Demand Response Opportunities for Electric Vehicle Charging Stations

Moving the Demand Response Cheese: How DR's Value Proposition is Evolving

Mahi Reddy, Founder & CEO, SemaConnect
Ryn Hamilton, Ryn Hamilton Consulting
Tom Ashley, PlugShare
Introduction

The focus of this presentation is opportunities for commercial grade PEV charging stations to provide demand response and ancillary services.

- The idea of PEV charging loads offering a resource that could be monetized has not been thoroughly tested although there have been some small studies.
- The demand response resource is created by modulating charging rates up and down in response to external control or price signals. This opportunity will expand as the penetration of PEVs increases, lessons from early studies are distilled and the regulatory environment evolves.
- This presentation frames a discussion around key opportunities and market drivers for commercial chargers to provide demand response and ancillary services.
- SemaConnect and PlugShare have achieved the proof of concept stage. Although much of the necessary hardware and software have been developed, real world utility and grid experience is still required.
Definition

Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.

Federal Energy Regulatory Commission

The definition of demand response has broadened to specifically include ancillary services which address grid contingencies and short term imbalances in energy markets.

Customer electric load profile with and without demand response

Source: ISO-New England
Introduction

Industry Comments

Scott Baker, PJM

“The grid operator sees electric vehicles as potential stabilizers for the system, helping to keep frequencies smooth, especially as intermittent alternative energy sources like solar are added to the grid.”

Willett Kempton
U of Delaware (PJM)

“We’re not earning enough money to get rich, but ... it earns more money than it costs to do it.”

Mahi Reddy
SemaConnect

“Demand Response will emerge as a "killer app" as we see more electric vehicles on the road, and using charging infrastructure. This is a perfect example of a flexible load that can be controlled to optimize grid capacity, and will give utilities a whole new market and capability.”

Tom Ashley
PlugShare

“Passenger vehicles are parked for 96% (on average) of their lives. Using electric vehicles for grid balancing and other energy services is a no brainer.”
Introduction

This discussion concerns the potential use of SemaConnect charging stations as a fast responding and calibrated form of demand response.

- While there has been some early stage research into the use of charging stations for this purpose, most pilots have focused on the use of PEV batteries.

- A key distinction is that PEV charging stations provide unidirectional control, whereas vehicle battery storage systems (onboard and added components) will eventually be commercially capable of also pushing power into the grid.

- The focus of our research is SemaConnect Level II chargers. (Level I chargers are still standard in residential applications.) Level II chargers deliver 240 Volts and 30 Amps, and have become the industry standard for charging away from home. They offer superior charging speed, networking capability, signaling and communications.
Introduction

Loads from individual charging sessions are quite small and must be aggregated to provide a viable grid resource. A curtailment service provider would be an essential link between the charging station and the utility or grid, sending and receiving signals.
Opportunity

Opportunities are expanding for PEV charging loads to participate in utility programs and ISO/RTO markets.

- **Utilities and Jurisdictions**: Offering more demand response programs that could potentially permit PEV loads. Although 37 states have a program or commitment to increase the number of zero emission vehicles on the road, there has not been huge progress.

- **ISO/RTO**: Rule changes in organized markets are permitting demand-side resources to participate in capacity, energy, regulation and reserves markets. (This may change depending on the outcome of the legal challenge FERC Order 745.)

- **Aggregators**: The market for curtailment service providers has matured and new kinds of loads are being pursued as the C&I market becomes increasingly saturated.

- **Smart Grid and Technology**: PEV capabilities are enabled by advanced metering and communication technologies, as well as standards such as OpenADR protocols that are becoming the international standard for DR communications.

- **Renewable generation**: Accelerated adoption of distributed energy resources (e.g., rooftop solar, PEV) are altering electric load profiles. Greater amounts of grid-scale renewable generation (e.g., solar, wind) with intermittent output are complicating grid operations.
Demand Response
A Brief History

1960 - 1970
Declining electric load factors due to rapid adoption of air conditioning.

1970s
Utilities introduce first generation of demand response programs to provide electric load reductions during system emergencies. High peak demands relative to average demand is increasing electricity cost and reducing reliability.

