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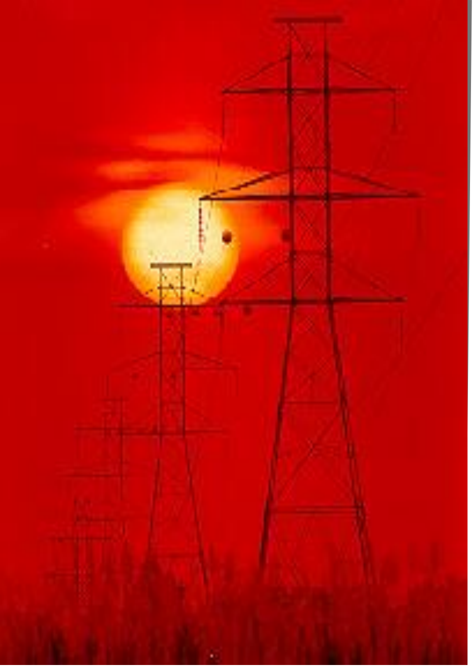

CEC Workshop on EVs:

Benefits and Challenges of Implementing Standards for Electric Vehicles and Charging Stations

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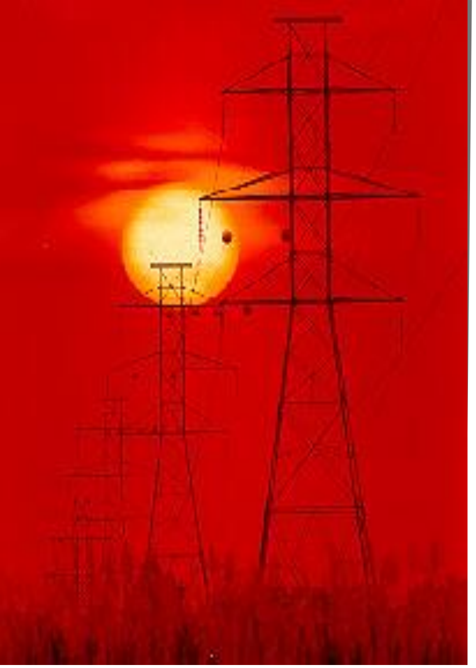
Topics

- Smart Inverter Working Group (SIWG) to update California's DER interconnection Rule 21
  - Context on the experience, thrust, and value of the SIWG
- Needs for reliability, interoperation, security, open market innovation in PEV DER.
  - Gaps analysis of standards and technological options being considered
  - Ideas for how to maximize the net value of standardization.



Smart Inverter Working Group:

Purposes and Process

California, Renewable Energy, and Distributed Energy Resources (DER) -> SIWG

- As part of achieving **33% renewables by 2020**, California Governor Jerry Brown called for 12,000 MW of "localized electricity generation" (DER).
- Now the mandate has been updated to **50% by 2030**
- Distributed Energy Resource (DER) systems have the potential to provide significant environmental and financial benefits to California at this scale.
  - However, DER systems also present challenges to managing the grid
  - **Smart Inverter-based DER, including EVs, are particularly capable of providing these benefits while helping to mitigate the adverse impacts of intermittency**.
- European experiences, including a 2003 blackout in Italy, have shown that DER systems must support the grid for both reliability and economic reasons.
  - In particular, DER systems need to be able to "ride-through" both frequency and voltage short-term anomalies
  - ***Europeans had to retrofit large numbers of DER systems to add these critical capabilities – a very expensive action***
- **California (CEC and CPUC) did not want to repeat that scenario** as the State moves to higher penetrations of DER systems

Smart Inverter Working Group (SIWG)

- The **CPUC and the CEC staff** convened the Smart Inverter Working Group (SIWG) in January 2013 to:
  - Discuss the emerging technical possibilities for DER systems
  - Develop the default DER functionality requirements
  - Establish an implementation plan for California
  - **Update California's Rule 21 on DER interconnection requirements**
- The SIWG currently has **over 260 participants** from all major stakeholder groups, including utilities, inverter manufacturers, integrators, customer groups, investors, and interested parties.
  - ***After some initial skepticism and pushback, we all understood we needed to work together to understand the issues of the different stakeholders***.
- The SIWG developed a phased approach:
  - Phase 1: Seven (7) critical autonomous functions **(final and in Rule 21 in Sept 2016)**
  - Phase 2: Communications capabilities for monitoring, updating settings, and control **(default protocol is IEEE 2030.5 (SEP2) – others permitted)**
  - Phase 3: Eight (8) additional DER functions **(picking up again in 2017)**
- **This California effort and other initiatives have triggered the updating of IEEE 1547**, first to 1547a to permit these functions, and now to a complete update of 1547

SIWG Phase 1: Seven Autonomous DER Functions

- SIWG Recommendations for Phase 1 Functions:
  - Support anti-islanding to trip off under extended anomalous conditions, coordinated with the following functions.
  - Provide ride-through of low/high voltage excursions beyond normal limits.
  - Provide ride-through of low/high frequency excursions beyond normal limits.
  - Provide volt/var control through dynamic reactive power injection through autonomous responses to local voltage measurements.
  - Define default and emergency ramp rates as well as high and low limits.
  - Provide reactive power by a fixed power factor.
  - Reconnect by "soft-start" methods (e.g. ramping and/or random time in a window).
- CPUC commissioners approved these SIWG recommendations on December 18, 2014. ***They will be mandatory for all new inverter-based generating systems by September 8, 2017.***
  - **UL 1741 SA** was updated to provide testing and certification for these functions. It was finalized on September 8, 2016
  - **IEEE 1547** is being updated based on California's requirements but on a broader basis
- Although not directly applicable to Electric Vehicles in V1G mode, they will be applicable to V2G if EVs supply energy back to the grid.

