CRITICAL STANDARDS FOR EVS AT SCALE AND PRIORITIES UNDER THE CODES AND STANDARDS PILLAR OF THE U.S. DEPARTMENT OF ENERGY (DOE)

SAE J3271 MCS Couplers- 1500v/3000A

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US DOE EVS AT SCALE CONSORTIUM OBJECTIVES

- Comprised of six national laboratories
  - Argonne National Laboratory (ANL)
  - Idaho National Laboratory (INL)
  - National Renewable Energy Laboratory (NREL)
  - Oak Ridge National Laboratory (ORNL)
  - Pacific Northwest National Laboratory (PNNL)
  - Sandia National Laboratories (SNL)
- Work with key stakeholders to conduct infrastructure research and development to address challenges and barriers for high-power electric vehicle (EV) charging infrastructure that enable increased safety, grid operation reliability, and consumer confidence.
- Research activities will advance innovations in and support standards development for on-road and off-road vehicle charging.
- Develop technologies to integrate vehicle charging with the electric grid and develop cybersecurity measures to protect drivers, vehicles, equipment, and the grid from multifaceted threats.

US DOE EVS AT SCALE CONSORTIUM WORK PILLARS

- Five work areas under EVs at Scale Consortium, plus stakeholder engagement
  - Vehicle- grid integration and smart charge management (SCM) {FuSE}
  - MW Level charging equipment and interconnection requirements {ECHiP}
  - Dynamic wireless power transfer (DWPT) technology
  - Oak Ridge National Laboratory (ORNL)
  - Cybersecurity for high power charging
  - Codes and Standards development and harmonization

- Codes and standards pillar has limited staff resources and funding leading to need to prioritize on the ‘top 10’ gaps or standards needed for EVs at Scale deployments.

- The EVSP Standards Roadmap is foundation to catalog relevant EV and EV charging standards as well as identifying gaps.

- The top two standards areas covered include MW charging (SAE J3271 MCS) and system level grid interconnection topics (IEEE P2030.13).

MW+ MULTI-PORT EV CHARGING SYSTEM SCOPE FROM INTERCONNECTION TO VEHICLE BATTERY TERMINALS

From Source to Load (grid-to-battery)

