Kn·Grid
Harnessing the Power of the Market

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California Energy Commission

Vehicle-Grid Integration Workshop

Lead Commissioner Workshop on Electric and Natural Gas Vehicles in California

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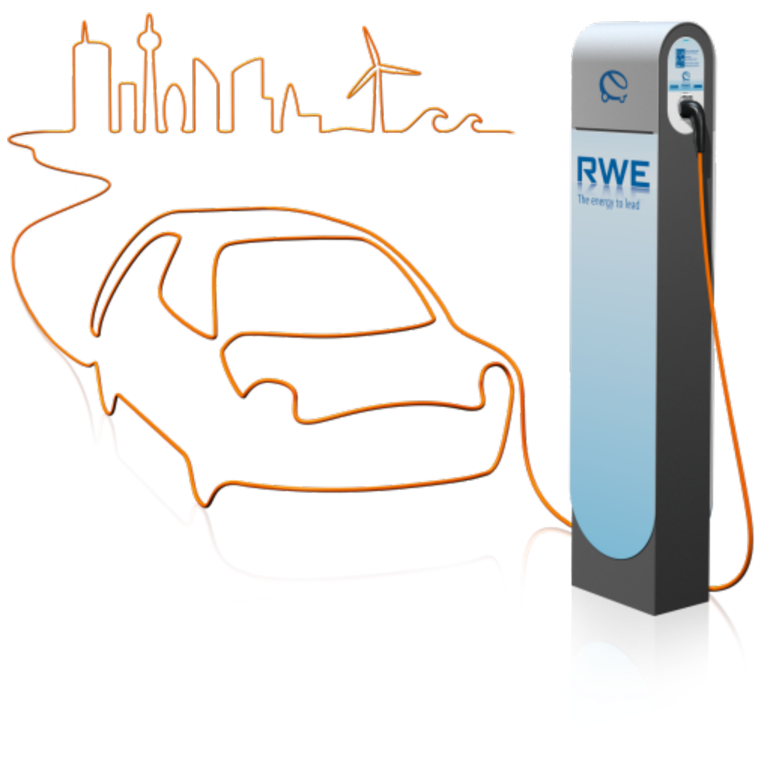


Background of KnGrid

KnGrid is the exclusive licensee in the NAFTA region for RWE eMobility, which is one of several solutions enabling the machine-to-machine communication required for intelligent plug-in electric vehicle (PEV) charging. The company currently supports RWE eMobility in an Energy Commission-funded PEV-grid integration demonstration project on the UC San Diego Campus. The key components and partners are as follows:

1. Project Participants: RWE, Daimler, SDG&E, UC San Diego, AESC and KnGrid
2. Charging stations: 26 AC Level 2 intelligent networked charging stations and three DC Fast Charging Stations
3. Goal: The demonstration of various intelligent charging use cases:
    1. "Plug and Charge" automatic authentication
    2. Dynamic price-responsive charging
    3. Static energy management response to grid constraints

The charging stations are paired with a back-end system developed by RWE Effizienz in Germany and operated by KnGrid. (RWE Effizienz is a wholly-owned subsidiary of RWE GmbH, a multi-national firm with over 70,000 employees, 30M power utility customers and $60B in revenue.) Forty Smart Electric Drive III vehicles equipped with the new ISO/IEC 15118 protocol are being leased to students and faculty as well as UCSD fleet operators to create an ecosystem with both the vehicles and the charging stations employing the new smart charging standard.

Summary

- Harmonizing the associated vehicle charging patterns with the power grid remains unaddressed.

- To achieve California's vision for vehicle-grid integration, an interoperability foundation must be laid beginning now. California's vision provides simplicity to the consumer at the 'edge' of the electric system: the charging station and the vehicle. This simplicity must not come at the expense of the ability of system operators to intelligently dispatch PEV loads in response to an increasingly complex set of grid considerations as California relies on higher percentages of intermittent renewable energy.

- The foundation of this vision involves standardizing two key interfaces: 1) the PEV and charging station, and 2) the "Demand Clearing House" or OEM Central Server.

- Importantly, the Demand Clearing House or OEM Central Server should not be interpreted as a way to side-step the notion that standardization of the physical connection method and data interactions between the EVSE and PEV can be avoided.

- This interface is crucial to California's future interoperability vision. The reason is that vehicles must all connect and present the same data set **every time** to the grid operator or other secondary actor to enable ubiquitous intelligent charging and dispatchability, without confusing or frustrating the vehicle owner.

- California would clearly benefit from a quick decision among OEMs to embrace a common smart charge interoperability standard.