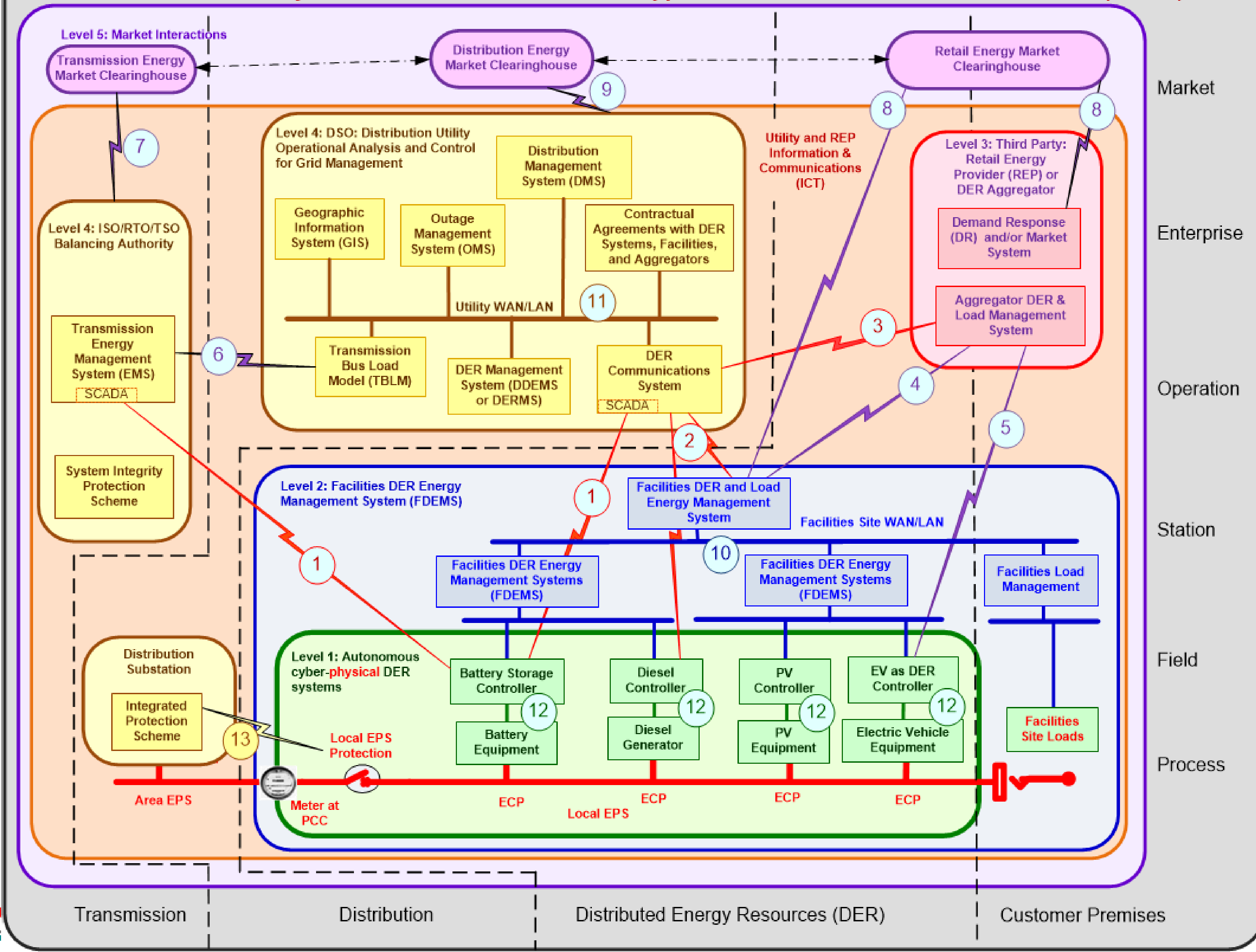
Phase 2 Recommendations for Rule 21 – expected to become mandatory (soon)

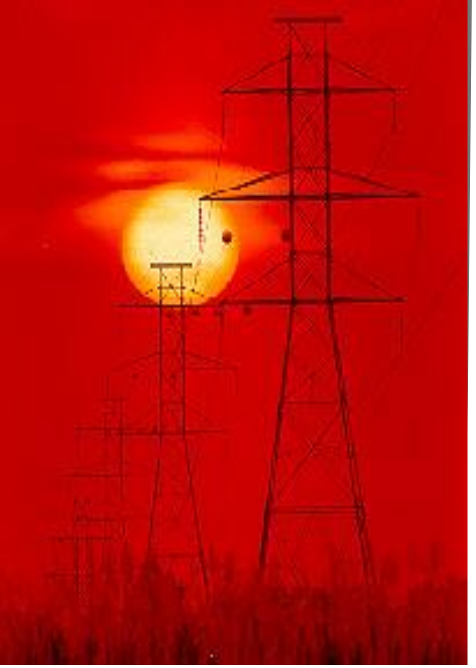
- **All inverter-based DER systems shall be capable of communications**
- The **data exchange requirements** shall be defined in "DER Data Exchange Requirements" document that shall be referenced by each utility's Generation Interconnection Handbook as the minimal that must be available to be compliant with Rule 21.
- The **default Application Level protocol shall be the IEEE 2030.5** standard. The details of the IEEE 2030.5 profile are defined in the California IEEE 2030.5 Implementation Guide.
- Other Application Level protocols may be used by mutual agreement, including **IEEE 1815/DNP3 for SCADA** real-time monitoring and control and **IEC 61850 as information model** and web protocol.
- Utility Generation Handbooks and the Protocol-Specific documents shall include **cyber security** and **privacy** requirements.

