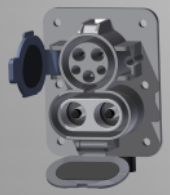
Regional Differences

220-240V/50Hz
220-240V/60Hz
100-127V/60Hz
100-127V/50Hz

- Not every country has the same electrical system
- Charging needs differ for vehicle type (PEV/PHEV)
- Charging needs differ for charging locations

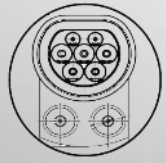
US charge power:
- AC single phase - low & moderate
- DC for high power fast charge

US connector:
- AC J1772™ for Lev1 and Lev2
- DC J1772™ (new revision)



EU charge power:
- AC single phase - low
- AC 3 phase - moderate and high power fast charge
- DC charge strategy - unclear

EU connector:
- AC single phase IEC 62196-2 "Type 1" (J1772™)
- AC single/3 phase IEC 62196-2 "Type 2"
- AC single/3 phase IEC 62196-2 "Type 3"
- DC - IEC 62196-3



Not to scale

•China charge power:
- AC single phase - low & moderate
- DC for high power fast charge

•China connector:
- AC - Chinese unique version
- DC - Chinese unique version

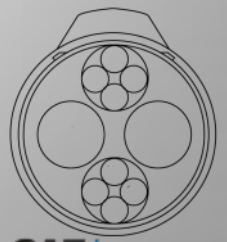
•Korea connector:
- AC - J1772™
- DC CHaDeMo system with unique DC coupler

China AC

China DC

Japan charge power:
- AC single phase - low to moderate
- DC for high power fast charge

Japan connector:
- AC J1772™
- DC ChaDeMo system and coupler



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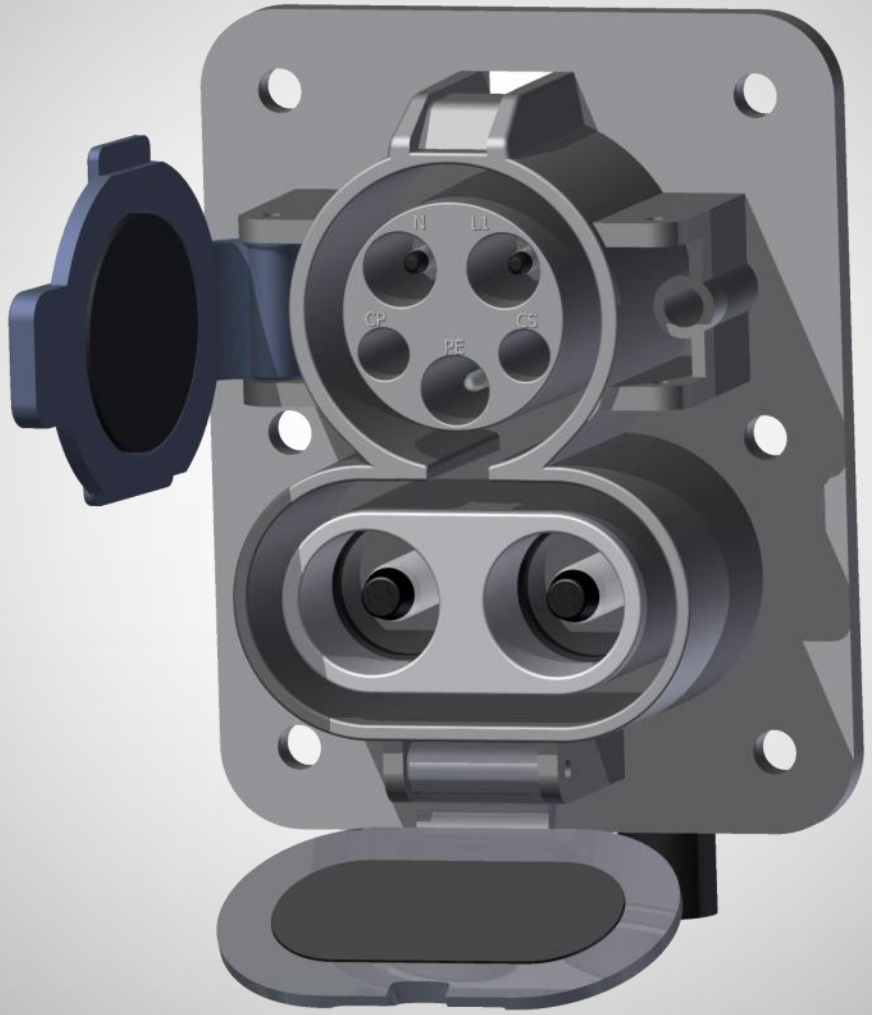
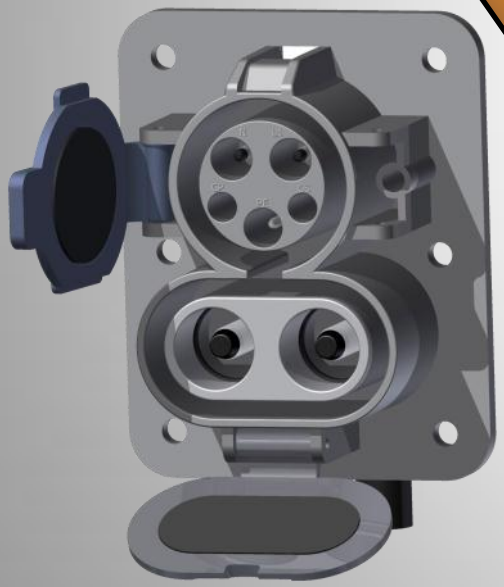
US Combo Connector