- Policymakers must quickly decide how best to coax that process along: this may involve a policy or market signal. Another approach could be to fund different central server demonstrations using competing standards in a "beauty contest" of sorts to see which approach offers the most simplicity and flexibility.

California's goals for a decarbonizing the electric power grid and personal transportation are now firmly in gear, supported by clear policy and backed up with budgets for both rapid implementation and continuing R&D. The state's large market for personal vehicles along with zero-emission vehicle mandates and state-funded clean vehicle rebates have pushed California to the forefront of global attention among automakers intent on embracing plug-in electric vehicles (PEVs) as growing part of their product mix. Given the state's success in getting early and follow-on adopters to buy PEVs in California, it seems that the Governor's objectives to have charging infrastructure to support 1M PEVs by 2020 and to have 1.5M PEVs on the road by 2025 are reachable.

However, harmonizing the associated vehicle charging patterns with the power grid remains unaddressed. Further, uncoordinated efforts among various stakeholders to go their own way on vehicle-grid communications protocols could imperil flexibility among electric system operators. The system operators require such flexibility to create and utilize 'virtual power plants' (VPPs), enabled by large amounts of PEVs, to manage rising levels of variability that accompany growing percentages of renewable power generation.

ISO/IEC 15118 is the global vehicle-to-grid communication interface standard developed in an important collaboration between the International Organization for Standardization (ISO) and the International Electromechanical Commission (IEC).

What is California's 'VGI' vision?

A future where:

- Any PEV owner can safely plug in (Level 2) anytime, anywhere and be dispatchable as a certified resource.
- These certified dispatchable resources help system operators maintain reliable service while achieving our California RPS and GHG reduction goals.

- The entire process is harmonious. It occurs:
    - seamlessly, without confusing the consumer
    - or impacting their transportation needs
    - in a way that lowers their total cost of ownership.

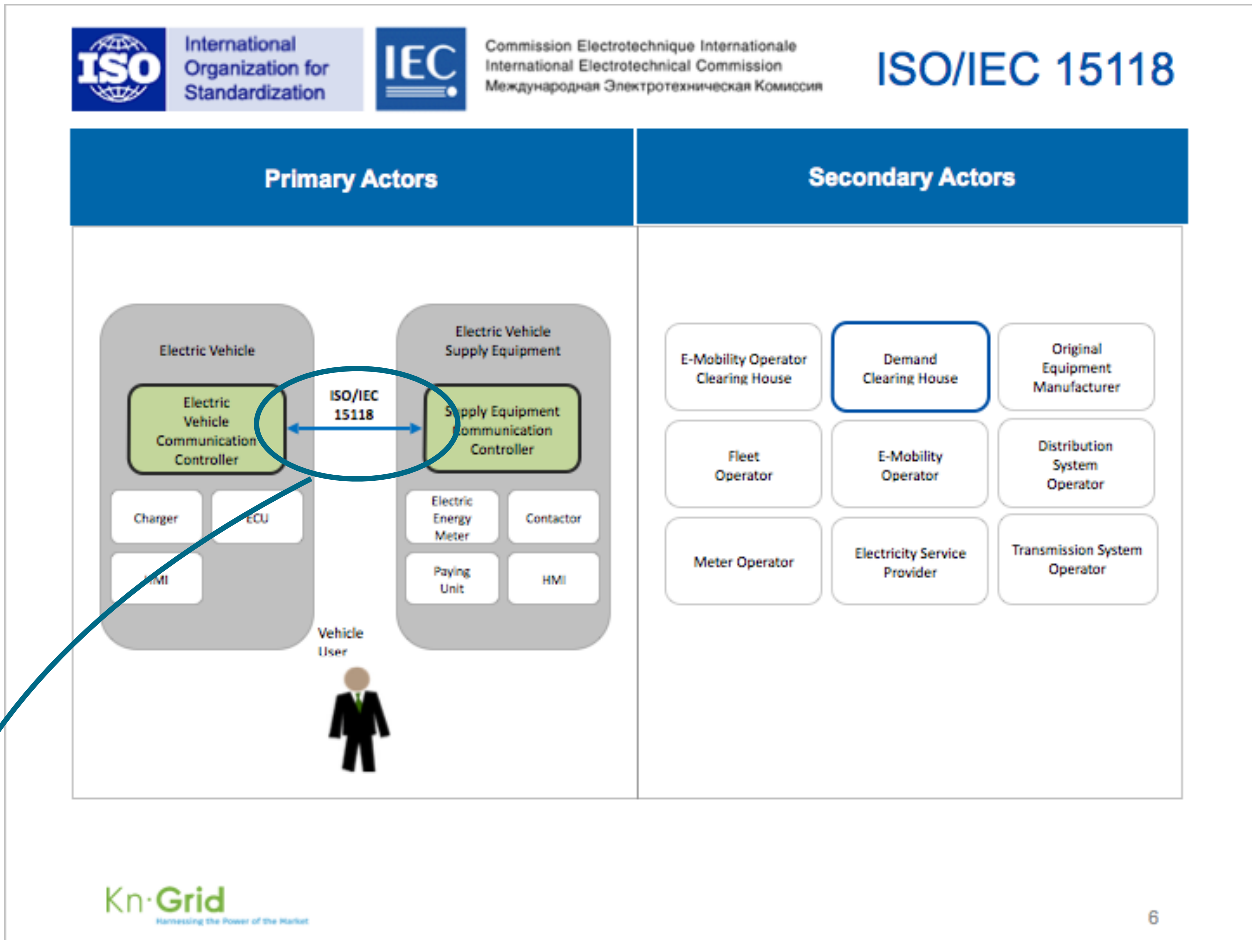
To achieve this vision, we need a common architecture as soon as possible.