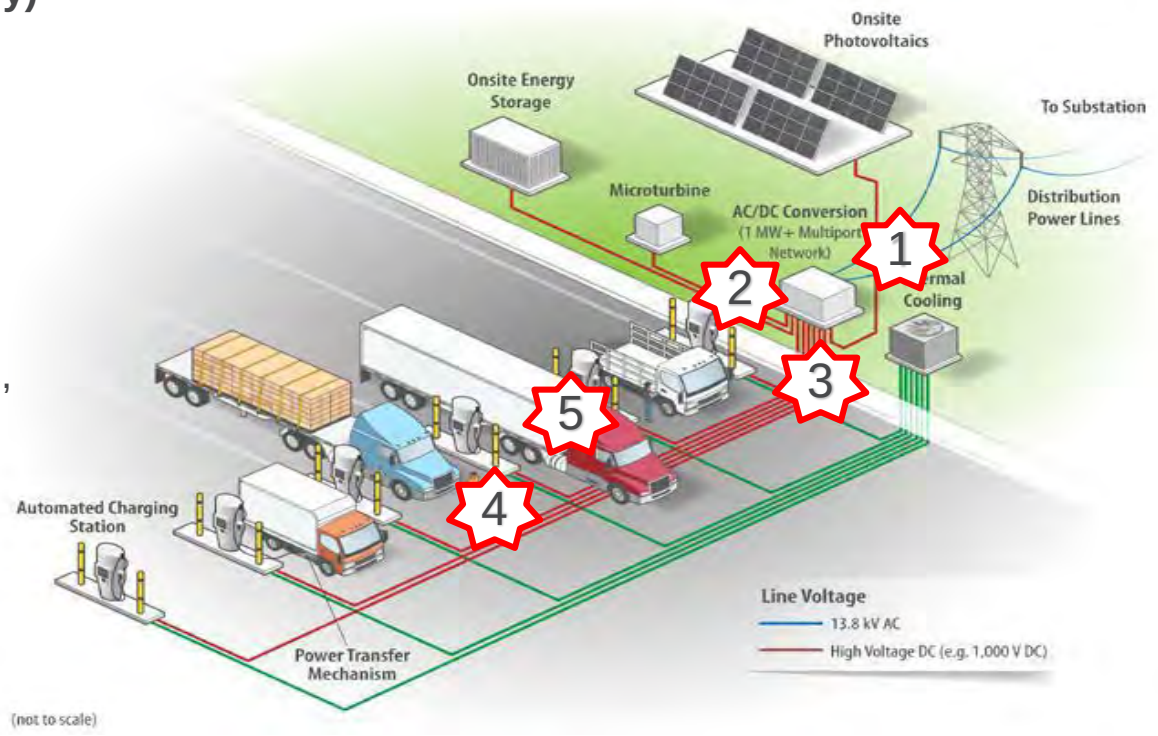
1) Utility Interconnection

2) AC/DC Power Conversion

3) DC Distribution, w/DER Elements

4) DC Dispenser Electronics, Cables, Couplers, Micro-siting

5) Vehicle Inlet, Battery-BMS, Safety



PRACTICAL EXAMPLES OF SITE PLANNING: ONTARIO CALIFORNIA

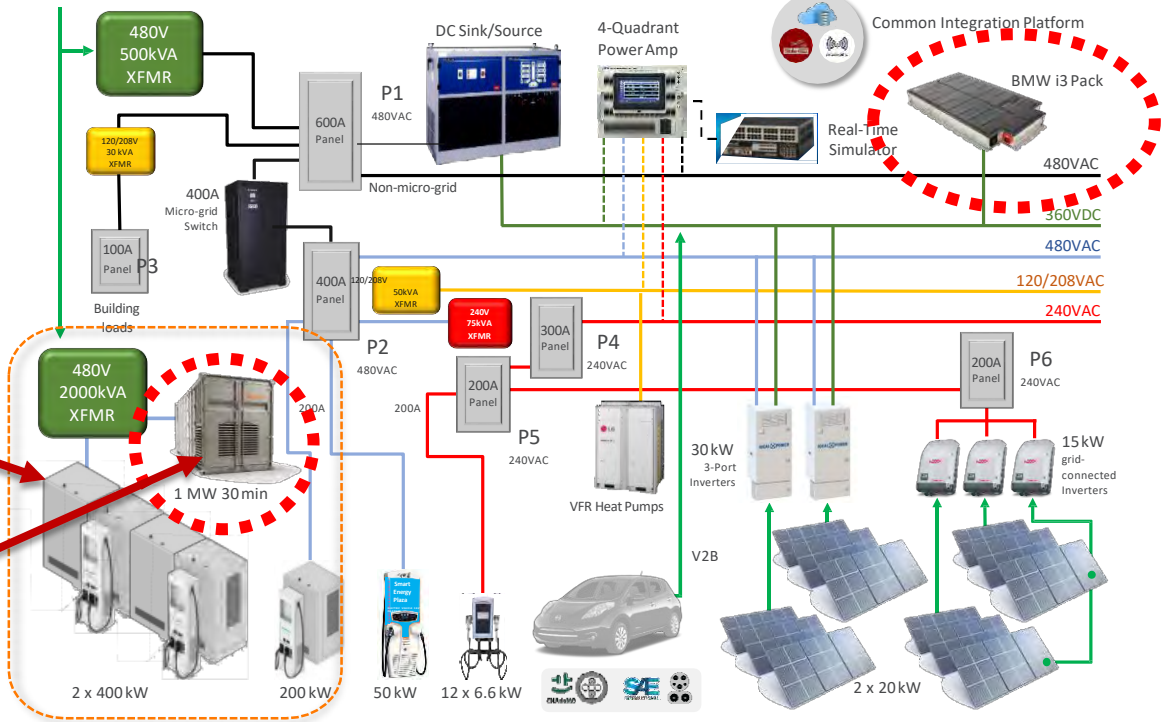
TA Petro Ontario California truck stop ~600 parking spots (on left); again as many on right. Electrifying up to 1200 parking/charging spots is both an opportunity and a challenge

ANL SMART CHARGING PLAZA; AC AND DC COUPLED STORAGE, MW CHARGE

Big and small charging ports, energy storage, arrays of OCPP EVSEs

1+MW Total DC EVSEs (2x400kW+1x200kW +50kW..)