US connector:
- **AC J1772™ for Lev1 and Lev2**
- **DC J1772™ (new revision)**

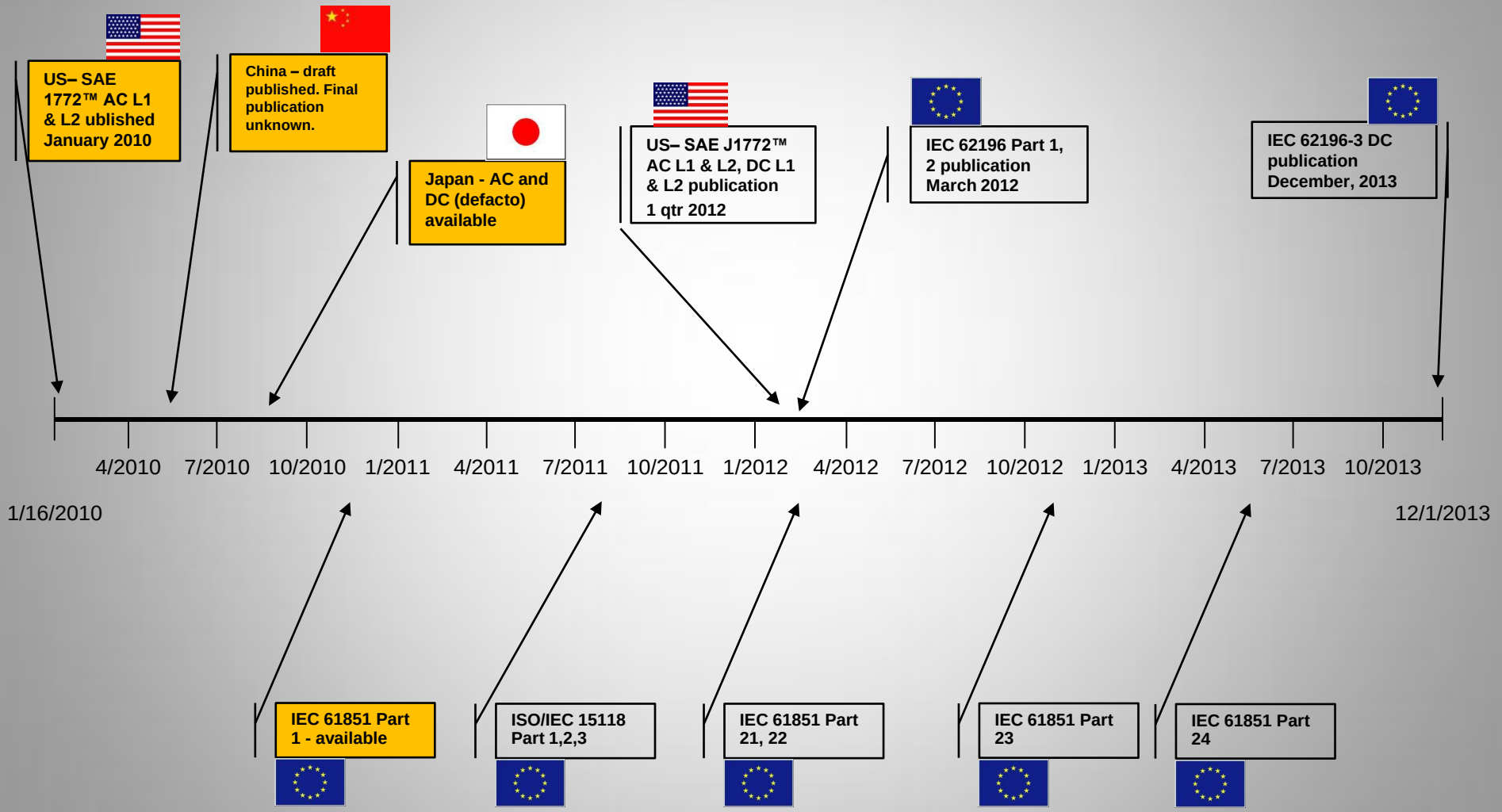
Harmonization



Harmonizing
Type 1 core
Adding DC contacts

Harmonizing
Type 2 core
Common control signals

Connector Standards Timing



SAE International

Harmonization – what if we don't?

- Vehicle OEMs will need to package different charge receptacles and have different vehicle controls
- Number of vehicle sheet metal openings will be different for different regions
- Infrastructure cannot be shared
- Vehicle and infrastructure costs will be higher - with no benefit to customers

V2G – Critical SAE Standards

SAE J	Title	Scope	Status
SAE J2293/1	Energy Transfer System for Electric Vehicles--Part 1: Functional Requirements and System Architectures	Describes the total EV-ETS (Energy Transfer System) and allocates requirements to the EV or EVSE for the various system architectures.	Published July, 2008
SAE J2293/2	Energy Transfer System for Electric Vehicles--Part 2: Functional Requirements and System Architectures	Describes the SAE J1850-compliant communication network between the EV and EVSE for this application (ETS Network).	Published July, 2008
SAE J2758	Determination of the Maximum Available Power from a Rechargeable Energy Storage System on a Hybrid Electric Vehicle	Describes a test procedure for rating peak power of the Rechargeable Energy Storage System (RESS) used in a combustion engine Hybrid Electric Vehicle (HEV).	Published April, 2007
SAE J1711	Recommended Practice for Measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles	Sets recommended practices for measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles, Including Plug-in Hybrid Vehicles.	Published June, 2010
SAE J2841	Definition of the Utility Factor for Plug-In Hybrid Electric Vehicles Using National Household Travel Survey Data	Describes the equation for calculating the total fuel and energy consumption rates of a Plug-In Hybrid Electric Vehicle (PHEV).	WIP

Summary of SAE Communication Standards

J2836™ – General info (use cases)

Dash 1 – Utility programs *

Dash 2 – Off-board charger communications ****

Dash 3 – Reverse Energy Flow

Dash 4 – Diagnostics

