

A Guide to Inform Institutions about Participation in PJM's Demand Response Programs

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May 2013

Masters Project submitted in partial fulfillment of the requirements for the Master of Environmental Management degree in the Nicholas School of the Environment of Duke University

2013

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Abstract

Increasing reliability concerns over the last decade have led stakeholders within the Energy Industry to place a great deal of attention on the management of electricity load. Traditionally, consumers have been shielded from the price signals that indicated high stress on the electricity grid, but through a process known as Demand Response (DR), customers are now being offered incentives to actively manage their load for increased reliability. Attention on DR has grown with its profusion into electricity markets; at both the wholesale and retail levels. Focusing on institutional customers and DR programs within the PJM wholesale electricity market, this study provides a comprehensive resource to answer questions associated with (1) the regulatory structure of PJM's markets for DR and (2) the possible benefits that can result from market participation. As a first step in addressing these objectives, this report first provides an analysis of the current publically available information, and establishes that there is no single resource that provides sufficient information to resolve all the questions an institution may have. This report then offers clear and concise content by which institutional customers can assess the framework of PJM's DR programs. Further, a tool for estimating the potential revenue available from participation in the capacity auction was created to help institutions understand the profitability of engaging in the capacity market. Finally, this report concludes that while participation in PJM's demand response programs is a complicated undertaking, there are a wide variety of options available to meet the unique needs of individual customers, as well as significant financial incentives.

Acronyms

Acronym:	Definition:
BRA	Base Residual Auction
CSP	Curtailed Service Provider
DASR	Day-Ahead Scheduling Reserve
DR	Demand Response
EDC	Electricity Distribution Company
FERC	Federal Energy Regulatory Commission
FRR	Fixed Resource Requirement
FTR	Financial Transmission Rights
ISOs/RTOs	Independent System Operators
LMP	Locational Marginal Price
LSE	Load Serving Entity
OATT	Open Access Transmission Tariff
PJM	PJM Interconnection LLC
PLC	Peak Load contribution
REG	Regulation
RPM	Reliability Pricing Model
RTO	Regional Transmission Organizations
SR	Synchronized Reserve

Key Terms

Term:	Definition:
Behind the Meter Generation	“A generating unit that delivers energy to load without using the Transmission System or any distribution facilities unless the entity that owns or leases the distribution facilities consented to such use of the distribution facilities and such consent has been demonstrated to the satisfaction of the Office of Interconnection. <i>Behind the Meter Generation</i> may not include at any time any portion of a generating unit’s capacity that is designated as a Capacity Resource or any portion of the output of a generating unit that is sold to another entity for consumption at another electrical location or into the PJM Interchange Energy Market at any time.” ¹
Bilateral Agreement	“An agreement between two entities (one or both being PJM Members) for the sale and delivery of a service.” ²
Bilateral Market	“Provides LSEs the opportunity to hedge the Locational Reliability Charge determined through the BRA and Second Incremental Auction. The <i>Bilateral Market</i> also provides resource providers an opportunity to cover any auction commitment shortages.” ³
Capacity Resource	“Includes megawatts of net capacity from existing or planned generation capacity resources or load reduction capability provided by Demand Resources or ILR in the PJM Region.” ⁴
Curtailment Service Provider (CSP)	“Member or Special Member, whose action on behalf of itself or one or more other Members or non-members, participates in the PJM Interchange Market by causing a reduction in demand.” ⁵
Daily Unforced Capacity Obligation	“The capacity obligation of a Load Serving Entity during the Delivery Year.” ⁶
Delivery Year (DY)	“Planning period for which resources are being committed and for which a constant load obligation for the entire PJM region exists. For example, the 2007/2008 <i>Delivery Year</i> corresponds to the June 1, 2007 – May 31, 2008 Planning Period.” ⁷
Electric Distribution Company (EDC)	“PJM Member that owns or leases with rights equivalent to ownership electric distribution facilities that are used to provide electric distribution service to electric load within the PJM Control Area.” ⁸
eMKT	“Allows PJM members to submit information and obtain data needed to conduct business in the Day-Ahead, Regulation and Synchronized Reserve markets.” ⁹
Locational Marginal Price (LMP)	“The hourly integrated market clearing marginal price for energy at the location the energy is delivered or received.” ¹⁰

¹ PJM Manual 35: *Definitions and Acronyms*. Revision: 19, Effective Date: June 24, 2011. Section 2, Page 11.

² PJM Manual 35: *Definitions and Acronyms*. Revision: 19, Effective Date: June 24, 2011. Section 2, Page 11.

³ PJM Manual 35: *Definitions and Acronyms*. Revision: 19, Effective Date: June 24, 2011. Section 2, Page 11.

⁴ PJM Manual 35: *Definitions and Acronyms*. Revision: 19, Effective Date: June 24, 2011. Section 2, Page 14.

⁵ PJM Manual 35: *Definitions and Acronyms*. Revision: 19, Effective Date: June 24, 2011. Section 2, Page 18.

⁶ PJM OATT, Attachment DD: *Reliability Pricing Model*, Effective Date: 9/17/2010. Section 2.18: *Daily Unforced Capacity Obligation*, Page 2416.

⁷ PJM Manual 35: *Definitions and Acronyms*. Revision: 19, Effective Date: June 24, 2011. Section 2, Page 20.

⁸ PJM Manual 35: *Definitions and Acronyms*. Revision: 19, Effective Date: June 24, 2011. Section 2, Page 25.

⁹ PJM website: *eMKT*. Source: <http://www.pjm.com/markets-and-operations/etools/emkt.aspx>

¹⁰ PJM Manual 35: *Definitions and Acronyms*. Revision: 19, Effective Date: June 24, 2011. Section 2, Page 45.

