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Assessment of Wholesale Market Opportunities for Participation and Aggregation of Distributed Resources

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PRODUCT DESCRIPTION

This report provides an assessment of existing opportunities for participation and aggregation of distributed resources in organized wholesale electricity markets. The assessment provides an organized structure for identifying opportunities and requirements for distributed resources to participate in independent system operators (ISOs) and regional transmission organizations (RTOs) markets, either through direct participation or in aggregation. In the report, high-level aggregation, minimum size, and communication requirements for distributed resource participation are summarized by wholesale product and resource type. The result is a reference guide that can assist utility personnel, distributed resource owners, and other stakeholders in identifying real revenue opportunities and associated requirements for the provision of valuable services using distributed resources.

Results and Findings

The work is compelled by the need for a common reference that elucidates ISO/RTO market and program opportunities for demand response (DR) and distributed energy resources (DERs). Findings include identification of common product types procured through organized wholesale electricity markets and development of a common structure to compare and contrast different ISO/RTO opportunities and requirements for resource participation.

By using a common structure to summarize the practices employed by the nine North American ISOs/RTOs, the report facilitates improved communication and industry collaboration despite regional differences in wholesale product naming conventions that may exist. A well-structured assessment should enable stakeholders to quickly identify the similarities and differences between different ISO/RTO markets that accommodate the contribution of DER and DR in support of wholesale market operations. The work can also be applied to identify prevalent aggregation challenges and gaps in existing ISO/RTO requirements as well as recommendations for overcoming distributed resource integration barriers in organized wholesale electricity markets.

Challenges and Objectives

Modern electric power systems are facing shrinking reserve margins, elevated electricity costs, permitting difficulties, and financial risks of bulk expansion. Distributed resource integration addresses these problems through programs and projects that encourage the integration of distributed resources (that is, distributed generation, distributed renewables, curtailable loads, and distributed storage, including plug-in electric vehicles) into electric power system operations and planning in support of power systems and customer needs. Programs and pilot demonstrations that integrate distributed resources with wholesale electricity markets exist in different geographical regions. ISOs/RTOs have specific eligibility rules and requirements for resource participation in the markets in which they operate. Rules are specified by type of resource and wholesale market product and differ by ISO/RTO region. The resulting complexity of wholesale market structures and differing requirements and terminology for wholesale products and DR programs creates the need for a structured assessment of ISO/RTO programs and requirements for integrating distributed resources.

Applications, Values, and Use

FERC Order 719 requires ISOs/RTOs to offer the same opportunities to DR in their markets as they do for bulk generation resources. Most ISOs/RTOs have already started initiatives to enhance their market designs to comply with this order. The main issues regarding comparable treatment of generation and DR are minimum MW size and communication requirements. The work described in this report is useful for tracking existing wholesale market size and communication requirements. It is also useful for depicting the level of stringency of existing requirements and can be applied to reveal critical gaps to be addressed through the design of future research and development activities aimed at integrating distributed resources to support wholesale electricity market operations. As a first step, the report's findings provide a basis for ready comparison of key requirements for integrating distributed resources into electric power and market systems among different ISO/RTO markets.

EPRI Perspective

Respecting regional market differences, the Electric Power Research Institute (EPRI) employed power systems operations expertise to carefully analyze wholesale market structures and to discern key product types and common communication and resource size requirements. By comprehensively considering each existing ISO/RTO market and interactions of market products with one another in an operational environment, this work distills findings to simplify presentation of the complex landscape of market opportunities for distributed resources.

Approach

This report develops a structured assessment, based on literature review, for identifying and comparing distributed resource integration practices in wholesale electricity markets. The approach taken was a methodological assessment of each ISO/RTO market product and presentation of results in a common table format. The common format enables the requirements for monitoring and aggregating distributed resources to be readily compared among the different organized markets facilitated by ISOs/RTOs in North America. The ISOs/RTOs considered include Pennsylvania-Jersey-Maryland (PJM), ISO New England (ISO-NE), New York ISO (NYISO), Midwest ISO (MISO), Southwest Power Pool (SPP), California ISO (CAISO), Electric Reliability Council of Texas (ERCOT), Independent Electricity System Operator (IESO) of Ontario, and Alberta Electric System Operator (AESO).

Keywords

Aggregation
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1
INTRODUCTION

The Electric Power Research Institute (EPRI) has undertaken a series of industry demonstration projects to address key Smart Grid issues facing the electric power industry over the next decade. These demonstration projects and the supporting research include, among others, issues associated with integration of Distributed Resources into electric utility operations and planning, including integration of distributed generation, demand response resources, distributed electric and thermal storage, and renewable energy sources.

To accomplish this objective, EPRI has identified a number of tasks, one of which involves an assessment of methods and tools for aggregation of Demand Response (DR) and Distributed Energy Resources (DER) for participation in the organized wholesale electricity markets. This document provides an update on initial assessments conducted in support of the described project task.

The report summarizes key aggregation and minimum size restrictions for distributed resources (i.e., both DER and Demand Response resources) participating in organized wholesale market environments. The report also provides a high-level assessment of communication requirements for aggregating resources that otherwise do not individually qualify for participation in regional electricity markets due to megawatt (MW) size limitations. Requirements are summarized for monitoring and aggregating distributed resources through market and grid management systems operated by Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs) in North America. The ISO/RTOs considered include Pennsylvania-Jersey-Maryland (PJM), ISO New England (ISO-NE), New York ISO (NYISO), Midwest ISO (MISO), Southwest Power Pool (SPP), California ISO (CAISO), Electric Reliability Council of Texas (ERCOT), Independent Electricity System Operator (IESO) of Ontario, and Alberta Electric System Operator (AESO).

2
ISO/RTO PRODUCT MARKETS

The main products transacted in the organized ISO/RTO markets related to electricity production and consumption are Day-ahead and Real-time Imbalance Energy, Ancillary Services, and Capacity. Transmission Rights are also facilitated in ISO/RTO markets, but they pertain exclusively to transmission assets and are not considered here. The relevant market time frames generally include "long-forward", "day-ahead", and "day-of" (e.g., "hour-ahead" and "real-time" markets). Capacity is generally a long-forward (monthly, seasonal, and/or annual) product, whereas Energy and Ancillary Services are often transacted in day-ahead and day-of markets. Ancillary Service products in different ISO/RTOs distinguish between Regulation and Reserve services. Different ISO/RTOs offer different flavors of these services as briefly summarized below and in Table 2-1.