- 2667kVA transformer and switchgear
- 1 MW/500kWhr AC coupled Y-Cube storage
- 33kWhr DC coupled BMW i3 pack on DC busway



ANL AC COUPLED MW (COMBINED) DC CHARGING/BATTERY

- 5x 200kW power conversion cabinets, 3x 500A dispensers (1500A/1MW total)
- Aggreko 1 MW 480vac coupled storage system, 80kW on PV canopy
- Dedicated metering (Schneider SCADA) on each branch/device

BALANCING ACT; SCALING, FINANCING, EXPANDABILITY, INTEROPERABILITY

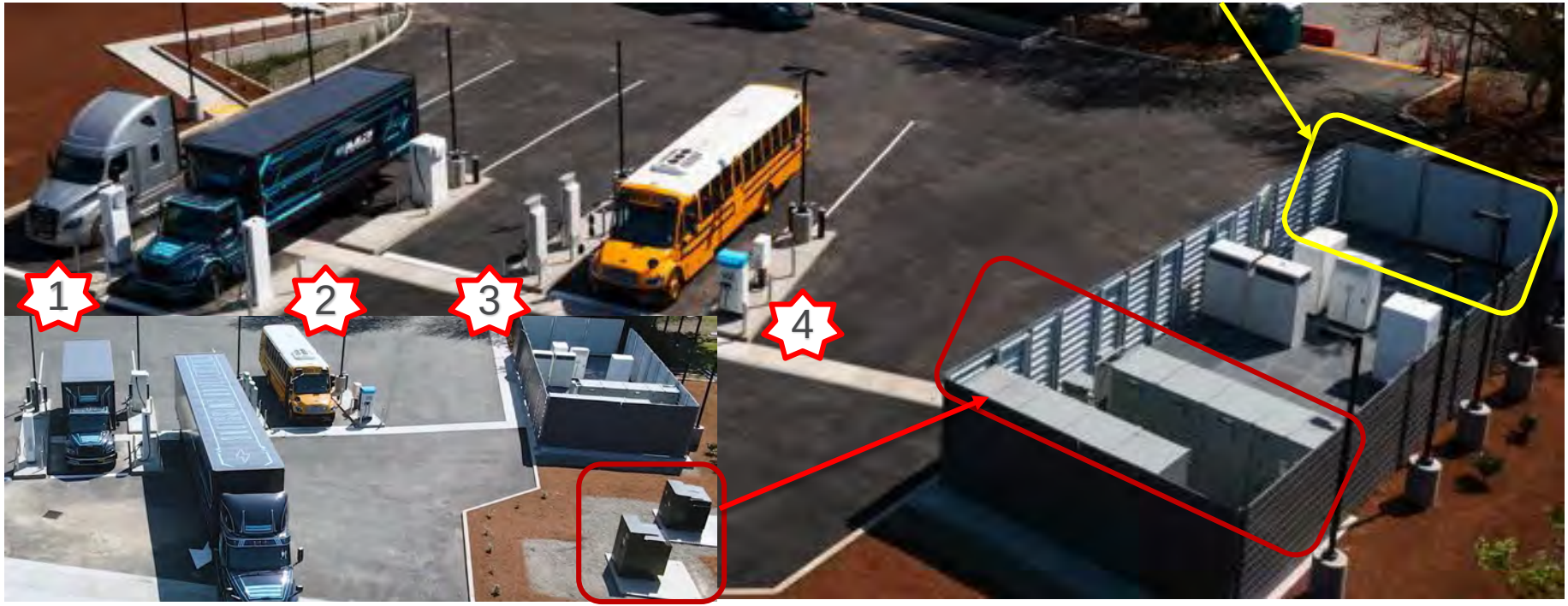
- Multi-port MD/HD electric bus and MD/HD truck charging source-to-destination (utility interconnection to battery terminal), up to 1MW or above
- More realistically multiple vehicles at a single location, addressing utility interconnection **pad mounted transformer 2.5MVA limitations.**
- At the 1MW-2.5MW level, ignoring losses this equates to simultaneous charging of