Dash 5 – Customer and HAN

Dash 6 – Wireless charging/discharging

J2847– Detailed info (messages)

Dash 1 – Utility programs *

Dash 2 – Off-board charger communications ****

Dash 3 – Reverse Energy Flow

Dash 4 – Diagnostics

Dash 5 – Customer and HAN

Dash 6 – Wireless charging/discharging

J2931– Protocol (Requirements)

Dash 1 – General Requirements **

Dash 2 – In-Band Signaling (control Pilot) **

Dash 3 – NB OFDM PLC over pilot or mains **

Dash 4 – BB OFDM PLC over pilot or mains **

Dash 6 - RFID

J2953– Interoperability

Dash 1 – General Requirements

Dash 2 – Testing and Cert

Dash 3 –

- * Two have initial versions published
- ** Six are expected to ballot 1Q 2011

Current work status (as of January 1, 2011)

SAE J	Current revision status
SAE J1772™	2011 Current activity: Plan to re-ballot 1st Quarter 2012 • Include interoperability to multiple suppliers (PEV & EVSE) • Add DC (level 1 – up to 20 kW) back into document • Detection circuit monitored by EVSE and PEV • Require lock controlled by PEV 2012 Next Steps: • Add DC (level 2 – up to 80 kW) connector • Add temp sensor and other safety items • Potential to add Reverse energy flow
J2836/2™	• DC Use cases and general info
J2847/2	• DC Messages and detail info • Messages and signals mature, finalizing sequence and state diagrams
J2931/1	• Digital Communications for Plug-in Electric Vehicles • Communication requirements and protocol (AC & DC)
J2931/2	• In-band signaling Communication for Plug-in Electric Vehicles
J2931/3	• PLC Communication for Plug-in Electric Vehicles

Future work (as of January 1, 2011)

SAE J	Future scope
J2836/5 J2847/5	• Customer and HAN (J2836/5™ & J2847/5) • Plan is to build on customer messages pulled from J2847/1 plus Open SG effort.
J2847/4 J2836/4	• Diagnostics • Plans to build on effort presented to CARB plus vehicle diagnostics
J2953	• J2953/1 Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE)
J2847/3	• Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow
J2836/3™	• Use Cases for Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow • Reverse Energy Flow (J2836/3™ & J2847/3) • Developing use cases and reviewing architecture for both on-board and off-board conversion.

