How Can Mobile Load Participate In New England Wholesale Markets?

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Disclaimer: This paper represents the thoughts of the author and should be interpreted as a description of the final implementation plans of ISO New England Inc.

Abstract

With FERC order 745 requiring the payment of full LMP for demand response resources participating in the wholesale market, ISO New England (ISO-NE) is developing a plan to fully integrate demand resources into the wholesale market on a comparable footing with supply resources (generators). These resources would see similar market requirements to the supply resources, and would be able to participate in those markets in which the demand resource can prove that they can provide the service required by that market. These markets are presently well defined and so are their requirements. Aggregators will need to communicate with these mobile loads and provide the required information back to ISO-NE. Interoperability between the mobile load and the aggregator will be essential. ISO-NE will not want to communicate with 100,000 mobile loads individually. The paper will discuss what the type of information presently required of supply resources and the types of similar information that would be required of aggregated mobile loads for their participation.

1. INTRODUCTION

New England presently does not have a large penetration of electric vehicles (EVs). As a result, exactly how these resources might participate in the wholesale electricity markets might be modeled after demand response resources. On March 15, 2011, the FERC issued its final rule on demand response compensation, Order 745.[1] Order 745 pertains to ISOs and RTOs that permit demand response to participate in their energy market by reducing their consumption of electric energy from their expected levels in response to price signals. Under these situations, Order 745 requires ISOs and RTOs to:

- pay demand response resources the full LMP when these resources have the capability to balance supply and demand;
- dispatch demand response when the payment is cost-effective as determined by a net benefits test accepted by the Commission; and
- allocate the costs proportionally to all entities that purchase from the relevant energy market in the area(s) where the demand response reduces the market price for energy.

A primary point of the final rule is that demand response providers must be paid the full LMP when the demand response resources have the capability to balance supply and demand. The capability to balance supply and demand makes it clear that the resource must be dispatchable by the ISO or RTO. In order to be dispatchable by the ISO or RTO, the demand response resource must submit an offer into the wholesale energy market. In the case of ISO NE, the offer will be similar to a generator or dispatchable load offer (accounting for differences between generation and demand response resources). The second requirement in the order, “when it is cost effective, as defined by a net-benefits test”, to dispatch demand response resources adds a layer of complexity.

[1] FERC Order No. 745, Demand Response Compensation in Organized Wholesale Energy Markets (Issued March 15, 2011), 134 FERC ¶ 61,187. URL: http://www.ferc.gov/EventCalendar/Files/20110315105757-RM10-17-000.pdf. ISO New England submitted their compliance filing to the Federal Energy Regulatory Commission (FERC) on August 19, 2011. As of the drafting of this paper, an order on that filing has not been issued by FERC.

2. WHOLESALE MARKET

The New England wholesale electricity markets include capacity, ancillary services, and energy. To have value in the wholesale market, the resource must be able to provide a service that the ISO or RTO needs.

The capacity market is a three year forward looking market where resources receive compensation for having invested in capacity and delivery of that capacity by the appropriate capacity commitment period. In New England this forward market is FCM. FCM is a locational capacity market whereby the ISO will project the needs of the power system three years in advance and then hold an annual auction to purchase capacity resources to satisfy the region's future needs. Generation (including renewable and intermittent resources), passive demand response (energy efficiency and distributed generation), and active demand response participate in the auction as supply resources to satisfy region’s capacity supply requirement.

Ancillary services are services that ensure the reliability of production and transmission of electricity. These services include operating reserve (10 minute and 30 minute operating reserve), and regulation (call automatic generation control (AGC)[2] or Automatic Voltage Regulator (AVR) for controlling system frequency). [4]

Through the energy market, ISO NE provides a system for purchasing and selling electricity using supply and demand to set the price. Electric energy must be produced when it is needed by consumers. If there is an over production of energy, the frequency on the system will increase and if there is less energy produced than is needed by consumers, the frequency on the system will decrease. ISO NE uses the energy offers from generators to dispatch these resources to meet the system needs including operating reserve requirements. The objective function for economic dispatch is to minimize the total cost of producing electricity over the entire day while keeping the system in balance. Economic dispatch uses the least-cost resources in a single period (hourly in the Day-Ahead Energy Market, 10-minutes in the Real-Time Energy Market) to meet the demand. ISO NE assesses hourly resource cost and establishes the wholesale cost of energy based on a uniform clearing price auction. [1, 4]

[2] Frequency of the system will vary as load and generation change. During a severe overload caused by the tripping or failure of generators or transmission lines the power system frequency will decline, due to the imbalance of load versus generation. Loss of an interconnection, while exporting power (relative to system total generation) will cause system frequency to rise. Automatic generation control (AGC) is used to maintain scheduled frequency and interchange power flows.