SIWG Phase 3: DER Functions Requiring or Benefiting from Communications

- Phase 3 Functions and Modes:
  - **Monitor Key DER Data**: All DER systems shall have the capability to provide key DER data at the DER's ECP and/or at the PCC.
  - **DER "Cease to Energize" and "Return to Service" Commands:** Cease exporting power and allow DER to return to service at the referenced ECP
  - **Limit Maximum Real Power Mode**: Limit real power at a referenced ECP
  - **Set Real Power Mode:** Set real power at a referenced ECP
  - **Frequency-Watt Emergency Mode**: Counteract frequency excursions during H/LFRT events by decreasing or increasing real power
  - **Voltage-Watt Mode**: Respond to changes in the voltage at the referenced ECP by decreasing or increasing real power
  - **Dynamic Reactive Current Support Mode**: Provide reactive current support in response to dynamic variations in voltage rather than the voltage itself
  - **Scheduling power values and modes**: Scheduling of real and reactive power, as well as the enabling and disabling of the DER modes
- Additional functions may be added that are specifically applicable to energy storage systems (**See MESA Specification**, downloadable from http://mesastandards.org)
- These functions and modes are expected to involve **revenue streams** for participants as Grid Support functions.
  - In planning, could involve incentives for both locational decisions and grid support agreements
  - In operations, could involve incentives for providing and/or scheduling these functions

Hierarchical DER System Five-Level Architecture, Mapped to the Smart Grid Architecture Model (SGAM)

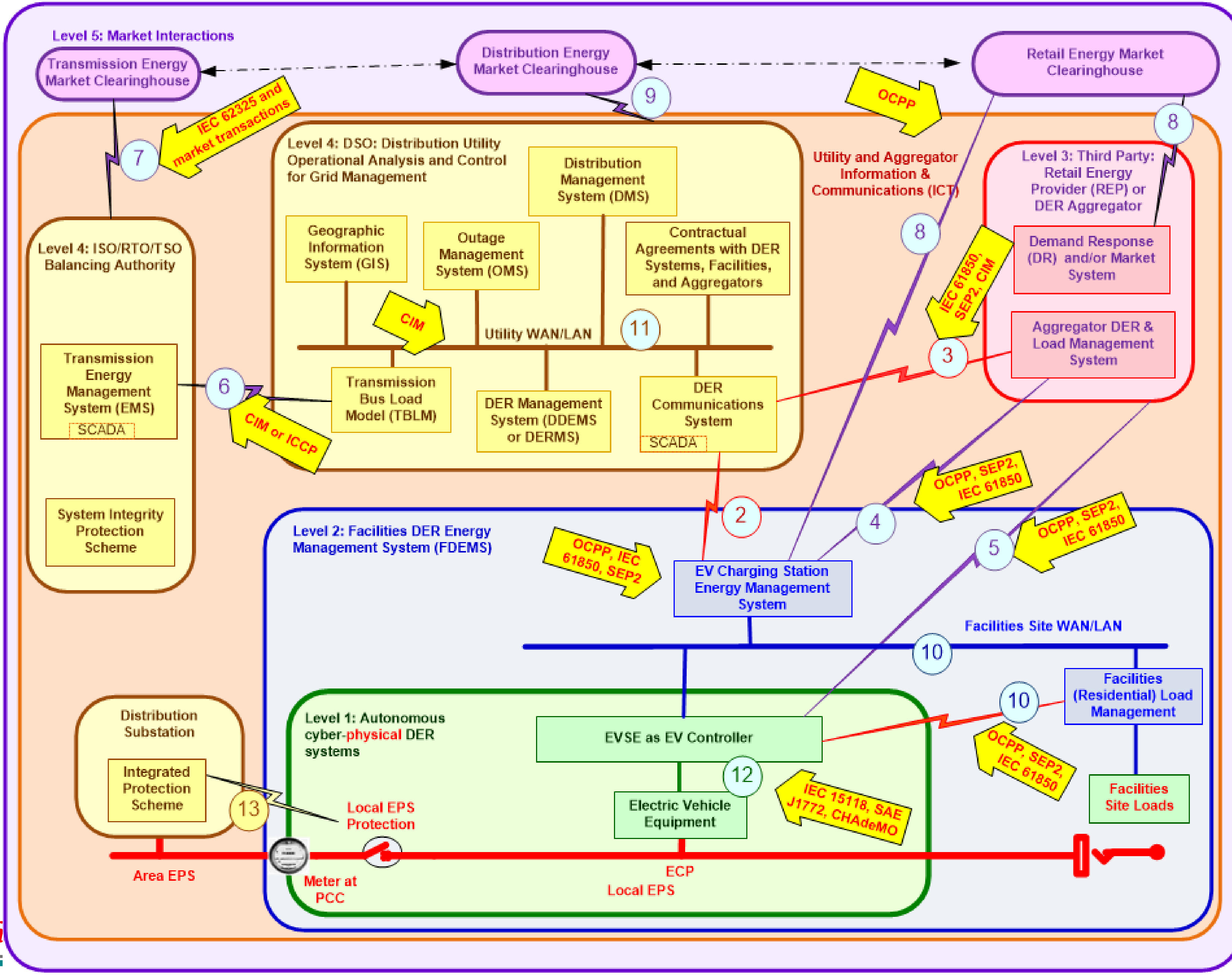




Electric Vehicle Communication Requirements:

Reliability, Interoperability, Security, and Market

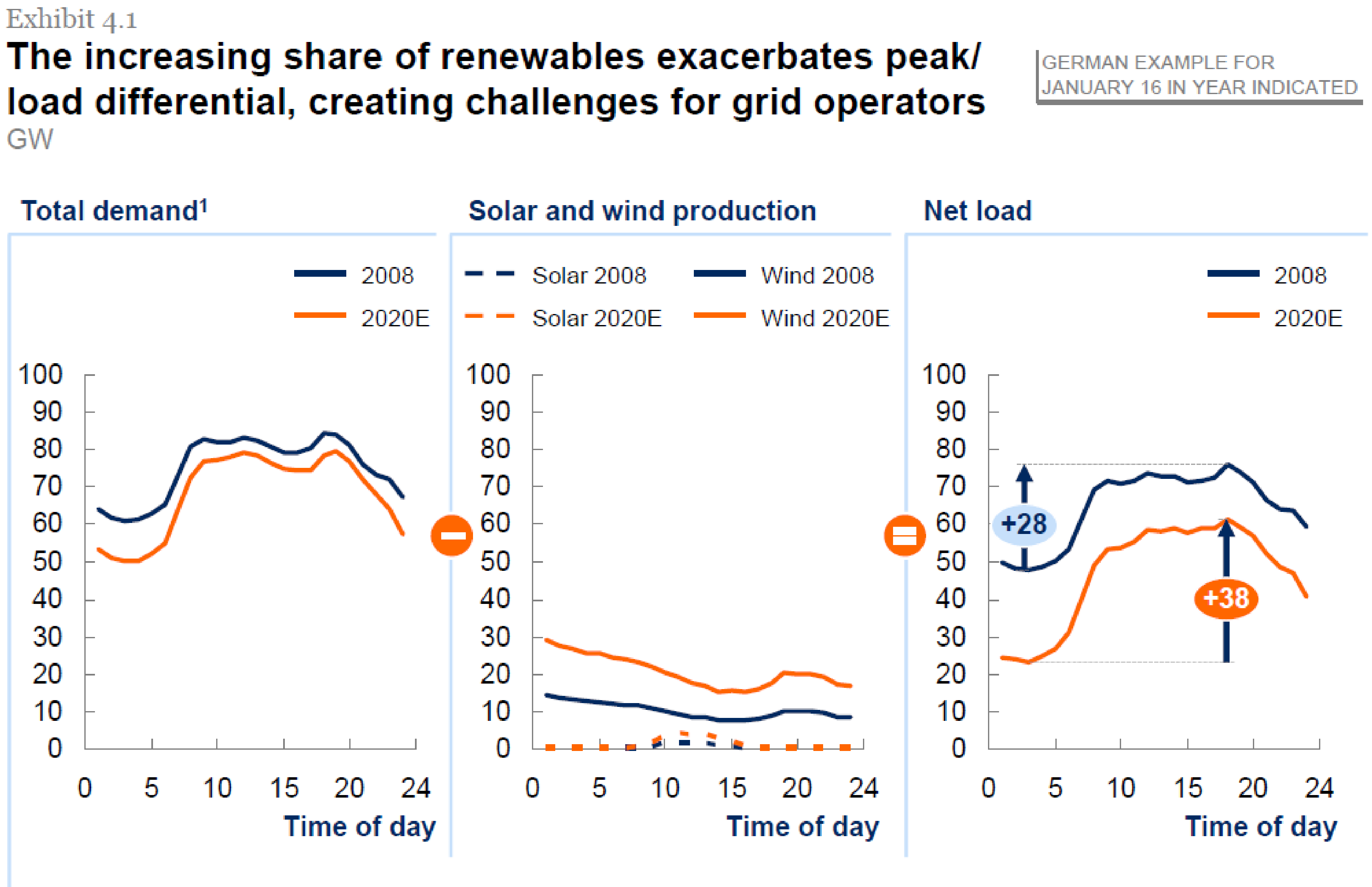
Where Do EVs (V1G and V2G) Fit Into DER Picture?



EV Communication Issues: Different interfaces, Different stakeholders, and Different purposes

- Different interfaces, stakeholders, purposes:
  - EV to EVSE (Charging)
  - EV to Third Party (OEM)
  - EV to Third Party (Market)
  - EV Driver to Third Party (Smart Phone Apps, Car Sharing)
  - EVSE to Facility EMS (Residential)
  - EVSE to Facility EMS (Charging Station)
  - EVSE to Third Party (Market)
  - Facility EMS to Third Party (Market)
  - Facility EMS to Utility (Grid Support)
  - Utility to Third Party (Grid Support)
  - Utility to Market (Grid Support)

Grid Challenges of EVs in Europe – and California



[Electric vehicles in Europe - McKinsey & Company]

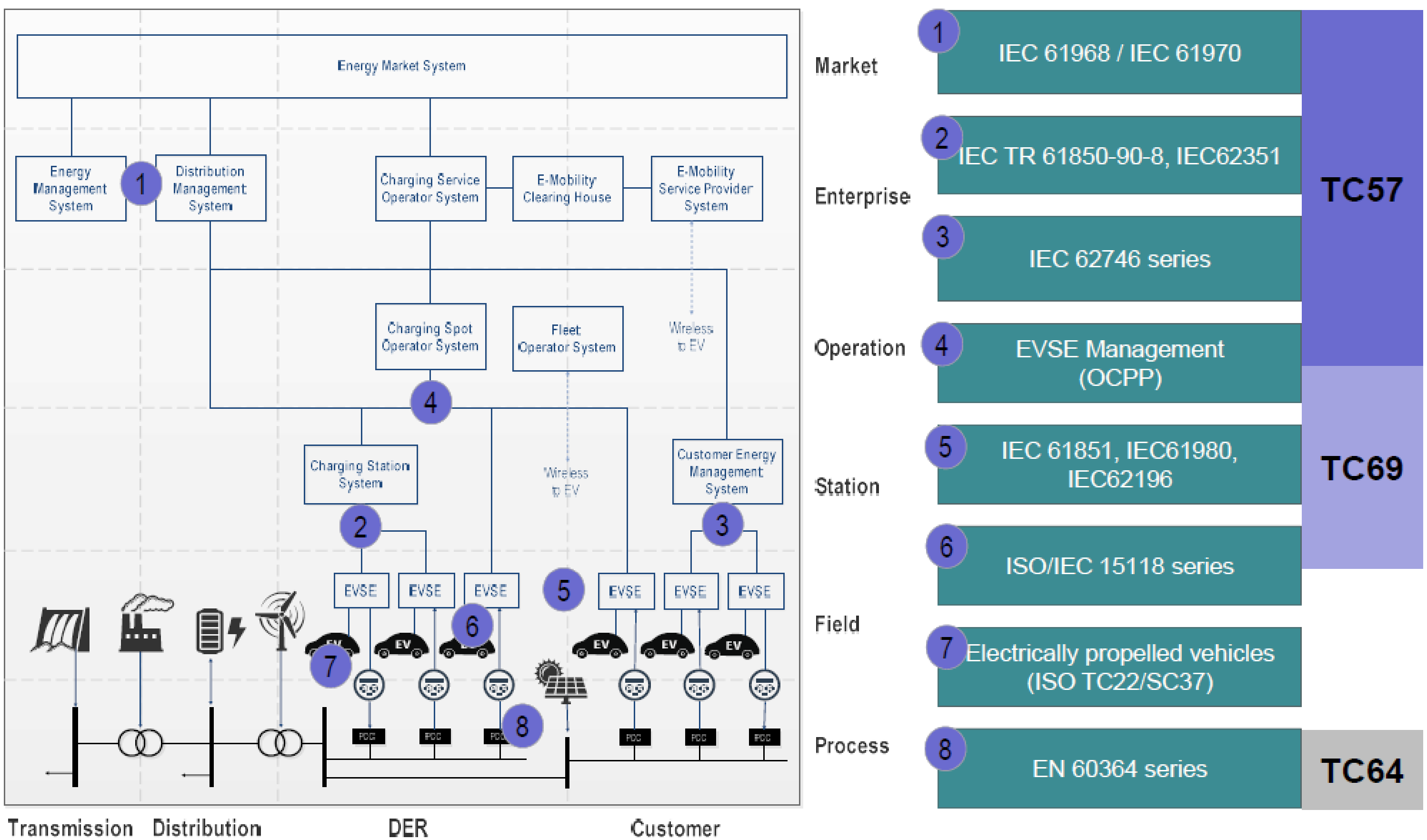
Grid Codes Which May Provide Revenue Streams to EVs