1990s
Electric industry restructuring ends many vertical utility monopolies, and demand response programs are abandoned. These situations include needle peaks and pockets of T&D congestion.

2005
Utility demand response programs are resuscitated – the advent of ‘DR 1.0’. The legal framework for demand response in wholesale power markets emerges.

2011
Regulations establish specific rules and payment structures for DR. ‘DR 2.0’ brings enhanced communication automation making DR feasible for more kinds of resources. Legal challenge to FERC jurisdiction over demand response.

2014
As DR programs expand, the role of ancillary services expands in certain markets. ‘DR 3.0’ and smart grid introduce 2-way communications and intelligent load management to the distribution network.

Beyond
Depends on outcome of FERC Order 745, and alternative options for DR.
Demand response provides a greater share of ancillary services.
PEV charging loads will eventually provide demand response to utilities and grid operators.
Regulations and standards are facilitating adoption of enabling technologies.
Demand Response

**Schematic**

- Demand response has evolved into a more dynamic resource and ancillary services become part of the conversation.
- Demand response can be categorized as reliability products (capacity market), price responsive demand (energy) ancillary services which safeguard reliability.

**Dispatchable (Supply-side)**

- **Reliability (Capacity)**
  - Commitments to deliver energy at some forward date, such as three years
  - When this capacity becomes available it is dispatched to meet system reliability needs
  - Load shedding is normally required within 1-3 hours of notification

- **Price Responsive Demand**
  - Price Responsive Demand is predictable change in electricity consumption in response to electricity prices in the energy market

- **Ancillary Services**
  - Grid balancing services have been historically provided by ancillary fossil fuel generators
  - Response required within seconds to minutes of notification
  - Demand response provides only a small percent of this resource now, but this will increase

**Non-Dispatchable**

- **Time Varying Rates**
  - Rate structures offered by utilities that reflect cost of service at different times

- **Energy Efficiency**
  - Customers respond by reducing electric use based on time of use or critical peak pricing structures
## Demand Response

### Assorted Initiatives

There is emerging interest in supporting PEVs through various mechanisms. The examples below show diverse areas of interest, but also the gap that SemaConnect intends to fill (charging station loads for demand response).

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* Grants have typically been from state and local governments. With the exception of ARRA funding, the federal government’s emphasis has been to make EVSEs more appealing to customers (branding rather than incentives).
Ancillary Services

**PEV Charger Station Resource versus Generation**

Regulation and reserves have historically been provided by generation resources, but are now being supplemented in some jurisdictions by demand resources. SemaConnect envisions a future in which PEV charging stations provide these services.

PEV charging stations can provide ancillary services by modulating the rate of charging in response to external signals and control.

The ISO/RTO control room assess moment to moment options and dispatches resources.

Generators have historically provided ancillary services. Power production is ramped up and down for grid balancing.
Ancillary Services

Changes in the power industry are creating a greater need for demand-side resources to support moment-to-moment grid operational needs.

- The use of demand response for ancillary services is a refinement of an existing tactic.

- Ancillary service must respond as quickly as an ancillary power plant would, from seconds to 30 minutes.

- Controlled PEV charging loads that can be finely modulated can provide the same quality of operating reserves and regulation resource as a generating unit.

- Ancillary services are under the purview of FERC which has issued several orders intended to create a larger role for demand side resources to participate.

**Definition**

Ancillary services support the reliable operation of the transmission system as it moves electricity. The kinds that could potentially be provided by PEV charging loads:

- **Regulation Market.** Corrects for short term changes in electricity use that could affect the stability of the power system. This is part of normal system operations.

- **Spinning and Non-Spinning Reserves.** Supplies electricity when the grid has an unexpected need for more power (reduced use) on short notice in contingency situations.
Many ISOs/RTOs have demand response in their ancillary services markets, including PJM, NY-ISO, MISO, CAISO and ISO-NE.