  - **1 to 2.5** charging ports at **1MW** each
  - **2 to 5** charging ports at **500kW** each
  - **10 to 25** charging ports at **100kW** each
  - **50 to 125** charging ports at **20kW** each

- One can do the math on oversubscription of 4-10x for sharing DC sources (10's at MW level to hundreds at the 100kW/20kW per port from one 480vac/2.5MW AC-DC conversion feed (**1500vdc*1666A=2.5MW** DCaaS DC bus distribution feed)

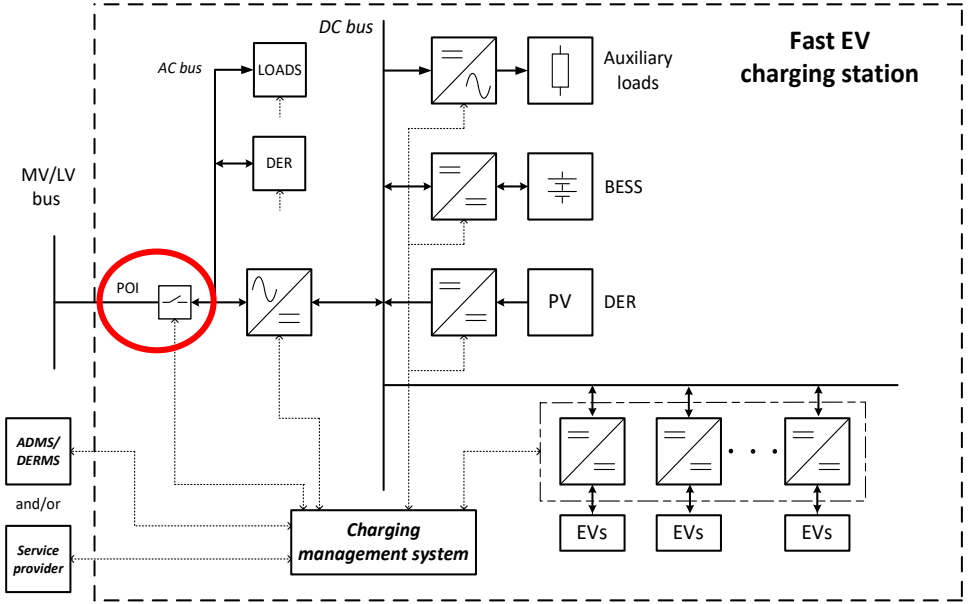
ELECTRIC ISLAND CHARGING PLAZA; PORTLAND (DTNA, PGE)

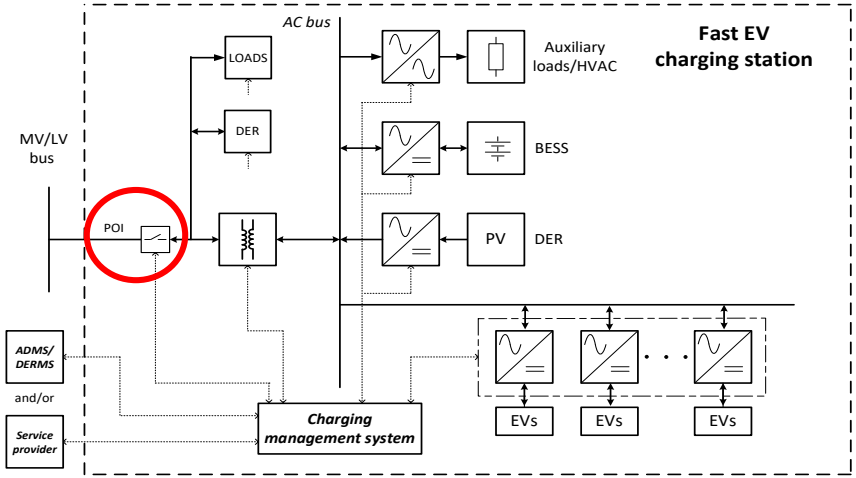
5MW (2x2.5MW transformers), reconfigurable gutters/covers, 4 charging islands {left to right} (ABB, BTCP, Chargepoint, Power Electronics SA/Proterra), Phase 2: MCS/MW EVSE, V2G capabilities and peak shaving energy storage