- **Coordinated Charge/Discharge Management Mode:** The EVSE/Charging Station determines when and how fast to charge or discharge so long as it meets its target state of charge level obligation by the specified time.
- **Dynamic Volt-Watt Mode:** The EVSE/Charging Station dynamically absorbs (V1G) or produces (V2G) additional watts.
- **Frequency-Watt Mode:** The EVSE/Charging Station responds to changes in frequency by changing its charging or discharging (V2G) rate based on frequency deviations from nominal, as a means for countering those frequency deviations.
- **Active Power Limit Mode:** Limits the charging level of the EVSE/Charging Station at the PCC.
- **Peak Power Limiting Mode:** The EVSE/Charging Station limits the load at the PCC after it exceeds a threshold target power level.
- **Generation Following Mode:** The charging of the EVSE/Charging Station counteracts generation power at the PCC.
- **Volt-Watt Mode:** The EVSE/Charging Station responds to changes in the voltage at the PCC by changing its charging or discharging rate.
- **Volt-VAr Control Mode:** The EVSE/Charging Station responds to changes in voltage at the Referenced ECP by supplying or absorbing vars in order to maintain the desired voltage level.
- **Watt-VAr Mode:** The EVSE/Charging Station responds to changes in power at the PCC by changing its power factor.
- **Scheduling of Power Settings and Modes:** The EVSE/Charging Station is provided with schedules of pricing for different Grid Support functions