2.1 Energy

All ISO/RTOs have a Real-time Energy market, but not all facilitate a Day-ahead Energy market. Where day-ahead Energy markets are facilitated by an ISO/RTO, energy sellers can submit priced offers (to sell at or above their stated price) and energy buyers can submit priced bids (to buy at or below their stated price). In contrast, in the real-time markets, only sellers of energy (whether selling energy from generation sources or through Demand Response) can state a price. Energy buyers are price takers in the real-time market. Another distinction between Day-ahead and Real-time Energy markets is that Day-ahead Energy markets are generally financial. That is, Day-ahead Energy buyers and sellers take financial positions either in anticipation of real-time delivery or consumption, or to arbitrage between Day-ahead and Real-time prices. In contrast, Real-time markets are physical, in that Real-time market settlement is based on actual deliveries or consumptions. More specifically, where a Day-ahead Energy market exists, Real-time settlement is based on the difference in actually deliveries (MWh) compared to Day-ahead positions. Energy transacted in the Real-time market is often referred to as Imbalance Energy, since its purpose is to balance supply and demand in real-time.

2.1.1 Day-Ahead Energy Markets

As indicated in Table 2-1, PJM, ISO-NE, NYISO, MISO, and CAISO facilitate a Day-ahead Energy market. ERCOT, SPP, IESO and AESO currently do not have a Day-ahead Energy market. ERCOT plans to start a Day-ahead Energy Market in December 2010, and SPP plans to have one in late 2012. Regardless of whether or not an ISO/RTO facilitates a day-ahead Energy market, generally all ISO/RTOs perform some form of unit commitment in the day-ahead time frame to ensure adequate resources are online to meet the forecasted peak demand of the next operating day.

Where the ISO/RTO does facilitate a Day-ahead Energy market, unit commitment may take place as part of the Day-ahead market-clearing process as well as in the so-called "Reliability Unit Commitment" (RUC) process. The latter is called "Reliability Assessment Commitment" (RAC) in MISO and "Residual Unit Commitment (RUC) in CAISO. There are "re-bid"

provisions for RUC in PJM, ISO-NE, and MISO. In other words, after these ISO/RTOs publish their Day-ahead Energy market results (i.e., commitments, quantities, and prices), the resource owners/operators are given the opportunity to re-bid the resources not committed in the Day-ahead Energy market to revise their offers for consideration under RUC (or RAC in the case of MISO). In contrast, CAISO and NYISO do not offer such re-bid opportunity. The offers submitted for the Day-ahead Energy market are used in the RUC process, There is a subtle but important difference between NYISO and CAISO in this regard. NYISO performs the Reliability Unit Commitment as part of the Day-ahead market-clearing process, thus allowing RUC to impact the Day-ahead Energy prices. CAISO, however, performs the RUC after clearing the Day-ahead Energy market. Another distinction is that CAISO allows resources that are not under Resource Adequacy contracts to submit "RUC Availability" offers and get paid the "RUC Availability Locational Market-Clearing Price" for their capacity committed in the RUC process.

2.1.2 Real-Time Energy Markets

As presented in Table 2-1, all ISO/RTOs have a Real-time (Imbalance) Energy market. The timeline for submitting offers in these markets are not the same, however. In most ISO/RTOs offers may be submitted independently for each hour up to an hour or so before the Operating Hour. For example, CAISO closes the submission of Real-time offers for each hour 75 minutes before the start of that hour, whereas MISO closes it 30 minutes before the start of the hour. PJM is a rare exception in that it does not allow separate offers for separate hours. In PJM, the Real-time Energy offer for each resource is to be submitted during the re-bid period (4:00 p.m. to 6:00 p.m. the day before), with the same offer being applicable to all hours of the next day.

Generally the Real-time Energy market dispatch and pricing is done every 5 minutes. ERCOT is an exception and performs 15 minute dispatch and pricing. NYISO uses the 5-minute prices and quantities for Real-time Energy settlement with supply resources. CAISO computes 10-minute resource-specific Real-time prices for each resource, computed from the two 5-minute prices in a 10-minute Real-time Settlement Interval. PJM, ISO-NE, and MISO use hourly Real-time prices computed from 5-minute prices. ERCOT uses 15-minute prices for Real-time Energy Settlement.

2.2 Regulation

Generally, the Regulation service is used to control system frequency and net interchange of the footprint under operational jurisdiction of the system operator. Resources providing Regulation must be AGC-enabled (i.e., must have real-time telemetry, and must be able to respond to Automatic Generation Control signals as often as every 2 to 4 seconds).

Some ISO/RTOs distinguish between upward Regulation (Regulation Up) and downward Regulation (Regulation Down) as separate products. CAISO, ERCOT, and SPP's new market design fall in this category. Other ISO/RTO markets treat Regulation as a single, symmetrical up/down product.

CAISO, NYISO, and MISO have both a Day-ahead and a Real-time market for Regulation. In CAISO, Regulation, and Reserves are co-optimized with Energy in the Day-ahead market. However, the CAISO clears its Real-time Energy market separately from its other markets. For

example, CAISO's Real-time market for Energy clears every 5 minutes, whereas CAISO's Real-time Ancillary Services market clears every 15 minutes. In NYISO and MISO, Regulation, Reserves, and Energy are co-optimized both in Day-ahead and in Real-time.

PJM and ISO-NE do not procure Regulation and Reserves in the Day-ahead market. In PJM offers for Regulation and 10-minute Reserves (which PJM calls Synchronized Reserves) are submitted by 6:00 p.m. the day before the Operating Day, by close of the re-bid period. The offers and are fixed for all hours of the next Operating Day. Furthermore, if a resource is listed as available for regulation but does not submit a Regulation offer price, its Regulation offer price is set to zero by PJM. PJM clears the Regulation market simultaneously with the Synchronized Reserve market, and posts the results no later than 30 minutes prior to the start of the operating hour. In ISO-NE Regulation, Reserves and Energy are co-optimized in real-time (i.e., every 5 minutes).

SPP does not have an Ancillary Services market for procuring reserves in 2009. Regulation is self arranged (i.e., self-scheduled) from the Participant's own resources or through bilateral arrangements.

2.3 Reserves

The term "reserves" is used here to refer to operating reserves, as opposed to planning reserves used in the context of Resource Adequacy and Capacity markets. Operating reserve includes spinning reserve, non-spinning reserve, and supplemental operating reserve.

Practically all ISO/RTOs distinguish "Spinning Reserve" as a 10-Minute responsive product from resources that are on-line and synchronized to the grid. In most ISO/RTO markets in North America, Spinning Reserve resources must be frequency responsive.

Non-spinning or supplemental operating reserves are generally provided by off-line generation resources or on-line demand response resources. Some ISO/RTOs distinguish reserves provided by off-line resources, depending on the purpose and response time requirements. They may distinguish 10-minute Non-Spinning Reserves from 30-Minute Supplemental Reserves. Generally, a resource does not have to be off-line to be eligible to provide Non-Spinning Reserve service. Rather, this service may also be provided from unloaded on-line capacity of a resource. Moreover, in general the ISO/RTO facilitating a market for Ancillary Services may procure more Spinning Reserve to satisfy its Non-Spinning Reserve requirements if the former is offered at lower cost. However, this service substitution practice is not allowed in some markets such as ERCOT.