IEEE P2030.13- GUIDE FOR ELECTRIC TRANSPORTATION FAST CHARGING STATION MANAGEMENT SYSTEM FUNCTIONAL SPECIFICATION

- DC and AC bus system diagrams in P2030.13 (POI-point of interconnection is significant)
- V2G and DC as a Service implications/interpretations, islanded/microgrid operation modes
- Applicable to kW level systems/chargers to MW sized installations, w/wo storage/PV





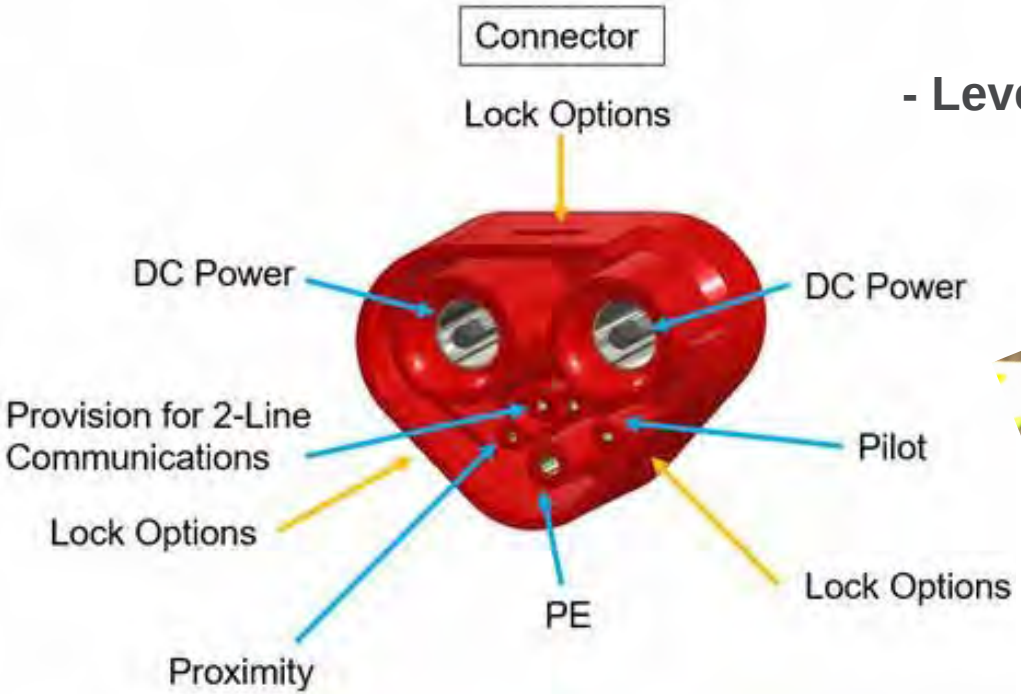
SAE MEGAWATT CHARGING STANDARDS

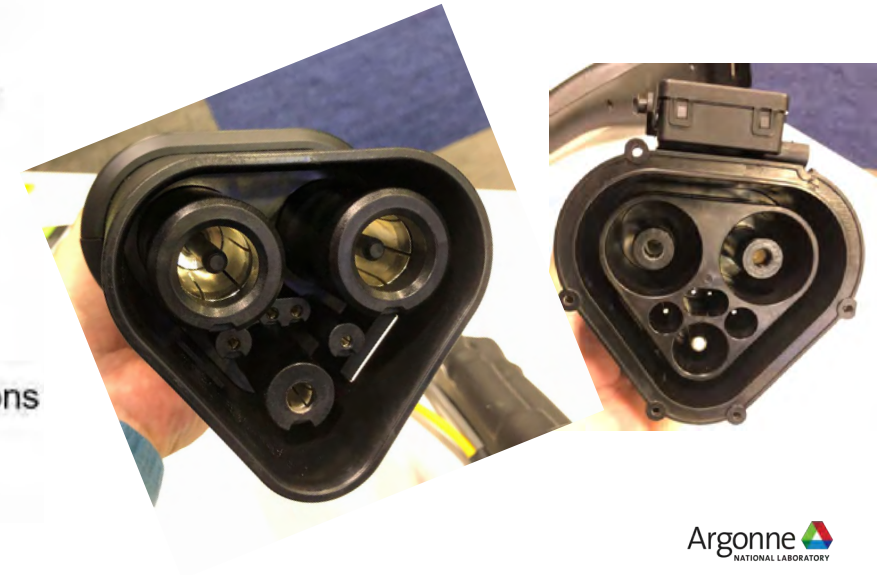
- **SAE J3271** TIR covers system level charging requirements, aimed at *“Any Large Battery Vehicile that Rolls, Flies or Floats”*)
  - Five volumes spanning utility interconnection to vehicle battery
  - Version 0 Technical Information Reference draft released December 2022