Different Views of EV Communications Standards

IEC

SGAM overview of E-Mobility standards



IEC Approach to EV Stakeholders Modeling

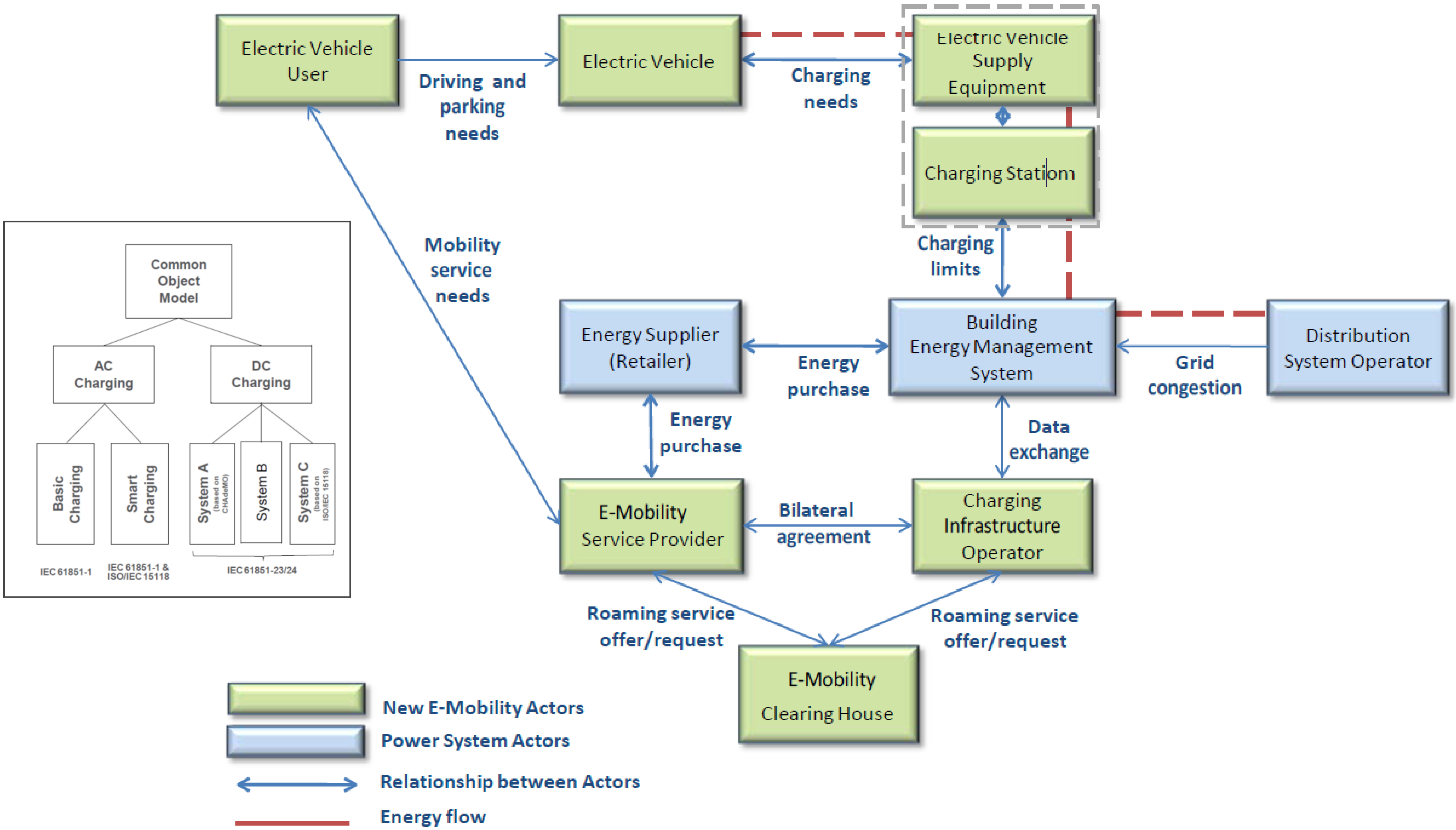
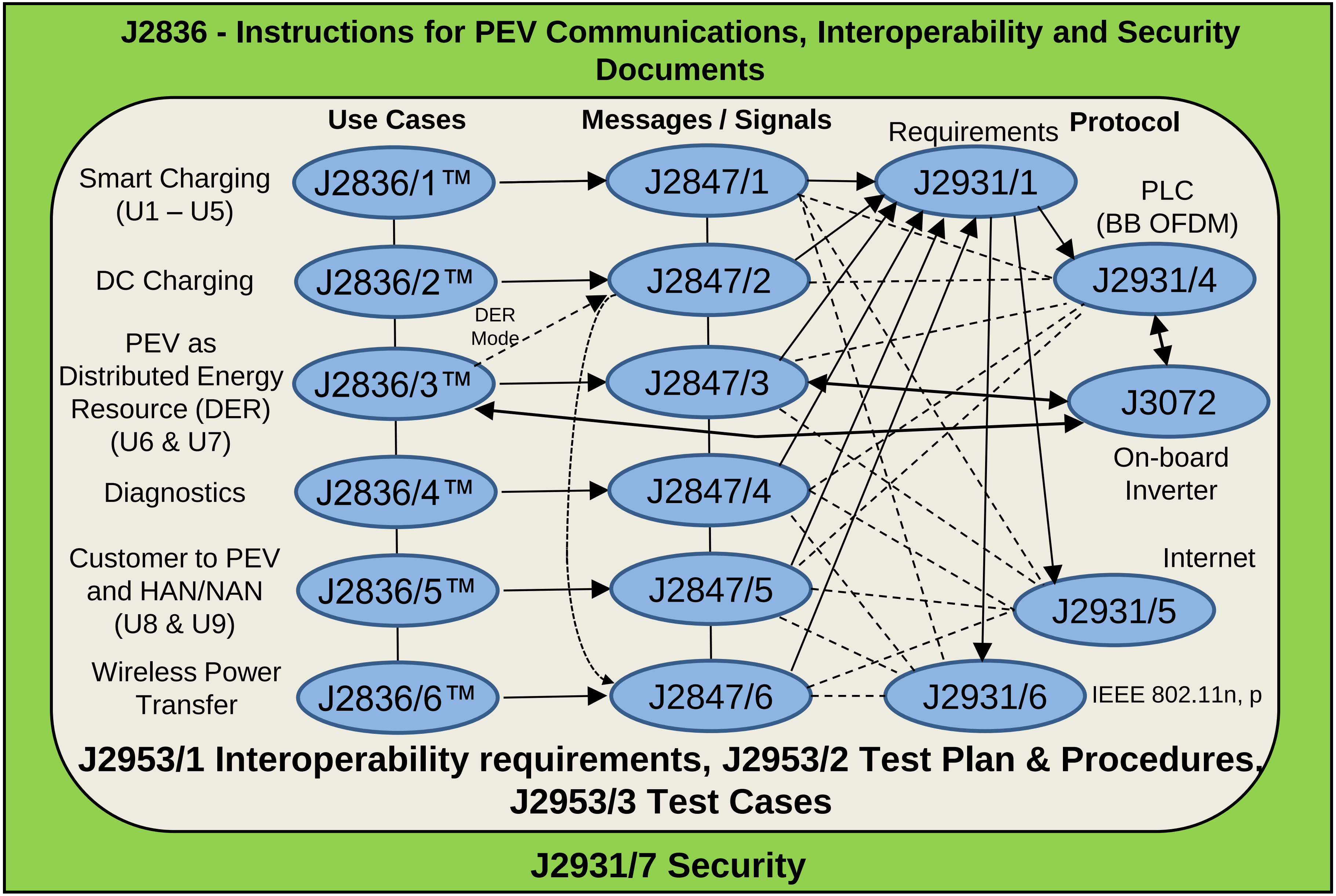
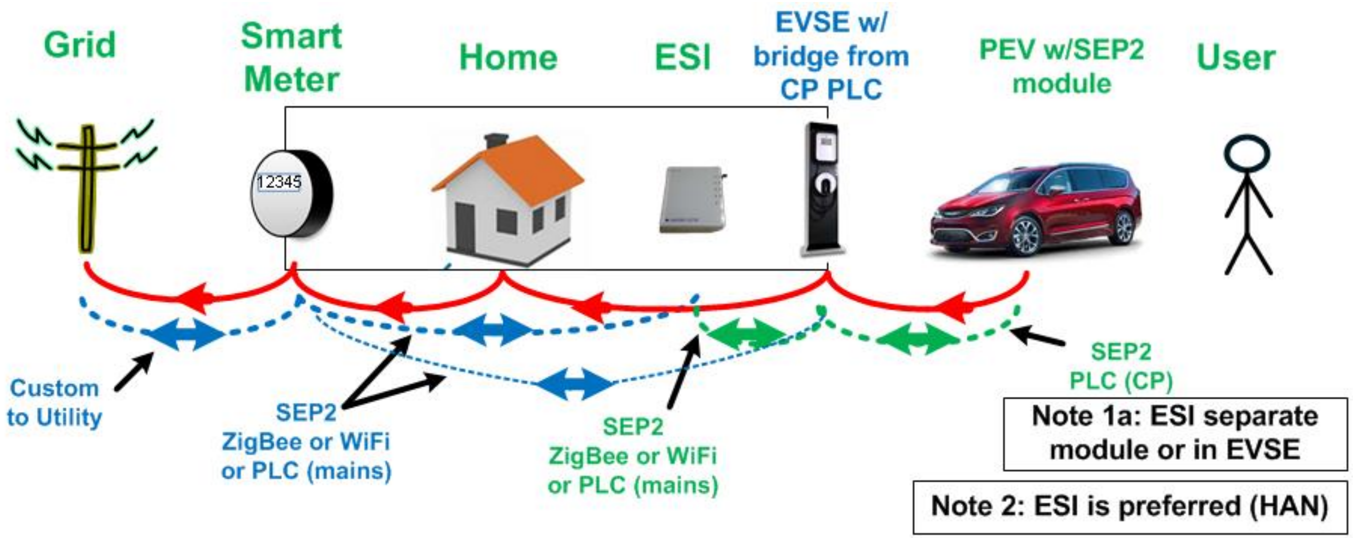