Under the present energy market rules, almost all generation resources are required to submit offers into the day ahead and real-time energy market. Under the ISO New England Order 745 compliance filing, demand resource which could include mobile loads would be required to submit offered into both the day ahead and real-time energy market.[3] These offers would then be used to dispatch the resources.

3. MOBILE LOADS

EVs include plug-in electric vehicles (PEV) and plug-in hybrid electric vehicles (PHEV). EVs can be compared to a storage battery on the electric system. Imagine for the moment that there are 1000 EVs parked at a large metropolitan parking area and plugged-in to charging stations. These EVs could be visualized as if they were a single large battery on the electric system. Their collective stored charge represents energy available to the system and their ability to charge (consume energy) represents a dispatchable load. Among the interesting twists for EVs is that they do not remain at the parking area, but rather they relocate to numerous locations. In some cases, those locations can be modeled in a similar fashion to the metropolitan parking area, but in other cases the number of EVs at a “location” will be much smaller. EVs can be charged at the owner’s home, a parking area (corporate offices, parking lots, shopping center, sport stadium parking area, etc.) or a charging station.

Each parking area can be represented as a unique asset by the aggregator for participation in the wholesale market rather than participation by each individual vehicle. The aggregator would be responsible to notifying the ISO of the availability of each asset (resulting from the number of vehicles parked at a facility). For example, the parking lot is only half full and therefore the capability of this asset is less than its full rating or no vehicles are plugged-in at home and therefore the capability is zero (a redeclaration of the asset’s capability). Table 1 provides information regarding charging times for EVs from a fully depleted state based on the charging level. It is expected that public area charging would be either level 2 or level 3. Home charging is expected to be level 1 or level 2.

[3] If aggregated mobile loads are considered a generation and storage resource rather than a demand response resource, then mobile loads would be required to bid into both the day-ahead and real-time energy market.

Table 1 – Charging Times by Level

Charger Level	Voltage	Replenishment From Fully Depleted
Level 1 (1.4 kW)	120 VAC	16-18 hour
Level 2 (3.3 kW)	208-240 VAC	3-8 hours
Level 2 (6.6 kW)	208-240 VAC	2-4 hours
Level 3 (DC Fast Charge)	400-600 VAC	< 30 minutes

The aggregator is the market participant and as such, the aggregator will determine the level of acceptable risk and the resulting level of their participation in the wholesale market. The aggregator will take positions in the day-ahead energy market or the forward reserve market based on their best estimate of the number of EVs that will be available to them on weekdays, weekends, and overnight.

The modeling of these resources in the wholesale market is more complicated than a storage battery because the resources change location. Further, the size of the resource is different. The metropolitan parking garage might represent a storage device with a 20 MW capability. However, this resource is only available from 8 a.m. to 5 p.m. In addition, the level of the resource will increase from zero at just before 8 a.m. and then decrease again as it approaches 5 p.m. The aggregator must redeclare this resource's capability as the number of vehicles changes. After majority of the vehicles have left the parking lot, the resource would have a zero capability until the next day when the vehicles arrive again.

In the overnight period, the vehicles are charge at homes, apartment parking lots, or charging stations. These resources are smaller than the daytime resources but equal in total capability. This resource has zero capability during the normal workday. The wholesale market operator must model both the daytime and nighttime resources and then account for their operational hours.

4. COMMUNICATION

In its simplest form, the communication between the mobile load and the ISO can be viewed like a combination of a generator and a dispatchable load. The ISO issues electronic dispatch instructions to resources in the energy market and for AGC from the ISO control room through an intermediary called the Designated Entity (DE)[4]. The DE is responsible for communicating the dispatch instruction to the generating unit or dispatchable load. The DE may represent a single company or some subset of the company's resources and act as the central communication point for that company between the ISO and their generating facilities. The communication between the ISO and the DE takes place over a frame relay secure network with a remote terminal unit (RTU) at the DE that receives instructions from the ISO's dispatch software through the ISO's computer front end (CFE). [2, 4] Figure 1 depicts the equipment involved in this communication process between the ISO and DE.