- **Subtopic documents:**
  - SAE J3271/1; Electromechanical coupler/inlet requirements (like J1772)
  - SAE J3271/2; Physical/software layer communication (~J2931, J2847, J1939)
  - SAE J3271/3; Charging cables (cooling, cord handling/automated connection)
  - SAE J3271/4; Use cases including DER/microgrid interconnections (V2G)
  - SAE J3271/5; Interoperability/testing requirements
- **SAE AIR7357** MW charging for electric aircraft; iteration/subset of J3271

SAE J3271/IEC TS63379 (MCS V3.2) DESIGN/FUNCTIONS; 3000A1500V(1250V)

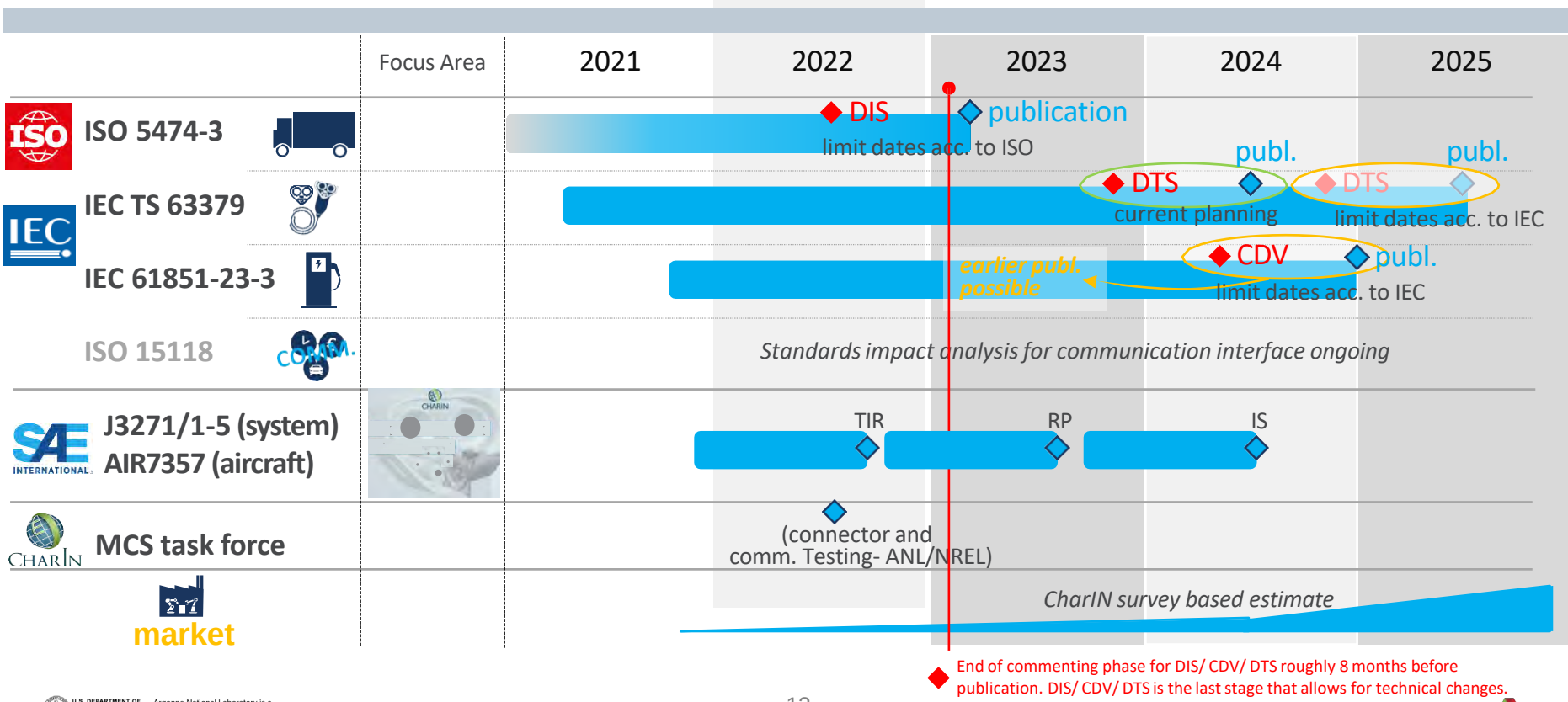
- **Level 1;** non-cooled charging cable, non-cooled inlet (~350A+)
- **Level 2;** cooled charging cable, non-cooled inlet (~1000A+)
- **Level 3;** cooled charging cable, cooled inlet (~3000A)