Figure 4: Generic role model of relevant actors for smart charging EVs [CEN BT N987]

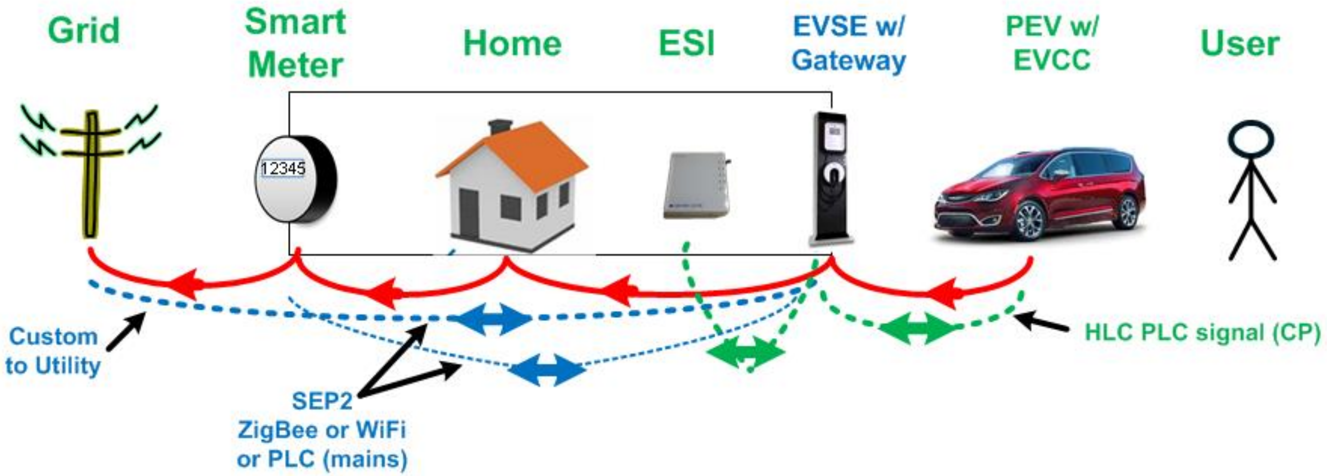
SAE Document Interaction



DC DER



DC DER (off-board Inverter) – Smart Energy Profile 2.0 (SEP2)