What About Safety?

National Electrical Code
Article 625 – Electric Vehicle Charging System
I – General
II – Wiring Methods
III – Equipment Construction
IV – Control & Protection
V – EV Supply Equipment Locations

On Board Battery Charger UL 2202. Conductive and inductive charging system equipment for recharging the storage batteries of electric vehicles

J2929 EV and PHEV propulsion Battery System Safety Standard (Safety Performance Criteria)

Charging inlet UL 2251. Plugs, receptacles, vehicle inlets, and connectors intended for conductive connection systems, for use with electric vehicles

Charging plug SAE J1772™

UL 2231-1
Personnel Protection Systems for EV Supply Circuits

UL 2231-2
Protection Devices for Use in Charging Systems

UL2594
Outline for Investigation for EV Supply Equipment

SAE International

Wireless Charging of EV's & PHEV's

SAE J2954 standard in development

- **Wireless connection and power transfer**
  - Inductive Charging Technologies
  - Smart Grid Interoperability / Programmability

Who's Involved?

- Auto and Commercial Vehicle OEM's (11)
- Automotive Suppliers
- Organizations (laboratories, government agencies, universities, SDO's, power companies)

SAE Standard will define:

- Performance
- Safety
- Testing Methodologies
- Charge Levels
- Location
- Communications

Potential Charging Locations:

- Residential
- Public
- On-Road
  - Static (parking lots, curb side)
  - Dynamic (embedded in roadway)

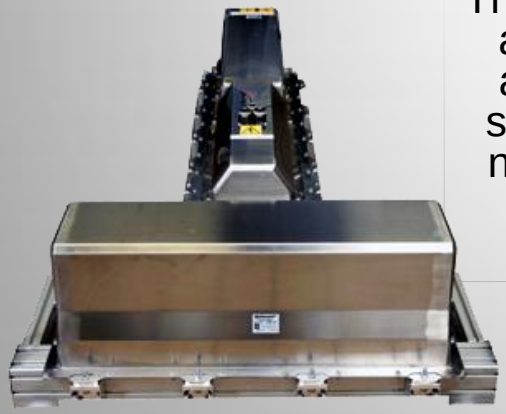
UniServices - The University of Auckland

