

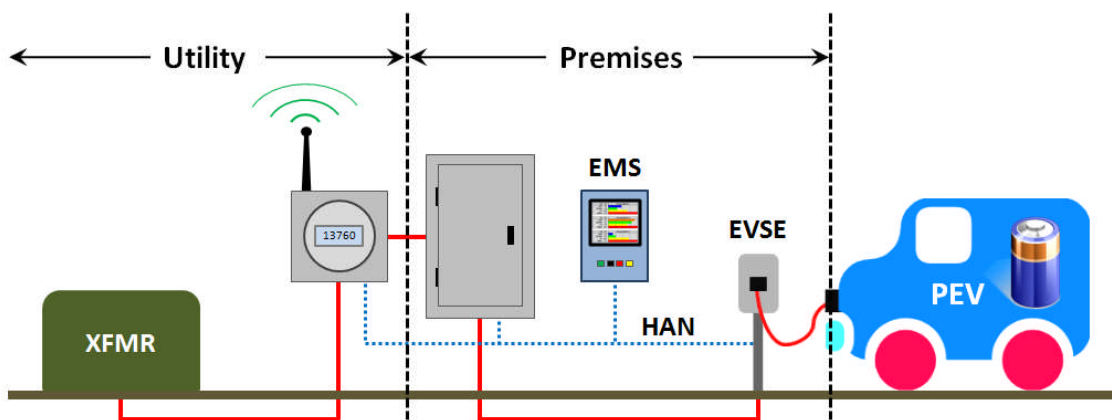
Roaming, V2G, and the Premises Infrastructure

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The critical role of the premises and its infrastructure is often overlooked in the discussions of roaming and vehicle to grid (V2G). The focus is most often about how the utility will communicate with the PEV to manage power flows (either in or out of the vehicle) and deal with the financial aspects of the transaction. Yet, the premises infrastructure is the gateway for connecting any roaming PEV to the utility. The Electric Vehicle Supply Equipment (EVSE) is the master control valve for electric power flow either to or from the PEV. No power can flow in or out of the PEV except as allowed by the EVSE. This makes the premises infrastructure the most critical element in any communication with the PEV.

The diagram below is a very simplified view of the world of electric power and electric vehicles. Utility in this chart means all of the relevant players in the electric power industry. It includes the distribution utility, the system operator, energy service companies, independent ancillary service aggregators, and others. The “utility world” ends at the meter. Any premises infrastructure provided by a utility beyond the meter or control over any equipment within the premises must be by mutual agreement of the premises owner with the utility.

The definition of premises is also broadly defined. It means everything from the meter to the PEV. It can be a residential property. It can be a commercial property with public access to charge stations. It can be a factory with employee access to charge stations. It might even be a group of charge stations along a street. There will always be a meter, a distribution panel, and an EVSE.



Roaming and the Ancillary Services Aggregator

One of the concepts being discussed is where an aggregator signs up thousands of PEVs to participate in demand dispatch (V1G) or full bidirectional service (V2G). The aggregator bids an ancillary service, such as frequency regulation, in a one or two megawatt block to the ISO/RTO. The aggregator then manages the rate of charging or reverses flow for each vehicle in this large fleet to perform the service. The vehicle owners are compensated for participating in the program.

This vision of roaming PEVs under the control of an aggregator is compelling. The aggregator establishes a service contract with each PEV owner and then pushes and pulls power from all over the grid to satisfy its commitment to the ISO/RTO. All of the PEVs are securely and privately communicating with the aggregator to coordinate the power flow and deal with the business transaction.

Who's accountable?

The problem with this vision of roaming is that the power does not directly flow between the PEV and the aggregator. While a PEV may roam, the point of connection of any PEV to the grid is always fixed. The PEV connects through an EVSE and the EVSE is always part of the infrastructure of some premises. The local distribution utility holds the premises owner accountable for the power demand and power quality at the interface. The premise owner is a key stakeholder.

The Utility will always hold the premises owner accountable for compliance with IEEE 1547™ and power quality for any reverse flow. This is true today for distributed generation. It is not likely that a local utility would have a direct business relationship with a roaming PEV that would hold the charging facility premises owner harmless for a safety breach caused by the PEV. A PEV will never be allowed to put power back into any premises wiring and out to the grid without full coordination with the premises infrastructure.

A business will generally have demand and energy charges and may also be enrolled in demand response or other utility programs as a facility. The utility infrastructure is designed to support the facility. It would not be good for an independent aggregator to cause a demand spike during the month. If PEVs in a large parking garage are signed up with different aggregators, how is the total facility peak power demand managed? The facility needs to be accountable for managing its own loads and working with the utility.

Who's in control?

The flow of information and control authority is always a topic of interest – particularly with regard to roaming. As you move from the system of system perspective of the Smart Grid to the vehicle at the end of the power cord, the perspective changes. The large system thinkers see the PEV as a small element on a huge open network that must be secured. The vehicle manufacturer seeks first to protect the vehicle and the people and immediate infrastructure around the vehicle.

Safety considerations require that a PEV will never draw more power than the premises infrastructure can support. For AC charging this limit is set by the EVSE through an analog signal known as the Control Pilot. This is defined by SAE J1772™. The vehicle is designed to never draw more current than authorized by the EVSE Control Pilot. Even if the vehicle on-board charger is

capable of drawing a higher power than this limit and the PEV receives a message authorizing a higher level, it will not override the Control Pilot. An intelligent EVSE can dynamically control the limit – it does not have to be fixed at the level supported by branch circuit. The EVSE is the ultimate control valve. For DC charging the EVSE is the charger and it directly controls the amount of power it draws from the grid, but never more than the vehicle will accept.

The SAE has not yet defined the communications and protections required for reverse flow. However, safety and power quality considerations will most likely result in the EVSE becoming the ultimate master control for enabling reverse flow and for establishing the maximum level of current allowed to be sourced by the PEV.

From a system of system perspective it might seem appropriate for an aggregator to only communicate with a PEV and not with a premises EMS or EVSE. Some even foresee the aggregator using a wireless connection directly with the PEV. The reality is that a vehicle will always seek to protect itself and part of this protection is that it will never allow itself to override an EVSE. The ultimate control that the EVSE has is to disconnect the vehicle using its circuit breaker. Power will only flow in and out of a PEV if both the PEV and EVSE allow it.

Implications for communication with roaming vehicles

When a utility reaches inside a private residence and turns off a water heater, this is by agreement with the owner of the residence and for the benefit of the home owner. The contract isn't with the water heater for the benefit of the water heater. If an aggregator reaches into a charging facility to manage the rate of charging of a PEV, it can't do this without a contract with the facility as well.

The facility needs to be engaged in any communication between any external aggregator and any PEV within the facility. The facility owner is ultimately accountable for the power flowing across its interface with the utility and it may need to be able to manage the aggregate load of the facility at any instant. If an aggregator directly communicates with a PEV to command an increase in the rate of charging, the facility may need to override this command. The facility can reduce power demand of a charging vehicle or disengage any reverse flow at the EVSE. This is ultimate control.

A facility owner could unilaterally decide to be the only source of control for the rate of charging for PEVs served by the facility. It can make it a condition of using the facility that PEVs charge using SAE J2847 optimized energy transfer. This does no harm to the battery and may be needed to intelligently manage total facility demand. Reverse flow is another issue. The facility can enforce this (at least in the down direction) by using the EVSE control pilot if the PEV does not follow facility digital commands.

It is much less complex if the first tier of load management is done by the facility EMS and the external aggregator deals only with the facilities. This is an established model. Facilities don't roam.