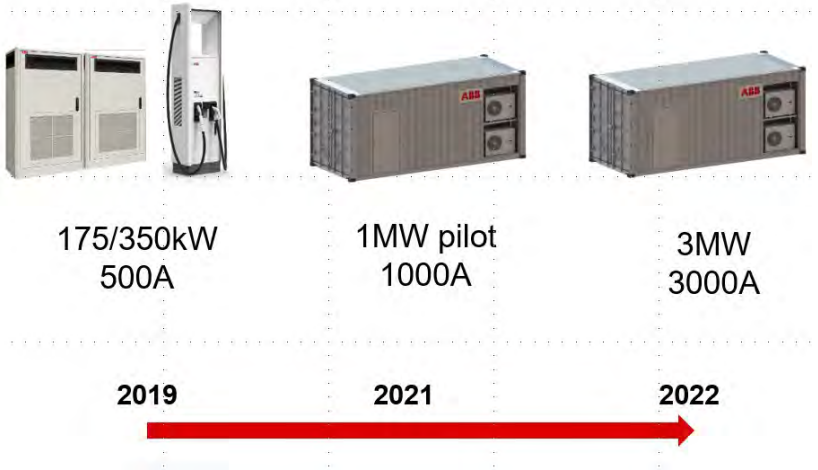
MCS STANDARDIZATION ROADMAP- INTERNATIONAL HARMONIZATION

Timeline and key milestones of international groups involved in MCS standardization.



MODULAR CHARGERS; ABB TERRA360 CONFIGURABLE ISO MODULES

- ABB latest product, 4x outputs one station https://new.abb.com/ev-charging/terra-360
- Configurable from 120kW-360kW
- Other ABB presentations show DC coupled groups of stations, up to 3000A output