SAE Vehicle Battery Standards Committee

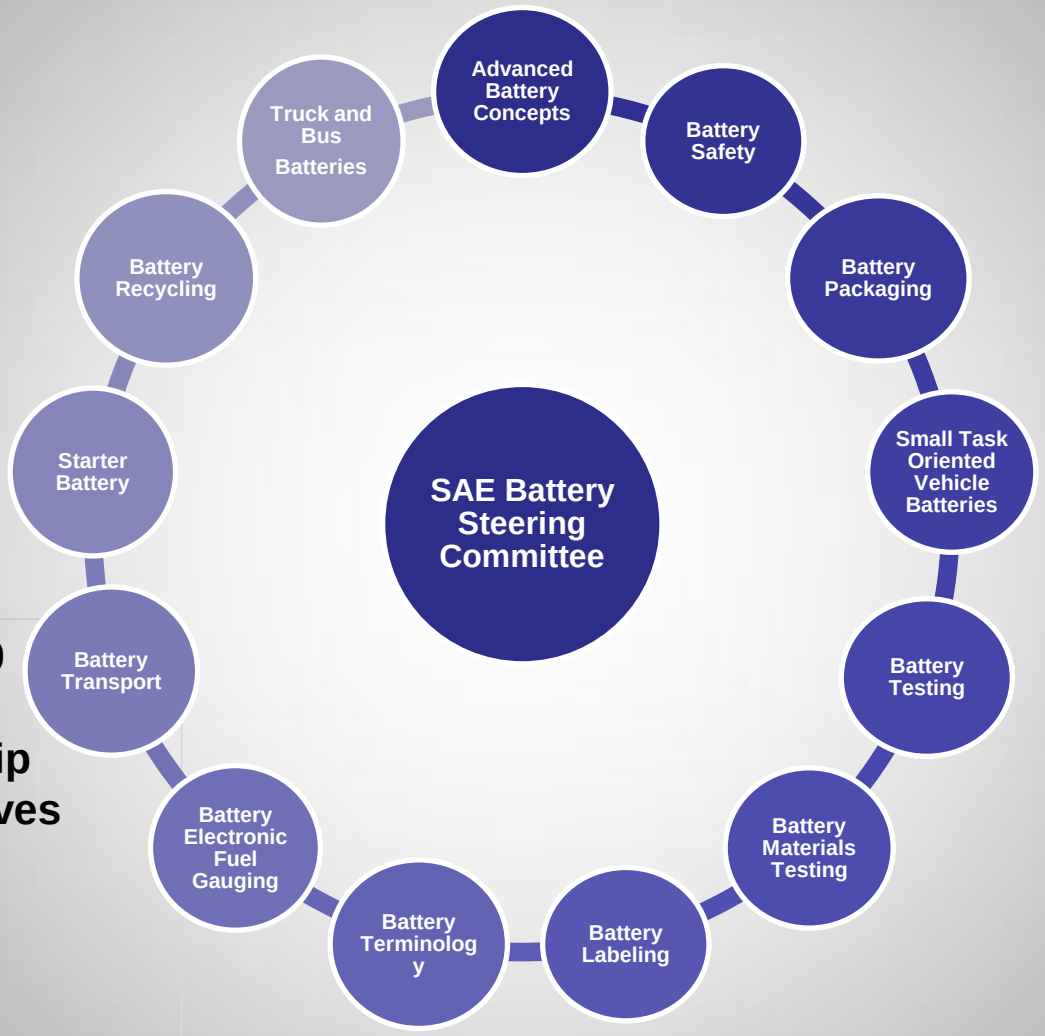
The future of battery electric vehicles depends primarily upon the cost and availability of batteries with high energy densities, power density, and long life. This will help alleviate range anxiety.

Scope

These new technology challenges, along with maintaining the past and present battery technology standards, is the essence of this newly formed Battery Standards Committee.



SAE Vehicle Battery Standards Committee



Started – Nov. 2009

Current Membership

- **216 Representatives**
- **120 companies**
  - **OEM's,**
  - **Suppliers,**
  - **Government**
  - **Academia**

Batteries – Critical SAE Standards

SAE J	Title	Scope	Status
SAE J1798	Recommended Practice for Performance Rating of EV Battery Modules (Revision)	Common test and verification methods to determine Electric Vehicle battery module performance. Document describes performance standards and specifications.	WIP
SAE J537	Storage Batteries (Revision)	Testing procedures of automotive 12 V storage batteries and container hold-down configuration and terminal geometry.	WIP
SAE J2936	Vehicle Battery Labeling Guidelines (New)	Labeling guidelines for any energy storage device labeling (such as: including cell, battery and pack level products).	WIP
SAE J2929	Electric and Hybrid Vehicle Propulsion Battery System Safety Standard **(New)**	Safety performance criteria for a battery systems considered for use in a vehicle propulsion application as an energy storage system galvanically connected to a high voltage power train.	**Published 02/18/11**
SAE J2758	Determination of Max. Power from a HEV Rechargeable Energy Storage System	Describes a test procedure for rating peak power of the Rechargeable Energy Storage System (RESS) used in a combustion engine Hybrid Electric Vehicle (HEV).	WIP
SAE J2380	Vibration Testing of Electric Vehicle Batteries	Describes the vibration durability testing of a electric vehicle battery module or an electric vehicle battery pack.	Published 2009
SAE J2464	Electric Vehicle Battery Abuse Testing	Describes a body of tests for abuse testing of electric or hybrid electric vehicle batteries.	Published Nov., 2009
SAE J2288	Life Cycle Testing of EV Battery Modules	Defines a standardized test method to determine the expected service life, in cycles, of electric vehicle battery modules.	Published June 2008
SAE J2289	Electric-Drive Battery Pack System: Functional Guidelines	Describes practices for design of battery systems for vehicles that utilize a rechargeable battery to provide or recover traction energy.	Published July 2008
SAE J551/5	Magnetic and Electric Field Strength from EV's	Test procedures and performance levels describe the measurement of magnetic and electric field strengths.	Published Jan., 2004
SAE J1113	Electromagnetic Compatibility—Component Test Procedure	Defines a component-level test procedure to evaluate automotive electrical and electronic components for electromagnetic disturbances.	Published 2006



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