A handful of electric vehicle frequency regulation pilots are online or in process, including:

- University of Delaware
- NRG
- Department of Defense
- Los Angeles Air Force Base
- Southern California Edison
- Southwest Research Institute

Pilot: Frequency Regulation
Pilot: Frequency Regulation
Pilot: Frequency Regulation
Pilot: Demand Response
Pilot: Operating Reserves
Ancillary Services

Required time between notification and demand response dispatch

Dispatch normal conditions

Contingency conditions

Source: Regulatory Assistance Project, adapted from NERC, et al
Ancillary Services

**Regulation Markets**

Regulation is the method by which the grid operator continuously maintains optimal balance on the system.

- Historically this has been provided by ramping generators (natural gas) up and down in response to a dispatch signal.

- Demand-side resources are now permitted to participate in certain frequency regulation and regulation reserve markets.

- Frequency regulation manages the quality of energy on the grid, balancing generation and load, to keep the system frequency reliably at 60 Hz.

- Resources are compensated for the ability to modulate demand up or down.
Ancillary Services

Regulation Markets

- Resources are bid into the market on a regular basis, whether hourly or every five minutes. Bids are organized by price and key operating characteristics. These include ramp rates, power factors, maximum and minimum limits, length of time the resource can be available.

- Better forecasting and dispatching of power (five or fifteen minutes instead of every hour) is reducing the need for regulation service. Better forecasting is also reducing the cost of integrating wind and solar into the grid.

- The size of the regulation market varies by region. ISO-NE, for example, dispatches every five minutes, which keeps the system fairly well balanced. As a result, the regulation market is comparably small and prices for regulation service low compared with regions that have hourly dispatch.
Ancillary Services

**Operating Reserves**

Operating reserves consist of spinning (synchronized) reserves and non-spinning (supplemental) reserves.

- These terms are carried over from the generation side to indicate the state of readiness of units that are either in an online state (available now) or offline state (available soon).

- Resources participating in synchronized reserve programs are generally dispatched a few times a month.

- Spinning reserves are a first strategy for maintaining reliability following a contingency such as a loss of a generation or transmission. The typical required response time is 10 minutes to 30 minutes. Demand response participates by providing a predetermined amount of energy in order to meet a reliability standard.

- PJM has a synchronized reserve market and a day-ahead scheduling reserve. Most of the demand side ancillary services are bid into the market by aggregators. One estimate is that this represents about 18 percent of PJM’s synchronized reserves.
The markets and programs that PEV charging loads will one day participate in are regulated at the Federal and State level. This shapes rules for participation.

### Wholesale Markets (Federal Energy Regulatory Commission)

- FERC regulates independent system operators and regional transmission operators.
- These ISOs and RTOs file individual tariffs that must be approved by FERC.
- Market rules are based on CAISO’s tariffs with FERC. Shapes CAISO markets, pilots and initiatives, some of which are in collaboration with other regulatory authorities.

### Retail Programs (State regulatory commissions)

- State regulatory commissions govern utility operations.
- Utilities, including those with statewide programs, file individual program tariffs with their respective commissions.
- PG&E’s program rules and time-varying rates are based on their tariffs with the California PUC. PG&E programs DR programs, pilots initiatives, collaborations.

For example…

For example…
Regulatory

Federal Energy Regulatory Commission

FERC regulates the nation’s Independent System Operators and Regional Transmission Operators. Together they serve two-thirds of all electric customers.
Regulatory

Federal Energy Regulatory Commission

FERC has been a strong proponent of demand response, creating rules intended to provide a level playing field with generation.


ISOs/RTOs file individual program tariffs with FERC, which govern rules for demand response participation and compensation.

Three ISOs/RTOs have capacity markets – ISO New England, New York ISO and PJM). These pay incentives to attract investment in exchange for a commitment to stand ready to provide energy into the market. The remaining regions have energy-only markets that pay only for the actual energy provided.

Differences exist between various ISOs/RTOs, as well as within individual states in a particular market. ISO New England includes the six northeast states that have a tradition of collaborative action on energy matters. The largest grid operator, PJM spans 13 states that are not closely affiliated.
Regulatory

FERC’s hallmark action on demand response was Order 745 (2011). This transformed energy markets by requiring that demand response be paid the locational marginal clearing price (same price as generation).