PJM's classification of reserves is distinct from the other ISO/RTOs. As shown in Table 2-1, currently PJM has the so-called 10-Minute Synchronized Reserve, which is a mix of 10-Minute Spinning and 10-Minute on-line reserves (i.e., curtailable loads). As stated above, the PJM Regulation and Synchronized Reserves are co-optimized in the "day-of" time frame (i.e., after close of the re-bid period and before the start of the operating hour). PJM also has a 30-Minute Scheduling Reserve (supplied by supplemental operating reserves) that is co-optimized with Energy in the Day-ahead market.

ISO-NE and NYISO have both 10-Minute Non-Spinning and 30-Minute Operating Reserves, in addition to 10-Minute Spinning Reserve. As stated above, ISO-NE co-optimizes 10-minute Spinning Reserves (TMSR), 10-minute Non-spinning Reserves (TMNSR), and 30-Minute Operating Reserves (TMOR) simultaneously with Energy in the Real-time market (every 5 minutes). In addition ISO-NE facilitates a Forward Reserve market for these reserve services that are not part of ISO-NE's Day-ahead or Real-time markets. ERCOT has a 10-Minute Spinning and a 10-Minute Non-Spinning Reserve. However, under ERCOT Nodal (a market design slated to commence operation as of December 2010), ERCOT will have the so-called 10-Minute Responsive Reserve and a new 30-Minute Operating Reserve. CAISO currently has 10-Minute Spinning and 10-Minute Non-Spinning Reserves, but no 30-Minute Operating Reserve. Similarly, MISO currently has 10-Minute Spinning and 10-Minute Supplemental Reserves, but no 30-Minute Operating Reserve. SPP does not have an Ancillary Services market for procuring operating reserves. Its participants self-schedule reserves from their own resources or through bilateral arrangements.

A number of markets, including ISO-NE, NYISO, MISO, and CAISO, also allow sub-hourly clearing of Reserve products in real-time. Instances for which operating reserves are procured in real-time in addition to day-ahead are denoted by the symbol "(DA, RT)" in Table 2-1.

2.4 Capacity

Capacity trades are used to meet Resource Adequacy obligations of Load Serving Entities. Resource Adequacy obligations are established by local, state, or federal regulatory entities depending on jurisdictional boundaries.

Generally ISO/RTOs have Resource Adequacy (RA) reporting mechanisms in place to ensure that Market Participants serving load in their footprint (Load Serving Entities) have lined up adequate capacity to meet their RA obligations (peak demand plus a planning reserve margin). Market Participants can meet their RA obligation through their own generation resources, bilateral arrangements with suppliers, or a combination. In most ISO/RTOs Demand Response resources qualify towards satisfying the RA obligations.

As shown in Table 2-1, some ISO/RTOs, including PJM, NYISO, and ISO-NE facilitate centralized capacity markets. MISO facilitates only a residual capacity market (Voluntary Capacity Auction (VCA) as a backstop to bilateral arrangements for Resource Adequacy. CAISO does not have a capacity market, but has defined a Standard Capacity Product for purposes of valuating the effective capacity of RA resources considering resource outages and de-rations. As of the time of publication, ERCOT and SPP have not yet finalized whether or not they will facilitate capacity markets in their respective new market designs.

Generally, resources with Resource Adequacy contracts (either bilateral or through centralized capacity markets) must either schedule or offer their contracted capacity in the Energy market, or in some cases in the Ancillary Service markets. They may self-commit or submit three-part offers (i.e., start-up offer, no-load/minimum load offer, and energy offer curve). Resources that are not under Resource Adequacy contracts may be eligible for additional compensation if force-committed by the ISO/RTO in the Reliability Unit Commitment (RUC) process.

Table 2-1 summarizes the products offered at different ISO/RTOs.

Table 2-1
Main Products at ISO/RTO Markets (as of December 2009)

Product	ISO-NE	NYISO	PJM	MISO	ERCOT	CAISO	IESO	AESO	SPP
Regulation	X (DA, RT)	X (DA, RT)	X (Day-of) Offer submitted during rebid period and processed just before RT	X (DA, RT)	X (DA)	X (DA, RT)	LT bilateral contract for regulation	X (DA)	Self arranged
10 Minute Spin	X (DA, RT)	X (DA, RT)	X (Day-of) Offer submitted during rebid period and processed just before RT. "Synchronized Reserve Market"	X (DA, RT)	X (DA)	X (DA, RT)	X (DA)	X (DA)	Self arranged
10 Minute Non-Spin	X (DA, RT)	X (DA, RT)		X (DA, RT)	X (DA)	X (DA, RT)	X (DA)	X (DA)	Self arranged
30 Minute Reserve	X (DA, RT)	X (DA, RT)	X (DA, Re-bid between 4:00-6:00 p.m., processed just before RT)				X (DA)		
RT Energy	X	X	X (Day-of) Offer submitted during re-bid period; processed just before RT	X	X	X	X	X	X
DA Energy	X	X	X	X		X	DA Commitment Process		
RUC (RAC)	X (re-bid Period)	X (part of DA)	X (re-bid period)	X (re-bid period)	Out of market process under zonal. Will be formalized under nodal in Dec 2010.	X (Bid before close of DA market; clear after DA market)			
Capacity Market	X	X	X	RA Requirement (bilateral)		RA Requirement (bilateral)			

Notes:
An "X" indicates that the Market Product (in the row) exists and is procured through a short-term auction market by the ISO/RTO (in the column).
"DA" entry indicates day-ahead market clearing and resulting prices.
"RT" entry indicates the possiblility of subhourly market clearing and resulting prices.
Blank indicates that the Market Product is not offered by the ISO.
Refer to narrative for explanation of other entries in the table cells.
Note: ERCOT is planning to have a DA Energy Market starting in December 2010.

3
OPPORTUNITIES FOR DEMAND RESPONSE AND DISTRIBUTED ENERGY RESOURCES

The nine ISO/RTO markets in North America, with a few exceptions, provide opportunities for generation resources to participate in the following wholesale market product types:

- Regulation Reserve
- 10-Minute Spinning Reserve
- 10-Minute Non-Spinning Reserve
- 30-Minute Supplemental Operating Reserve
- Real-Time Energy
- Day Ahead Energy
- Capacity (long forward market facilitated by the ISO)
- Reliability Unit Commitment (RUC); also referred to as Residual Unit Commitment (RUC) in CAISO, and Reliability Assessment Commitment (RAC) in MISO.

The opportunities offered to Distributed Resources (i.e., both demand resource and distributed energy resources) for provision of these products at different ISO/RTOs are not necessarily the same as those provided for conventional generation resources. This is particularly true of Demand Response and Storage resources. Table 3-1 summarizes the products available to Demand Response (DR), Storage, and Renewable resources to provide in different ISO/RTOs.