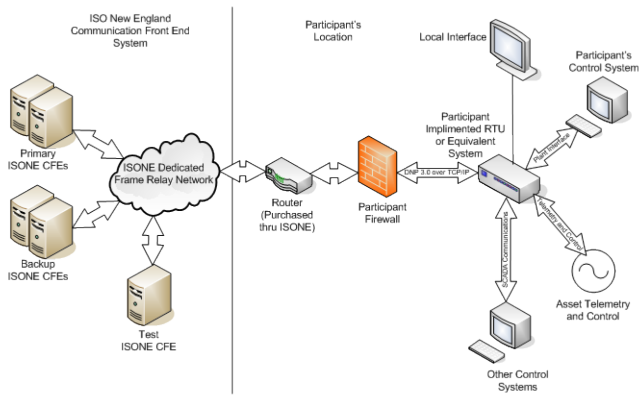

Figure 1 – ISO/DE Communication Mechanism

From an information standpoint, the most demanding service is AGC. Dispatch instructions from the ISO are issued every 4 seconds and data must be supplied by the DE before the next instruction. For each resource, the DE must provide the ISO with a response rate and the high and low operating limits for the resource. The high limit would be the maximum output or least consumption level (supply measured in MWs is represented as a positive value) of the resource, and the low limit would be maximum consumption (charging load measured in MWs is represented as a negative value) of the resource. The aggregator must communicate with all the vehicles, receive information back from all the vehicles, aggregate that data, and present that data to the ISO each cycle. Among the information provided as part of the instruction, the ISO provides a set point which is a level of output (a positive value) or consumption (a negative value) for each AGC resource.

In the case of the metropolitan parking garage, vehicles are always entering and leaving. Much of this pattern is regularly discernable and the aggregator should be able to

[4] An aggregator could be their own DE or the aggregator could contract with a company that specializes in communications and data handling to provide the service.

model the changes in the capability of the resource. Large numbers of vehicles arrive at the start of the workday, and similarly, as the workday draws to an end, the majority of the vehicles leave to head home. As the level of controllable vehicles varies significantly, the DE will have to redeclare the capability of the resource. As the time for the vehicles to leave and head home approaches, it may become necessary to only charge vehicles. The DE would redeclare the high operating limit of the resource to indicate that the resource can no longer provide energy (the high limit would be zero or a negative value).

When the vehicle arrives at home, it is again plugged-in. The owner desires to charge the vehicle when the cost of energy is relatively low. Low energy costs generally occur during the overnight hours (midnight to six in morning). In this situation, the EV is a dispatchable load. When the price of the energy is below the EV owner's established price, the vehicle should increase consumption of the energy to charge the EV. In accordance with the wholesale energy market rules, the aggregator would have submitted a bid to purchase energy at or below a specific price by noon of the day before the dispatch day. Again, the EVs in the area are combined into a resource (a dispatchable load) and they are dispatched by the ISO in accordance with their bids. Dispatch instructions are issued by the ISO to the DE who communicates those instructions to the individual vehicles. The dispatch instructions for the real-time energy market are issues every five minutes, and the DE must provide consumption information (meter data) for each five minute interval before the next instruction is received.

The DE must redeclare the level of available dispatchable load to the ISO as the vehicles become fully charged.

5. CONCLUSION

Mobile loads present a unique and sometimes complex problem for the wholesale market. Supply resources are typically located a know point on the transmission system and have a consistent capability. While the individual mobile load has a consistent capability, the wholesale market operator is not desire to deal with tens of thousands or hundreds of thousands individual EVs. These individual EVs will have to be aggregated and presented to the wholesale market as a larger resource. However, this resource will have one set of attributes during the peak hours when the EVs are drive to work and parked during the on-peak hours, compared to the aggregation of EVs when the vehicles are parked at home for the night. The basic dispatch of the electric system requires that the system operator be able to model the each significant injection of energy or consumption of energy.

The model must recognize multiple resources whose total capability is equal, and whose availability is opposite. During the on-peak hours when people are at work, the EVs are located in a metropolitan parking garage, and the resources where the EVs are charged overnight have little or no available capacity.

Reference List

[1] ISO New England Operating Procedure No. 1: Central Dispatch Operating Responsibility and Authority of ISO New England, the Local Control Centers and Market Participants

[2] ISO New England Operating Procedure No. 14: Technical Requirements for Generators, Demand Resources and Asset Related Demands

[3] ISO New England Operating Procedure No. 18: Metering and Telemetering Criteria

[4] Overview of New England Wholesale Electricity Market

Biography

Mr. Burke is a Principal Analyst in Market Development with ISO New England (the RTO for the New England control area). He has over thirty-five years of experience in the energy industry. Since joining ISO-NE, he has held various positions and been involved with the development and subsequent on-going improvement of the wholesale energy markets. Mr. Burke has been involved in the development and implementation of the ISO's system for real-time demand response activation and providing near real-time data on demand response assets, the Internet Based Communication System Open Solution, and its successor system.

Mr. Burke has been a member of the GridWise Architecture Council (GWAC) since 2009, and he is also a member of IEEE. Mr. Burke has a B.E. in heat and power from Stevens Institute of Technology, MBA and MS in Computer Science, both from Rensselaer Polytechnic Institute, and has completed all examination requirements in Connecticut for a CPA.