The D.C. Circuit Court overturned Order 745 in May 2014. FERC and numerous other parties (state commissions, grid operators, demand response providers, industrial customers and consumer advocates) came together to request a rehearing by the entire eleven member court (the decision was based on the opinion of three justices). The court denied this request. FERC and the U.S. Solicitor General (Department of Justice) must decide by December 16, 2014 whether to appeal this ruling to the U.S. Supreme Court.

- This order was the result of a petition led by the Electric Power Supply Association based on objections to demand response compensation based on locational marginal cost.
- This court decision exceeded the scope of the plaintiff’s case by ruling expansively on jurisdictional issues and the role of demand response in wholesale markets.
- There is no consensus about when this matter will be settled or what the outcome will be. ISOs/RTOs are responding differently to the possibility that Order 745 will not be reinstated.
Regulatory – Federal

ISO-NE Response to FERC Order 745 Legal Challenge

- Initiating market design changes to comply with Order 745, as directed by FERC. These have been cascading into numerous resource-intensive ISO projects.

- Deciding in early 2015 whether to expend additional resources to meet the June 2017 date for full market integration given uncertainties.

- Current rules surrounding demand response will sunset on May 2017, the day before the new market begins.

- If Order 745 remains invalidated, demand response will have no role in the new energy (and reserves) market under construction.
  
  - The crux of the problem is that under full integration the obligations that demand response resources take on can only be satisfied through performance in the energy market.
  
  - Capacity resources must perform during scarcity events yet paradoxically will be unable to perform. This is because these demand response resources will not have access to the energy market if Order 745 is not restored.
PJM Response to FERC Order 745 Legal Challenge

PJM Position
- PJM released a white paper in October outlining a approach that would permit demand response to continue to participate in the market, but in a way that is compliant with the Circuit Court’s ruling.

Current Situation
- Demand response is currently offered into PJM markets and paid as a supply-side resource alongside generation. The PJM markets would not separately compensate demand response.

Proposed Change
- Under the new plan, it would be a demand-side load modifying resource with compensation that is detached from the market clearing locational marginal price that generation is paid. The market participants will be load serving entities and competitive suppliers.

Purpose
- The PJM plan is intended to restore confidence, reduce litigation risk and avoid disrupting settled transactions from its capacity market.

Additional Challenge
- Further complicating matters, FirstEnergy has filed a legal challenge (which PJM responded to) to remove demand response from the capacity market as well.

PJM has a workable plan for treatment of demand response that will be ready in time for the May 2015 RPM auction.

ISO-NE has not proposed a plan or offered stakeholder guidance to prepare for the February FCM #9 auction.
PJM is the only ISO/RTO to have fully implemented Order 745. Demand response is offered into PJM markets and compensated the same as supply resources, as per Order 745.

PJM proposes that demand response participate in the capacity market as a demand-side (not supply side) resource.

- Demand response providers will be load serving entities and competitive energy providers.
- Aggregators, which represent 70% of the demand response in the PJM market today, will still have a role but no longer be allowed to participate directly in the market.
- PJM will model demand-side bids as load modifiers.
- Compensation will be based on avoided energy cost to the load serving entity plus any state incentives (not locational market clearing price).

The court invalidated Order 745 and ruled that FERC does not have jurisdiction over Demand response in energy markets.

In time for May 2015 auction

May 2014
Demand reductions are bid into the capacity auction at a price set by the load serving entity. Clear offers are treated as commitments to reduce load.

PJM models this as a reduction in the capacity requirement (energy demand curve shifts to the left), which means that PJM procures less capacity for that load serving entity.

If it performs when called upon there is no energy payment, only avoided payments by the load serving entity for energy it did not have to purchase.

Demand reductions no longer get compensated in energy market. Instead, PJM will allow demand bids from load serving entities to specify a price at which they choose not to consume.

For Price Responsive Demand, the load serving entity’s forecast is modeled by PJM to calculate the amount of avoided generation dispatch.

PJM created a method to handle existing capacity commitments that involves matching up demand offers with corresponding load serving entities.

The obligation is then converted to a demand side curtailment commitment, with provisions for providers to be released from their obligations.
Regulatory

State Regulation

Public utility commissions regulate utility demand response programs. PUC support for demand response and plug-in electric vehicles vary.