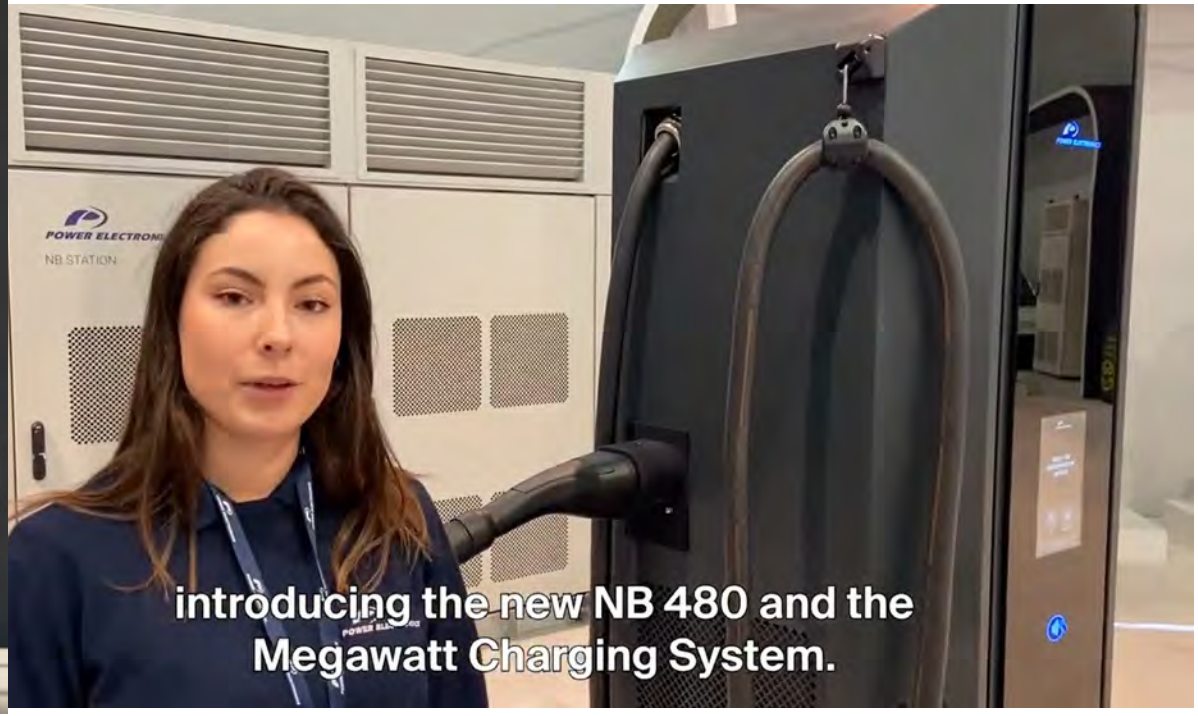


CAT 793 BEV MINING TRUCK DEMO

- https://www.caterpillar.com/en/news/corporate-press-releases/h/caterpillar-succesfully-demonstrates-first-battery-electric-large-mining-truck.html
- https://www.youtube.com/watch?v=it0k3TYFh3k

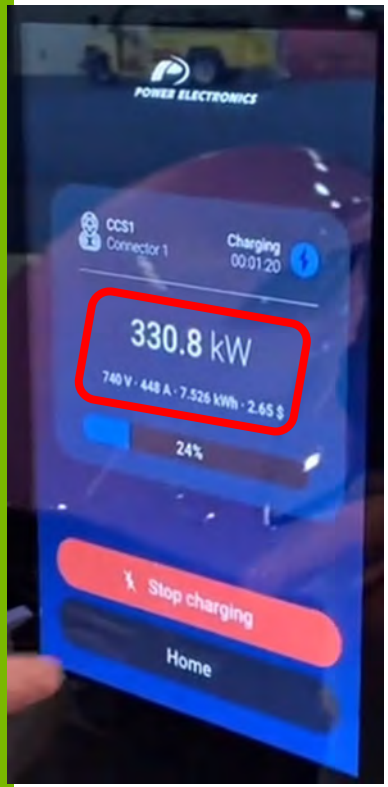
Power Electronics SA (Spain), CES Booth; NB480-MCS

- 6 meters^3 , 1400kW; Rema J3271 coupler



Power Electronics SA (Spain), CES Booth; NB480-MCS

Power Electronics SA (Spain), CCS Output



HIGH POWER CHARGING: BETA TECHNOLOGIES 'POWER CUBE', EVSE

- Powered cord reel; 4' high, 350kW (950v/350-500A), with matching EVSE power electronics
  https://www.beta.team/charge/