The meanings of the entries in Table 3-1 are as follows:

- Blanks in a table cell indicate that the particular ISO/RTO (in the table column) does not offer an opportunity for distributed resources to participate and count towards the Market Product (in the table row).
- The acronym DR denotes Demand Response, whether it is due to change in end-use electricity consumption or deployment of Behind-the-Meter Distributed Generation.
- In Table 3-1, the acronym DG without a qualifier designates Distributed Generation with ability to export electricity to the grid. Note: This designation is differentiated from “DG behind the meter” capable of providing demand response to the extent that it reduces the net consumption of a customer providing demand response under an ISO/RTO DR program.
- “Renewables” refers to bulk intermittent resources (e.g., excluding conventional hydro and geothermal power) that can export energy to the ISO/RTO grid.
- “Storage” designates bulk storage resources (e.g., excluding conventional hydro pumped storage) that can exchange electricity through import/export with the ISO/RTO grid. These include Flywheels, Compressed Air Storage, Battery Storage, and the likes. As of time of publication, Behind-the-Meter Storage is not recognized in any ISO/RTO as distinct from Demand Response Resources that provide an effective change in consumption of power delivered from the electric power grid.

Table 3-1 summarizes the opportunities for non-conventional resources like demand response resources, DG, storage, and renewable sources to provide services in ISO/RTO markets. The reader will note that bulk storage and bulk renewable resources are considered instead of their distributed counterparts. This is due to lack of defined ISO/RTO program and market opportunities specific to distributed storage and distributed renewable generators.

Table 3-1
Opportunities for Distributed Resources in Different ISO/RTO Markets (as of December 2009)

Product	ISO-NE	NYISO	PJM	MISO	ERCOT	CAISO	IESO	AESO	SPP
Regulation			Storage	Storage (RT); DR from DG behind the meter	DR from DG behind the meter only				
10 Minute Spin	Storage	Storage	DR, DG, storage	DR from DG behind the meter only	DR from DG behind the meter only		DR		
10 Minute Non-Spin	DR	DR		DR	DR	DR	DR	DR	
30 Minute Reserve	DR	DR	DR				DR	DR	
RT Energy	Renewables DR	Renewables DR	Renewables DR	Renewables DR	Renewables DR	Renewables	Renewables	Renewables DR	Renewables DR
DA Energy	DR	DR	DR	DR from DG behind the meter only					
RUC (RAC)				DR					
Capacity Market	DR, DG, storage, renewable	DR, DG, storage, renewable	DR, DG, storage, renewable	DR, DG, storage, renewable (for RA obligation)		DR, DG, storage, renewable (for RA obligation)			

Notes:
Blank indicates that the particular ISO/RTO (in the column) does not offer an opportunity for distributed resources to participate in the Market Product (in the row).
DR refers to a dynamic change in load coordinated with system or market conditions. DR can also come from DG behind the meter that displaces power delivered by the grid to end-use customers.
"DR from DG behind the meter generation only" refers to DG providing DR without exporting power to the grid
“DG, storage, renewables” refers to resources that can export power to the grid
Renewables in the table refers to intermittent types (not hydro)

3.1 Regulation Service from Distributed Resources

Storage, due to its fast response, is generally suited for providing regulation reserves. Although all markets surveyed allow conventional pumped storage to provide Regulation, except for PJM currently none of them allow distributed energy storage resources to provide regulation reserves. ERCOT allows the participation of behind-the-meter **Distributed Generation** (DG) in the regulation market. Starting in 2011, CAISO will allow the participation of **Demand Response** (DR) in the Regulation market under Dispatchable Demand Response (DDR) which is a nodal level product. CAISO is also considering the possibility for provision of Regulation from the so-called Proxy Demand Resources (PDR) that it is contemplating to implement prior to summer 2010. However, provision of Regulation and Reserves from Demand Response resources requires relaxation of some of the existing WECC regulations that restrict provision of ancillary services from Demand Response to non-spinning and supplemental operating reserve.

Midwest ISO defines two types of **Demand Response Resources** (DRR): Type I and Type II. DRR Type I are load interruption resources that provide a fixed binary (either all on or all off) amount of MWs. DRR Type II may include controllable loads or behind-the-meter generation that can be dispatched though a range of MW levels. Currently, only **DRR TYPE II** resources can provide regulation in the Midwest ISO market.

3.2 10-Minute Spinning Reserve from Distributed Resources

ISONE, NYISO, PJM, and MISO allow Storage resources to provide 10 Minute Spinning Reserves. CAISO currently does not accommodate Spinning Reserve from Demand Response resources, but may do so under PDR (2010) and/or DDR (2011) as stated above. Demand Response can provide 10-Minute Spinning Reserves in PJM and MISO (Type II). In MISO, Storage from Flywheel can only participate in the Real-time (5-minute) Regulation market, but not in the Reserve markets. Only PJM and ERCOT allow the participation of behind-the-meter DGs to provide 10-Minute Spinning Reserves. In IESO this service may be provided by distributed resources through self scheduling Demand Response resources.

3.3 10-Minute Non-Spinning Reserves from Distributed Resources

DR resources can participate in 10-Minute Non-Spin markets at ISONE, NYISO, PJM, MISO (both Type I and Type II), ERCOT, and CAISO. PJM allows the participation of both Storage and DGs in the 10-Minute Non-Spin market. As stated earlier, PJM 10-minute Spinning Reserve and Non-spinning Reserves from on-line resources are collectively referred to as Synchronized Reserve. In IESO and AESO this service may be provided by distributed resources through self scheduling Demand Response resources.

3.4 30-Minute Operating Reserves from Distributed Resources

Demand Response can provide 30-Minute Operating Reserve in ISONE, NYISO, and PJM. In IESO and AESO this service may be provided by distributed resources through self scheduling Demand Response resources. Other ISO/RTOs do not define a 30-Minute Operating Reserve product and consequently lack opportunities for distributed resources to participate in this product.

3.5 Real-Time Energy from Distributed Resources

Renewables can provide balancing energy in the Real-Time markets of all ISO/RTOs. Demand Response resources can provide Real-Time Energy in ISONE, NYISO, PJM, MISO, and ERCOT. At the time of publication, in CAISO, IESO, and AESO provision of Real-time Energy from DR is limited to real-time energy dispatched from qualified DR reserve capacity.

3.6 Day Ahead Energy from Distributed Resources

Demand response resources can generally participate in Day Ahead Energy markets where they exist. Although Renewable and Storage Resources are generally regarded as sources of Real-Time products, some ISO/RTOs may allow renewable resources to schedule in their Day-Ahead Energy market. Such schedules are regarded as financial positions.

3.7 RUC (RAC) Capacity from Distributed Resources

MISO allows DRR Type I and II to participate in RAC. CAISO incorporates Demand Response to adjust its RUC procurement target, but does not provide for any "availability payment" to DR resources. Where the ISO/RTO facilitates a capacity market and treats DR as an eligible capacity resource, DR is used similar to generation resources in the RUC process.