- Most states have load serving entities that are regulated by state commissions. Maine and Vermont have standalone state efficiency utilities that administer programs. Some states have transitioned previously separate utility programs into statewide programs.

- Utilities have historically developed and implemented programs to meet their own needs. The New England states have a somewhat different model insofar as they administer ISO-NE’s demand response programs (fate is undetermined until FERC 745 resolved). Additional states, including California, are moving toward greater integration between retail and wholesale markets.
Control Capabilities

ChargePro Level II Commercial Charging Station

- M2M connectivity via cellular modem
- Central control from cloud-based network platform
- Up-to-date status and metering data
- Fast response to demand response dispatch instructions
- RFID Identification of PEV driver
- Account on network platform
- Messaging and Charging Preferences
- J1772-compliant charge connector
- Standardized dynamic load signaling to vehicle
Control Capabilities

SemaConnect’s ChargePro Level II Commercial Charging Stations

Power flow can be controlled for any designated charging station or grouping of stations selected for control 1.5 kW and 7.5 kW at a particular station.

Power Levels
- Level I – 120V, 12 Amps
- Level II – 240V, 30Amps
- Fast Charging – 480V, Greater than 100Amps

Time to Charge (for 100 mile range battery)
- Level I – 20 hours
- Level II – 4 to 8 hours
- Fast Charging – 20 minutes

Standard Connector
- New connector called J1772, developed by Society of Automotive Engineers
- All major car companies have agreed to use
- Includes safety features to protect drivers and general public
Control Capabilities

Power Consumption Map

- Heavy Consumption
- Moderate Consumption
- No Consumption
Control Capabilities

Power Consumption Dashboard (Illustrative)

MW

Aggregated Resource

Sub-group

Station (n=1)
Control Capabilities

PlugShare Driver/Vehicle Interaction & Communications

- Communicate with drivers about demand response and other grid events and opportunities in their region.
- Provide real-time opportunities to opt in or out of events or have preferences pre-programmed.
- Determine participation based on driver range/battery charge level needs.
- Communicate station participation in AutoDR programs.
- Non-invasive vehicle hardware installation can facilitate timed charging, charge curtailment, modulated charging (load smoothing), and help integrate with charging station management systems and aggregator signals.
- Integrate vehicles and charging stations into designed charging programs.
Control Capabilities

PlugShare Driver/Vehicle Interaction & Communications

PlugShare is working with a West Coast municipal utility and a sample group of drivers with its app-based communications technology.

- This app notifies drivers of upcoming and current demand response events for voluntary reductions.

- Driver responsiveness was robust, resulting in a 30% reduction in charging load during the events.

The next step is to include an installation of the PlugShare ChargeManager device in a sample group of PEVs.

- PlugShare will signal these vehicles to charge at certain times of the day and to suspend/resume charging. Additional dispatch signals and instructions are also being tested.
**Control Capabilities** *(illustrative)*

- **Start**
  - Utility or ISO dispatches signal from its secure communications system to the scheduling coordinator.

- The signal is transmitted to individual stations via a web service over a cellular data connection.

- The aggregator transmits a signal for load control to selected charging stations.

- Settlement quality meter data is submitted to the utility or ISO.

- The aggregator confirms that the power matches the configured level.
  - The aggregator confirms that the signal has been received.

- Station continuously meters energy flow through the cable. Syncs the power level and cumulative energy with the server.

- The vehicle detects the change in control signal on the J1772 cable and reduces its power.

- Station software manipulates the control signal on the J1772 cable connected to the vehicle to indicate curtailment. The station signals the server that the control is being executed.

*The aggregator and scheduling coordinator may not be the same entity.*
Next Steps

SemaConnect and PlugShare are in discussions with utilities and ISOs/RTOs to shape the development of pilot studies.

We expect to have a few commence next year.

We are open to conversations with utilities and other industry partners about opportunities to develop and commercialize demand response and ancillary services capabilities.
Thank you!

Mahi Reddy, Founder & CEO, mreddy@semaconnect.com

Ryn Hamilton, ryn@rynhamiltonconsulting.com

Tom Ashley, Director, Utility & Regulatory Affairs, tom@plugshare.com