DC DER (off-board Inverter) – ISO 15118

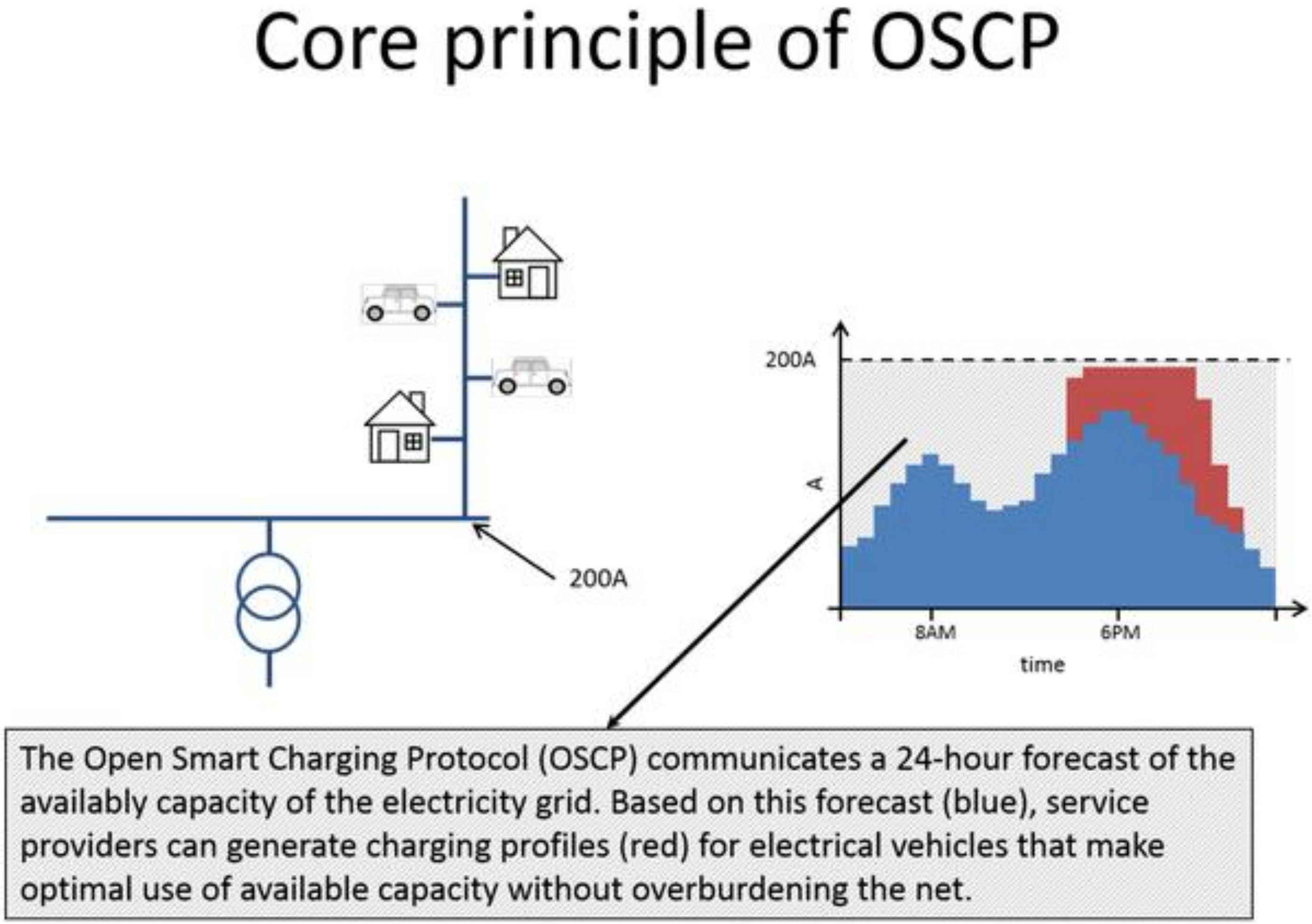
5 Major Automakers to Deploy 400 Ultra-Fast (350 kW) Charging Stations in Europe

- **BMW, Daimler’s Mercedes, Ford, and Volkswagen’s Audi and Porsche** announced today that they are creating a joint-venture
  - The new network will be based on Combined Charging System (CCS) standard technology and each station will feature not only both level 2 AC chargers and level 3 DC chargers, but also the new ” ultra-fast high-powered chargers” and, like the ones of the Ultra E project, they will be able to deliver up to 350 kW – more than twice the capacity of the current best charger, Tesla’s Supercharger at 145 kW.
- **Ultra E**, a project born out of an alliance between European carmakers, utilities and other companies, announced today the deployment of 25 new charging station for electric vehicles along the trans-European transport network (TEN-T). The network will be using the **Combined Charging System** (CCS) charging standard and it will be connecting the Netherlands, Belgium, Germany and A
- Competing standards include CHAdeMO and Tesla Supercharger.

Open Charge Alliance (OCA)

- "The **Open Charge Alliance (OCA)** *is a global consortium of public and private electric vehicle (EV) infrastructure leaders. Our mission is to foster global development, adoption, and compliance of communication protocols in the EV charging infrastructure and related standards through collaboration, education, testing, and certification.*
  - *Our strength is a fundamental commitment to open processes and products*
  - *Free to use: no constraints on the use of the standard*
  - *Development is open and market driven to meet existing and emerging technical and business requirements*
  - *Pragmatic approach that leverages knowledge and experience of experts in EV charging infrastructure*
  - *Uphold OCPP and OSCP as vital standards, with implementations widely adopted and deployed"*
- The OCA members selected the Organization for the Advancement of Structured Information Standards (**OASIS**) for developing the next version of OCPP (v2.0) while also adopting a preferred end goal of de-jure international standardization through the International Electrotechnical Commission (**IEC**).
- **OCPP is already the de-facto open standard for EV charger-to-network communications globally.** OCPP 1.6 has been downloaded more than 7,000 times to 77 countries. It is the only open standard in the EV charging equipment management space that is in common use anywhere in the world.

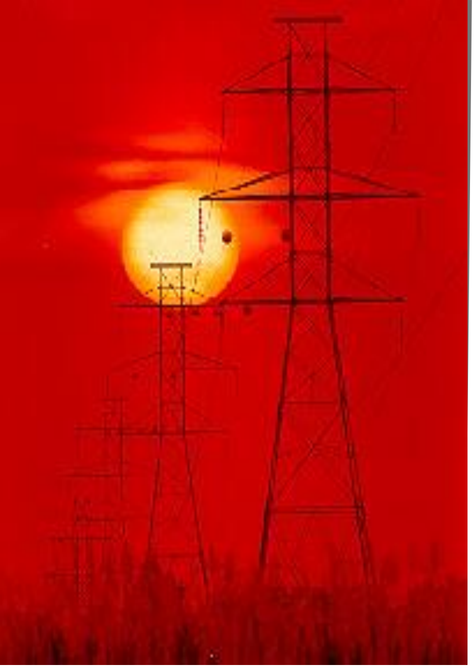
Open Smart Charging Protocol (OSCP) 1.0



http://www.openchargealliance.org/protocols/oscp/oscp-10/

Communications Issues to Resolve

- Inclusion or development of **Use Cases** for all purposes and stakeholders
  - Review and assessment of Market Use Cases requirements
  - Review and assessment of Grid Code Use Cases requirements
  - Development of Use Cases on Grid reliability requirements
  - Development of Use Cases on Cyber Security and Privacy requirements
- Assessment of **potential protocols** for different interfaces and purposes
- Identify possible **"default" protocols** for different interfaces
  - Accept certain standards where there are no major alternatives
  - Select "alternative" protocols and standards
  - Coordinate with US, Europe and Far East developments
- **Short schedule** for initial assessments and defaults
- **Flexibility** for new requirements as this EV domain evolves over time



Questions?

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