3.8 Capacity Market for Distributed Resources

All types of resources, including DR, DG, Renewables, and Storage, can participate as capacity products in ISO-NE, NYISO, and PJM. Midwest ISO and CAISO do not have centralized capacity markets, but allow these resources to satisfy Resource Adequacy Obligations through self-supply of a market participant's own resources or through bilateral arrangements.

3.9 Potential Revenues from Participation in ISO/RTO Markets

Revenues associated with provision of defined market products differ among different ISO/RTOs and change by system conditions, load forecast, season, day type (e.g., work day, weekend, holiday), and time of use (e.g., Peak, Off-peak). At a very high level, average revenues associated with Energy is roughly on the order of tens of dollars per MWh, for Regulation is on the order of teens of dollars per MW per hour, and for Spinning Reserves in the order of a few dollars per MW per hour. Average revenue associated with Non-spinning Reserves it is on the order of tens of cents per MW per hour and for Capacity (Resource Adequacy) is on the order of tens of dollars per kw-year.

Table 3-2 lists resulting analyses of high, low, and average product prices based on published prices for market products at various ISO/RTOs. The date range for which price analyses were conducted differs based on data availability and market redesign status of various ISO/RTOs. Unless stated otherwise in the table, the date range used for the price analyses is 6/1/2008 through 6/30/2009. Appendix A identifies existing ISO/RTO programs that accommodate Demand Response and Behind-the-Meter Distributed Generation Resources to contribute to the defined ISO/RTO products identified in Table 3-2.

Table 3-2
Examples of Potential Revenue from Participation in Various ISO/RTO Markets

Region	Market Product	Price Analyses	Comments
CAISO	RT Energy	PG&E: High: $76.43, Low: -$5.42, Avg: $27.12 SCE: High: $71.02, Low: -$5.09, Avg: $25.76 SDGE: High: $97.72, Low: -$5.13, Avg: $26.50	Date Range: 4/1/2009 to 7/2/2009.
	Reserve (Non-Spin)	High: $174.80; Low: -$9.65; Average: $0.71	Date Range: 4/1/2009 - 7/2/2009: Spin: High: $174.85; Low: $-9.65; Average: $1.33. Regulation Up: High: $190.00; Low: -$9.65; Average: $3.23. Regulation Down: High: $367.41; Low: -$0.25; Average: $6.00.
	Capacity	$75/kw-year	Based on the price of a peaker plant in CA.
ISO-NE	RT Energy	High: $261.26, Low: $10.48, Average: $64.54	
	DA Energy	High: $ 413.24, Low: $0, Average: $ 63.14	
	Reserve (TMOR)	High: $ 107.07, Low: $0, Average: $ 0.079	TMOR: (Thirty Minute Operating Reserve).
MISO	RT Energy	DECO.WPSZ: High: $149.96, Low: -$61.51, Avg: $26.60 Michigan.HUB: High: $149.56, Low: -$61.55, Avg: $26.58	Date Range: June 1, 2009 to July 20, 2009.
	DA Energy	DECO.WPSZ: High: $85.31, Low: -$9.11, Average: $26.61 Michigan.HUB: High: $87.27, Low: -$8.78, Average: $26.62	Date Range: June 1, 2009 to July 20, 2009.
	Reserve	GenSpin: High: $38.69, Low: $0.21, Avg: $4.35 DemSpin: High:$38.69, Low: $0, Avg: $4.35 GenSupp: High: $1.00, Low: $0.15; Avg: $0.26 DemSupp: High: $1.0, Low: $0, Avg: $0.26	MISO Wide; Date Range: Jan 6, 2009- June 30, 2009 Dem designates Reserves from Demand Response resources; Gen designated Reserves from Generation Resources.
	Regulation	GenReg: High: $51.55, Low: $3.88, Avg: $13.68 DemReg: High: $51.55, Low: $3.88, Avg: $13.68	MISO Wide; Date Range: Jan 6, 2009- June 30, 2009

Table 3-2 (continued)
Examples of Potential Revenue from Participation in Various ISO/RTO Markets

Region	Market Product	Price Analyses	Comments
NYISO	DA Energy	NYC: High: $373.61, Low: $29.92, Average: $96.25 HUD VL: High: $322.64, Low: $13.92, Average: $67.30	NYC: 1/1/2008 - 12/31/2008; HUD VL 6/1/2009-6/30/2009.
	Reserve (Non-Spin)	Non-Spinning: High: $10.0, Low: $0.1, Average: $1.72	Spinning: High: $60.0, Low: $0.1, Average: $4.84.
	Regulation	**East:** High: $250.0, Low: $21.21, Avg: $49.40 **West:** High: $250.0, Low: $21.21, Avg: $49.39	
	Capacity	High: $8.64, Low: $0, Avg: $3.64	June 2008 to June 2009 (only one value per month).
PJM	DA Energy	PEPCO: High: $499.10, Low: $0, Avg: $66.21 AECO: High: $433.88, Low: $0, Avg: $64.26	
	Reserve (Non-Spin)	**ComEd:** High: $153.67, Low: $0, Avg:$4.70 **Western:** High: $107.80, Low: $0, Avg: $4.70 **Mid-Atlantic:** High: $185.82, Low: $0, Avg: $4.70 **South: High:** $60.27, Low: $0, Avg: $2.70	5/1/2005 - 7/31/2006 (no new data after 2006).
	Regulation	High: $586.3, Low:$5.0, Average $36.64	

Note:
Unless stated otherwise in the table, the date range used for the price analyses is 6/1/2008 to 6/30/2009.

3.10 Comparable Treatment of Demand Response and Generation Resources

FERC Order 719 requires ISO/RTOs to offer the same opportunities to Demand Response (DR) in their markets as they do for generation resources. Most ISO/RTOs have already started initiatives to enhance their market designs to comply with this order. The main issues regarding comparable treatment of generation and DR are minimum MW size and communication requirements as explained in the next section.

4
SIZE LIMITATIONS, AGGREGATION, AND COMMUNICATION REQUIREMENTS

Different ISO/RTOs have established eligibility rules and requirements for participation of resources in their product markets. The rules pertain to specific types of resources participating in wholesale markets. Since Distributed Resources are mostly connected to the distribution grid, and are invisible to the market operator, some of the existing rules and requirements may make it difficult for these smaller resources to participate in and provide the market products that have thus far been primarily provided by conventional generation resources. Prominent among these requirements are minimum MW size, aggregation provisions, and communication requirements.

Table A-1 in Appendix A, which is adapted from an ISO/RTO Council (IRC) published matrix,[1] shows a summary of Demand Response programs currently implemented at various ISO/RTOs along with minimum MW size and communication requirements. The table also indicates whether aggregation of distributed resources is allowed to meet the minimum MW size requirement. This section summarizes the telemetry and minimum size requirements for various Demand Response programs listed in Appendix A.