To achieve the vision stated above, an interoperability foundation must be laid beginning now. California's vision provides simplicity to the consumer at the very 'edge' of the electric system: the charging station and the vehicle. That simplicity must not come at the expense of the ability of system operators to intelligently dispatch vehicle loads in response to an increasingly complex set of grid considerations as the state relies on higher and higher percentages of intermittent renewable sources of energy.

Rather, an intelligent system must provide temporal flexibility to deliver needed energy to the vehicle prior to planned departure 'in the background' and seamlessly for the consumer. This will build confidence in electric vehicles as we push toward mass-market uptake. With a smart charging standard, system operators can gain access to a critical mass of dispatchable loads faster and will have the ability to dispatch all brands using a common data set and control system. The charge stations and vehicles must communicate in a way that empowers system operators to experiment with new and gradually more complex approaches to load control that can optimize the use of existing distribution grid assets without compromising the range needs of the PEV owner or overwhelming them with complex or frequent decisions.

That foundation involves standardization of two key interfaces:

1. The vehicle and the charging station



2. **The "Demand Clearing House" or OEM Central Server:** There is one more interface that needs discussion and understanding. It is commonly referred to as the "OEM Central Server" and has profound implications. It can assist OEMs and electric vehicle service providers in interfacing with system operators and other "secondary actors" in the eMobility space. It is discussed at length in the next section.

The "Demand Clearing House": The architecture of ISO/IEC 15118 and its alignment with our goals

The vehicle and the charging station

The essential goals of a bi-directional information standard for smart charging are accomplished in the ISO/IEC 15118 diagram above:

1. A hard-wired (via power line carrier modem) connection and association is created between the vehicle and meter in the EVSE. This unified object model of the vehicle and charging station creates a 'DER' or distributed energy resource that can be certified by balancing authorities and utilities alike. Hard-wired association between the EVSE and the meter was deemed essential during the design phase of this standard as well as the SEP2 standard developed in the SAE Task Force working on J2836, J2847 and J2931.

2. There is maximum flexibility among other "secondary actors" that may have authority or control over the vehicle and/or charging station can communicate with the DER via the "Demand Clearing House." This could be the building energy management system, the fleet operator, or other listed secondary actors, but in most cases will be the local utility or system operator. This Demand Clearing House is essentially what is commonly referred to as the OEM Central Server. Importantly, the text below is taken from the ISO website that describes the Demand Clearing House:

Demand Clearing House (DCH)
Entity for grid negotiation that provides information on the load of the grid
Note 1 to entry: The demand clearing house mediates between two clearing partners: an SECC and the part of the power grid connected to this SECC. Most likely this function will be served by a system operator.
Note 2 to entry: Demand clearing house and meter operator may exchange information with each other as well as with other actors.
EXAMPLE:
A DCH typically fulfills the following tasks:
– Collect all necessary information from all parts of the power grid, e.g. current or forecasted load of local transformers, distribution grid, power substation, transmission grid, transmission substation, power plants (including renewable energies), and predicted charging schedules submitted by EVCCs.
– Consolidate the collected grid information to a "grid profile" (Diagram 1) **and offer it to SECCs/EVCCs.**

> **– Provide charging schedule proposal for the connected EV to the requesting SECC based on the collected grid profile.**
> **– Inform the SECC as to the necessity for an updated charging schedule if the grid profile has changed.**
> **– On the contrary, the SECC will inform the demand clearing house if the EV's charging schedule has changed.**
>
> **(ISO/IEC 15118 documents)**