4.1 Communication and Telemetry Requirements

The telemetry and communication requirements vary over a wide range among various programs, from two seconds telemetry periodicities to no telemetry at all. For faster data scan frequencies, ranging from two seconds to one minute, the prevailing communication technologies employed include SCADA, ICCP, and DNP3. For less stringent communication requirements, ranging from five minutes to slower data refresh rates, Internet-Based Communication System (IBCS) is the most common telecommunications protocol utilized to satisfy the communications requirement between the system operator control center and the physical distributed resource.

4.2 Minimum MW Size and Aggregation Requirements

Of all the DR programs listed for which data is available in Table A-1, only three programs have no minimum size requirements. These include AESO's DOS, FLSS, and VLCP programs. For other programs, minimum size requirements range from 100kw to 10 MW. The most common minimum size requirements are 100 kw and 1 MW in order for a demand response resource to participate in an ISO/RTO DR program.

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[1] "North American Wholesale Electricity Demand Response Program Comparison", ISO/RTO Council: March 2009. Available at: http://www.isorto.org/site/apps/nlnet/content2.aspx?c=jhKQIZPBImE&b=2613997&content_id={2857A414-E95C-4B25-8BC3-49245CEEFA0F}&notoc=1

In the event that a single demand response resource is too small to qualify for direct participation in an ISO/RTO DR market opportunity, aggregation may be allowed. Column six of Table A-1 indicates whether or not aggregation is allowed by the DR program named in the third column of the corresponding row of the table. Most of the DR programs listed in Table A-1 allow aggregation of resources. This a common practice at ISOs, such as AESO, ISONE, and at ERCOT.

4.3 Consistency and Uniformity of Programs across the ISO/RTOs

The ISO/RTO Council, comprised of ten ISOs and RTOs, has initiated efforts to bring some uniformity and consistency across various wholesale DR program and market opportunities. By and large there is currently a lack of consistency and uniformity in DR programs and their attributes across the industry. Despite differences among the ISO/RTOs, some similarities in requirements can be observed from Table A-1, which summarizes requirements for primarily Demand Response programs at different ISO/RTOs. For example, telemetry and minimum size requirements within the same ISO/RTO are similar for different types of distributed resources that are eligible to provide the same product. With some exceptions, the minimum size and telemetry requirements specified by an ISO/RTO for a particular product generally applies to all resource types. Tables 4-1 and 4-2 summarize these requirements for distributed resources eligible to provide the product (specified in the table row) at the ISO/RTO (identified in the table column). Where the telemetry and/or minimum size requirements in the same ISO/RTO for the same market product are different for different distributed resource types, the dominant telemetry and minimum size requirements are stated, plus any exceptions are noted in the table.

In each cell of Table 4-1, the minimum MW size requirement for the provision of the market product at the ISO/RTO is indicated first. If no qualifier follows, then this requirement applies to all resource types providing the market product at the ISO/RTO. A lack of a qualifier also means aggregation of smaller size resources is not allowed to achieve the minimum size requirement. In contrast, the entry “can aggregate” indicates that smaller size distributed resources may be aggregated to achieve the minimum size requirement. In cases where either the minimum MW size or the aggregation provisions do not apply to all resource types, the exceptions are explicitly noted in the table. For example MISO allows aggregation only for DRR Type I resources (i.e., resources operating in On/Off state), but not for other types of resources. As another example, CAISO permits minimum size of 0.1 MW for distributed resources providing demand response, but not for renewable resources. Rather, renewable resources having signed up in the CAISO Participating Intermittent Resource Program (PIRP) must be no less than 10 MW in size.

Table 4-1
Minimum MW Size Requirement for Provision of Different Market Products by Distributed Resources (as of Spring 2009)

Product	ISO-NE	NYISO	PJM	MISO	ERCOT	CAISO	IESO	AESO	SPP
Regulation			1 MW	1 MW	1 MW (portfolio biding allowed)				
10 Minute Spin	0.1 MW, can aggregate	1 MW	0.1 MW, can aggregate	1 MW	1 MW (portfolio biding allowed)		1 MW		
10 Minute Non-Spin	0.1 MW, can aggregate	1 MW		1 MW, can aggregate DRR Type I	1 MW (portfolio biding allowed)	0.1 MW , can aggregate [Exception: 10 MW for PIRP]	1 MW	5 MW, can aggregate	
30 Minute Reserve	0.1 MW, can aggregate	1 MW	0.1 MW, can aggregate				1 MW	5 MW, can aggregate	
RT Energy	0.1 MW, can aggregate	0.1 MW, can aggregate	0.1 MW, can aggregate	1 MW, can aggregate DRR Type I (Exception; 0.1 MW for EDR and LMR)	1 MW (portfolio biding allowed)	0.1 MW, can aggregate [Exception: 10 MW for PIRP]	1 MW (aggregation not allowed, except for Emergency Load Reduction Program)	N/A	1 MW, can aggregate
DA Energy	0.1 MW, can aggregate	1 MW can aggregate	0.1 MW, can aggregate	1 MW					
RUC (RAC)				1 MW, can aggregate DRR Type I					

Table 4-1 (continued)
Minimum MW Size Requirement for Provision of Different Market Products by Distributed Resources (as of Spring 2009)

Product	ISO-NE	NYISO	PJM	MISO	ERCOT	CAISO	IESO	AESO	SPP
Capacity Market	0.1 MW, can aggregate	0.1 MW, can aggregate	0.1 MW, can aggregate	0.1 MW, can aggregate		Resource Adequacy: 0.1 MW, can aggregate [Exception: 10 MW for PIRP]			

Notes:
Blank = the particular ISO (in the column) does not currently offer an opportunity for Distributed Resources to participate in the Market Product (in the row).
N/A = there is no specific minimum size requirement stated in the current protocols of the ISO/RTO (in the column) for the provision of the product (in the row).
“Aggregation allowed" = the minimum size for providing the market product can be met by a collection of smaller resources.
DRR Type I (Demand Response Resource Type I) = On/OFF Demand Response Resource (block-type)
DRR Type II (Demand Response Resource Type II) = Controllable Demand Response Resource (e.g., controllable load and behind the meter generation).
EDR = Emergency Demand Response
LMR = Load Modifying Resource
PIRP = Participating Intermittent Resources Program

Table 4-2 summarizes the telemetry and communication requirements for the provision of market products at each ISO/RTO. Each table cell indicates the telemetry time resolution and communication protocol required. Any exceptions are also indicated. Where no specific telemetry requirements for the provision of the product (in the row) is stated by the ISO/RTO (in the column), this is indicated by an “N/A” entry in the cell.

Table 4-2
Telemetry and Communication Requirement for Provision of Different Market Products by Distributed Resources (as of Spring 2009)

Product	ISO-NE	NYISO	PJM	MISO	ERCOT	CAISO	IESO	AESO	SPP
Regulation			2 to 4-second resolution (ICCP)	4- second resolution (ICCP)	2-seconds (DNP 3)				
10 Minute Spin	5 minutes (Internal IBCS Protocol)	6- second resolution (ICCP)	N/A	4- second resolution (ICCP)	2-seconds (DNP 3)		2-second (SCADA)		
10 Minute Non-Spin	5 minutes (Internal IBCS Protocol)	6- second resolution (ICCP)		4- second resolution (ICCP) (Exception: For DRR Type I after-the fact metering with 1 min. resolution suffices)	2-seconds (DNP 3)	1-min from Resource to eDAC; 4 seconds eDAC to CAISO [Exception: PIRP]	2-second (SCADA)	4- second resolution (ICCP)	
30 Minute Reserve	5 minutes (Internal IBCS Protocol)	6- second resolution (ICCP)	N/A				2-second (SCADA)	4- second resolution (ICCP)	
RT Energy	5 minutes (Internal IBCS Protocol)	N/A (Except for RT energy dispatched from AS Capacity)	N/A	4- second resolution (ICCP) (Exception: For DRR Type I after-the fact metering with 1 min. resolution suffices)	4- second resolution (ICCP) (Exception: For DRR Type I after-the fact metering with 1 min. resolution suffices)	N/A (Except for Energy from Non-Spin)	2- second resolution (Exception: No telemetry required for Emergency Load Reduction Program)	4- second resolution (ICCP)	4- second resolution (ICCP)

Table 4-2 (continued)
Telemetry and Communication Requirement for Provision of Different Market Products by Distributed Resources (as of Spring 2009)

Product	ISO-NE	NYISO	PJM	MISO	ERCOT	CAISO	IESO	AESO	SPP
DA Energy	N/A	N/A	N/A	N/A					
RUC (RAC)				N/A					
Capacity Market	N/A	N/A	N/A	N/A		N/A			

Notes:
Blank =t the particular ISO/RTO (in the column) does not currently offer an opportunity for distributed resources to participate in the Market Product (in the row).
N/A = there are no specific telemetry requirements for the provision of the product at the corresponding ISO/RTO.
IBCS = Internet-Based Communication System
ICCP = Inter-Control Center Protocol
DNP 3 = A specific communication protocol (standard) used in the electric power industry
eDAC = Data concentrator used by the CAISO for data acquisition and integration of distributed resources
SCADA = Supervisory Control and Data Acquisition
PIRP = Participating Intermittent Resources Program
DRR Type I (Demand Response Resource Type I) = On/OFF Demand Response Resource (block-type)

A
SUMMARY OF ISO/RTO DISTRIBUTED RESOURCE PROGRAMS

The following table adapted from a published IRC matrix[2] shows a summary of demand response programs currently implemented at ISO/RTOs, along with minimum MW size and communication requirements per program. The second column in the table lists ISO/RTO programs accommodating distributed resource participation, while the third column identifies the product type provided by the resource participating in the named program. Programs are grouped by ISO/RTO, with the ISO/RTOs ordered alphabetically. The fifth column of the table indicates whether aggregation of distributed resources is allowed to meet the minimum MW size requirement. Telemetry and communication requirements are noted in the sixth and seventh columns as applicable to the identified program.

[2] North American Wholesale Electricity Demand Response Program Comparison", ISO/RTO Council: March 2009. Available at: http://www.isorto.org/site/apps/nlnet/content2.aspx?c=jhKQIZPBImE&b=2613997&content_id={2857A414-E95C-4B25-8BC3-49245CEEFA0F}&notoc=1

Table A-1
Summary of Demand Response Programs at ISO/RTOs and Minimum MW Size and Communication Requirements (as of Spring 2009)

ISO/RTO	Program Name	Product Type	Minimum Resource Size	Resource Aggregation Allowed?	Frequency of Telemetry Reporting	Communication Protocol	Comments
AESO	Demand Opportunity Service (DOS)	RT Energy	None	Yes	4 Seconds (or on threshold crossing)	ICCP	Real-Time Energy
	Frequency Load Shed Service (FLSS)	Regulation	None	Yes	4 Seconds (or on threshold crossing)	ICCP	
	Supplemental Operating Reserves (SUP)	Reserve	5 MW	Yes	4 Seconds (or on threshold crossing)	ICCP	
	Voluntary Load Curtailment Program (VLCP)	RT Energy	None	Yes	4 Seconds (or on threshold crossing)	ICCP	Real-Time Energy
CAISO	Participating Load Program (PLP)	RT Energy	100 kW	Yes	N/A	N/A	Real-Time Energy from Reserve Capacity
	Participating Load Program (PLP)	Reserve	100 kW	Yes	1 Minute (resource to eDAC; 4-Second eDAC to CAISO)	DNP3 or ICCP	
	Participating Load Program (PLP)	Capacity	100 kW	Yes	N/A	N/A	Qualified for Resource Adequacy
	Participating Intermittent Resources (PIRP)	Capacity	10 MW for PIRP	Yes	10 Minute (resource to DPG; 4 Second DPG to CAISO)	DNP3 or ICCP	Qualified for Resource Adequacy
	Participating Intermittent Resources (PIRP)	RT Energy	10 MW for PIRP	Yes	10 Minute (resource to DPG; 4 Second DPG to CAISO)	DNP3 or ICCP	Real-Time Energy from PIRP, Imbalances netted on a monthly basis

Table A-1 (continued)
Summary of Demand Response Programs at ISO/RTOs and Minimum MW Size and Communication Requirements (as of Spring 2009)

ISO/RTO	Program Name	Product Type	Minimum Resource Size	Resource Aggregation Allowed?	Frequency of Telemetry Reporting	Communication Protocol	Comments
ERCOT	Emergency Interruptible Load Service (EILS)	Capacity	1 MW [Bid Size]	Yes	N/A	N/A	
	Loads Acting as a Resource providing Responsive Reserve Service -- Under Frequency Relay Type (LaaR/RRS/UFR)	Reserve	1 MW [Bid Size]	Portfolio-Based Bidding	2 Seconds	DNP3	
	Loads Acting as a Resource providing Responsive Reserve Service -- Controllable Load Resource Type (LaaR/RRS/CLR)	Reserve	1 MW [Bid Size]	Portfolio-Based Bidding	2 Seconds	DNP3	
	Loads Acting as a Resource providing Non-Spinning Reserve Service (LaaR/NSRS)	Reserve	1 MW [Bid Size]	Portfolio-Based Bidding	2 Seconds	DNP3	
	Controllable Load Resources providing Regulation Service (CLR)	Regulation	1 MW [Bid Size]	Portfolio-Based Bidding	2 Seconds	DNP3	
	Balancing Up Loads (BUL)	RT Energy	1 MW [Bid Size]	Portfolio-Based Bidding			
IESO	Emergency Load Reduction Program (ELRP)	RT Energy	1 MW	Yes	N/A	N/A	Real-Time Energy
	Emergency Demand Response Program (EDRP)	RT Energy	1 MW	No	2 Seconds	SCADA	Real-Time Energy
	Dispatchable Load (DL)	RT Energy	1 MW	No	2 Seconds	SCADA	Real-Time Energy
	Dispatchable Load (30 minute reserve) (DL)	30-minute Reserve	1 MW	No	2 Seconds	SCADA	