Importantly, the DCH should not be interpreted as a way to side-step the notion that standardization of the physical connection method and data interactions between the EVSE and PEV can be avoided. This is a common misconception. One could arguably have an OEM Central Server and end up with a fragmented charging ecosystem that undermines the goals of interoperability in a homogenous charging infrastructure: one where vehicle Brand A arrives at a charging station only to find that it won't enable smart charging because it does or doesn't support the protocol installed in the vehicle's onboard communications stack. OEMs can still maintain their flexibility to protect the consumer experience by using their telematics to populate preferences in the vehicle, but the negotiation and periodic update of forward 'grid profiles' happens between the EVSE and Vehicle via power line carrier on the pilot wire in BOTH SEP2 and 15118.

What are the risks of a fragmented, non-networked EVSE ecosystem?

As mentioned earlier, this interface is crucial to accomplishing the State's future interoperability vision. The reason is that vehicles must all connect and present the same data set **every time** to the grid operator or other secondary actor to enable ubiquitous intelligent charging and dispatchability **without** confusing or frustrating the vehicle owner.

As an example, imagine a vehicle owner who lives in one utility service area and commutes to employment in another. If that owner has an ISO/IEC 15118 vehicle and lives in an apartment complex with a compatible charging station, the owner knows what do whenever they connect at home: plug in and enter a departure time, either on their OEM-provided smartphone app or in the car. From that point on, everything is automated and happens in the background.

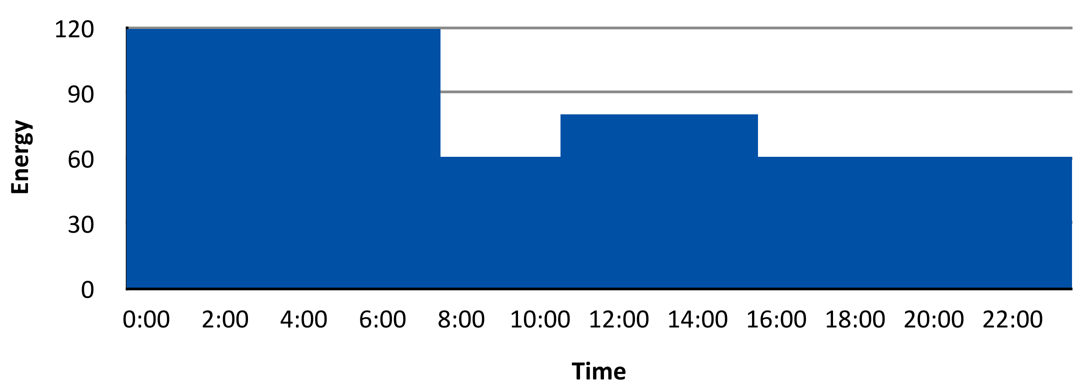
If this same owner plugs into a non-15118 charging station at work, their vehicle will be unable to:

1. Authenticate the owner's account for seamless roaming/settlement

2. Leverage the onboard intelligence that delivers the departure time and needed kWh via power line carrier to the charging station and back-end.

3. Set up an intelligent forward energy profile for charging such as the one in the diagram below.

Diagram 1: Forward Energy/Charging Profile



As a result, the system operator will be unable to impute local grid constraints, substation conditions, transmission and supplemental energy market prices into the energy profile or update that profile as grid conditions evolve.

How can California avoid these risks?

California would clearly benefit from a quick decision among OEMs to embrace a common smart charge interoperability standard. Policymakers must quickly decide how best to coax that process along. That may involve a policy or market signal.

Another approach could be to fund different central server demonstrations using competing standards in a 'beauty contest' of sorts to see which approach offers the most simplicity and flexibility.

Additionally, once that standard is identified, state investments in infrastructure should be limited to charging stations that adhere to the chosen interoperability standard.

Recommendation:

The CEC can fund Phase 2 (the goals of Phase 2 are being developed now by automakers) of the OEM Central Server process and can work with the OEMs to identify 'must haves.' In that process, utilities and OEMs alike can work to understand the available smart charging standards in the context of the State of California's long term vision. In addition, Central Server project participants can develop the process of converting grid considerations into 'forward energy profiles' that harmonize with the driving needs of the vehicle owner. The Central Server, in the end, will become the Demand Clearing House, capable of enabling secondary actors to impute their needs into the forward energy profiles and keeping all options open as regulatory and grid conditions evolve.