Table A-1 (continued)
Summary of Demand Response Programs at ISO/RTOs and Minimum MW Size and Communication Requirements (as of Spring 2009)

ISO/RTO	Program Name	Product Type	Minimum Resource Size	Resource Aggregation Allowed?	Frequency of Telemetry Reporting	Communication Protocol	Comments
IESO (continued)	Dispatchable Load (10 Spinning / 10 Non-Spinning Component) (DL)	10-minute Spin/Non-Spin Reserve	1 MW	No	2 Seconds	SCADA	
ISONE	Real-Time Demand Response Program (RTDRP) [Capacity Component]	Capacity	100 kW	Yes	5 Minutes	Internet (IBCS Protocol)	
	Real-Time Demand Response Program (RTDRP) [Energy Component]	RT Energy	100 kW	Yes	5 Minutes	Internet (IBCS Protocol)	Real-Time Energy
	Day Ahead Load Response Program for RTDRP (DALRP for RTDRP)	DA Energy	100 kW	Yes	N/A	N/A	Day-Ahead Energy
	Day Ahead Load Response Program for RTPR (DALRP for RTDRP)	DA Energy	100 kW	Yes	N/A	N/A	Day-Ahead Energy
	Demand Response Reserves Pilot (DRR)	Reserve	100 kW	Yes	5 Minutes	Internet (IBCS Protocol)	
	Real-Time Price Response Program (RTPR)	RT Energy	100 kW	Yes	N/A	N/A	Real-Time Energy
	Real-Time Demand Response Resource (RTDR)	Capacity	100 kW	Yes	5 Minutes	Internet (IBCS Protocol)	
	FCM: On-Peak, Seasonal Peak Resources (OP and SP)	Capacity	100 kW	Yes	N/A	N/A	
	Real-Time Emergency Generation Resource (RTEG)	Capacity	100 kW	Yes	5 Minutes	Internet (IBCS Protocol)	
MISO	Emergency Demand Response (EDR)	RT Energy	100 kW	Yes	N/A	N/A	Real-Time Energy

Table A-1 (continued)
Summary of Demand Response Programs at ISO/RTOs and Minimum MW Size and Communication Requirements (as of Spring 2009)

ISO/RTO	Program Name	Product Type	Minimum Resource Size	Resource Aggregation Allowed?	Frequency of Telemetry Reporting	Communication Protocol	Comments
MISO (continued)	Demand Response Resource Type I (DRR-I)	RT Energy	1 MW	Yes	N/A	N/A	After-the-fact metering with 1 minute resolution
	Demand Response Resource Type I (DRR-I)	Commitment (RAC Make-whole Payment)	1 MW	Yes	N/A		Paid for performance based on after-the-fact metering with 1-minute resolution
	Demand Response Resource Type I (DRR-I)	Supplemental Reserve	1 MW	Yes	N/A	N/A	Paid for performance based on after-the-fact metering with 1-minute resolution
	Demand Response Resource Type II (DRR-II)	DA/RT Energy	1 MW	No	4 Seconds	ICCP	
	Demand Response Resource Type II (DRR-II)	Commitment (RAC Make-whole Payment)	1 MW	No	4 Seconds	ICCP	
	Demand Response Resource Type II (DRR-II)	Spinning Reserve	1 MW	No	4 Seconds	ICCP	
	Demand Response Resource Type II (DRR-II)	Supplemental Reserve	1 MW	No	4 Seconds	ICCP	
	Demand Response Resource Type II (DRR-II)	Regulation	1 MW	No	4 Seconds	ICCP	

Table A-1 (continued)
Summary of Demand Response Programs at ISO/RTOs and Minimum MW Size and Communication Requirements (as of Spring 2009)

ISO/RTO	Program Name	Product Type	Minimum Resource Size	Resource Aggregation Allowed?	Frequency of Telemetry Reporting	Communication Protocol	Comments
MISO (continued)	Stored Energy Resource (SER)	Regulation	1 MW	No	4 Seconds	ICCP	
	Load Modifying Resource (LMR)	Capacity	100 kW	Yes	N/A	N/A	
NYISO	Day Ahead Demand Response Program (DADRP)	DA Energy	1 MW	Yes	N/A	N/A	Day-Ahead Energy
	Demand Side Ancillary Services Program (DSASP)	Spinning Reserve	1 MW	No	6 Seconds	ICCP	
	Demand Side Ancillary Services Program (DSASP)	Supplemental Reserve	1 MW	No	6 Seconds	ICCP	
	Demand Side Ancillary Services Program (DSASP)	Regulation	1 MW	No	6 Seconds	ICCP	
	Emergency Demand Response Program (EDRP)	RT Energy	100 kW (per Zone)	Yes	N/A	N/A	Real-Time Energy
	Installed Capacity Special Case Resources (Energy Component) (SCR)	RT Energy	100 kW (per Zone)	Yes	N/A	N/A	Real-Time Energy
	Installed Capacity Special Case Resources (Capacity Component) (SCR)	Capacity	100 kW (per Zone)	Yes	N/A	N/A	
PJM	Economic Load Response	DA/RT Energy	100 kW	Yes	N/A	N/A	
	Economic Load Response	Synchronized Reserve	1 MW [0.5 MW proposed]	Yes	N/A	N/A	
	Economic Load Response	Non-spinning Reserve	1 MW [0.5 MW proposed]	Yes	N/A	N/A	

Table A-1 (continued)
Summary of Demand Response Programs at ISO/RTOs and Minimum MW Size and Communication Requirements (as of Spring 2009)

ISO/RTO	Program Name	Product Type	Minimum Resource Size	Resource Aggregation Allowed?	Frequency of Telemetry Reporting	Communication Protocol	Comments
PJM (continued)	Economic Load Response, PHEV, Limited Energy Storage	Regulation	1 MW	No	2-4 Seconds	ICCP	
	Emergency Load Response - Energy Only	RT Energy	100 kW	Yes	N/A	N/A	Real-Time Energy
	Full Emergency Load Response (Capacity Component)	Capacity	100 kW	Yes	N/A	N/A	
	Full Emergency Load Response (Energy Component)	RT Energy	100 kW	Yes	N/A	N/A	Real-Time Energy
SPP	Variable Dispatch Demand Response (VDDR)	RT Energy	1 MW	Aggregation to a single withdrawal point from the Transmission Grid permitted	4 Seconds	ICCP	Real-Time Energy
	Block Dispatch Demand Response (BDDR)	RT Energy	1 MW	Aggregation to a single withdrawal point from the Transmission Grid permitted	4 Seconds	ICCP	Real-Time Energy

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