Open Access Transmission Tariff (OATT)	“The PJM <i>Open Access Transmission Tariff</i> on file with the Federal Energy Regulatory Commission, as it may be amended from time to time.” ¹¹
Peak Load Contribution (PLC)	“A customer’s contribution to a zone’s normalized summer peak load, as estimated by the zone’s Electric Distribution Company. Used in determining a Load Serving Entity’s obligation Peak Load.” ¹²
PJM Operating Agreement	“Governs how PJM operates. Members sign this agreement to be a part of PJM.” ¹³

¹¹PJM Manual 35: *Definitions and Acronyms*. Revision: 19, Effective Date: June 24, 2011. Section 2, Page 77.

¹²PJM Manual 35: *Definitions and Acronyms*. Revision: 19, Effective Date: June 24, 2011. Section 2, Page 58.

¹³PJM website: *Agreements / Governing Documents*. Source: <http://pjm.com/documents/agreements.aspx>

1 Introduction

Demand Response is the act of managing electricity load such that electricity consumers can change usual demand patterns in response to the price of electricity or when the electric grid system is in an emergency.¹⁴ This ability to reduce demand during times of high-stress is likely to have important environmental and economic benefits because it reduces the need to build new power generation infrastructure and/or transmission lines that can be costly, and it may also reduce the need to dispatch expensive and polluting electric power generators. Historically only a few of the largest commercial and industrial customers were contracted by their utilities to participate, but recent technological advancements such as the proliferation of advanced meter infrastructure, and changes in regulatory policy at the federal, state, and market levels has substantially improved the ability of all consumer classes to actively manage their load. One such group of customers is institutions such as colleges and universities which have high levels of demand, but are also typically progressive in their stance on environmental issues.

With more customers enabled to participate, and increased integration at both the wholesale and retail levels, Demand Response (DR) has received a great deal of attention in recent years. This attention has been beneficial in that more research, time, and effort is being spent on DR, yet it has also led to an overwhelming amount of written material that is unorganized and difficult to understand for those unfamiliar with the subject. Thus, this study aims to provide institutional customers located within the PJM Interconnection's (PJM) territory a comprehensive resource to answer important questions for institutions associated with (1) the regulatory structure of PJM's markets for DR and (2) the possible benefits that can result from market participation. The end goal is to offer a stand-alone document that empowers institutional customers with the information of how DR programs operate within PJM and a decision support tool that enables them to assess the benefits of such undertakings.

The content contained in the subsequent sections follows this two-pronged purpose of this study. In Section 2 there is a discussion of the State of Research, including a broad review and consolidation of the material currently available to institutions regarding DR. Section 3 articulates the methods and research used to fulfill the aforementioned purposes of this report. Section 4 explains the framework for understanding the regulatory structure of PJM's DR programs by starting with an overview of electricity markets and eventually outlining the way DR operates within the markets overall governance structure. Section 5 delves into the decision support tool, including a description of PJM's capacity market, a discussion of market-clearing prices, and scenario analysis of the revenue potential from participation. Finally, Section 6 offers general conclusions found while producing this study, as well as identifies further research that could be done to augment the information presented.

2 State of Research

2.1 Introduction

In the last decade, stakeholders within the Energy Industry have placed a great deal of attention on DR. This attention has grown proportionally with DR's integration into electricity markets; at both the wholesale and retail levels. Currently, there are many entities studying, analyzing, and researching DR in an effort to answer varying questions relating to profitability, reliability, and applicability. These entities range from industry participants such as market governing agencies, to national laboratories and consultants. Thus, the purpose of this section is to review the material that is currently available to institutional customers within PJM's territory, as well as to examine flow of this information.

¹⁴ FERC website: *Reports on Demand Response & Advanced Metering*. Source: <http://www.ferc.gov/industries/electric/indus-act/demand-response/dem-res-adv-metering.asp>

2.2 Available Information

Information regarding DR is abundant and publically available from a variety of sources (this study reviewed forty-seven different resources). Focusing on the PJM Interconnection, those sources of information come from the following entities:

1. Market administrator:
 - Specifically, PJM's Manuals, Operating Agreement, Reliability Assurance Agreement, and OATT. These documents describe the regulatory structure of PJM's market and associated DR programs.
2. Market participants:
 - These are actively participating CSPs¹⁵. These entities release whitepapers and professional service information in an effort to disseminate information and garner market participation.
3. Industry consultants:
 - Consulting firms with Energy Industry cliental such as DNV KEMA Energy & Sustainability, The Brattle Group, Booz Allen Hamilton, and Deloitte offer reports on the industry related issues.
4. Third party research entities:
 - Entities such as the National Laboratories and the ISO/RTO Council that provide insightful information and analysis on the market for DR.
5. Other federal regulatory agencies:
 - Agencies such as the FERC, EPA, and DOE that provide reports on the status of the market as well as help to set market trends and enact policy.

While the information from these resources is valuable and pertinent to participating in PJM's DR programs, it can be overwhelming to institutional customers who are trying to understand the regulatory structure of the market and the potential benefits of participation in DR programs (Figure 1 offers a visual representation of the information stream and this study's purpose). This study aims to provide a single source that answers the questions associated with (1) understanding the regulatory structure of PJM's DR programs and (2) assessing the possible benefits that can result from market participation. Using currently available information from the aforementioned sources, the following sections of this study offer clear and concise content by which institutional DR resources can assess the framework of PJM's DR programs and begin to understand the profitability of such undertakings.

¹⁵List of active CSPs in PJM is available here: <http://pjm.com/markets-and-operations/demand-response/csps.aspx>

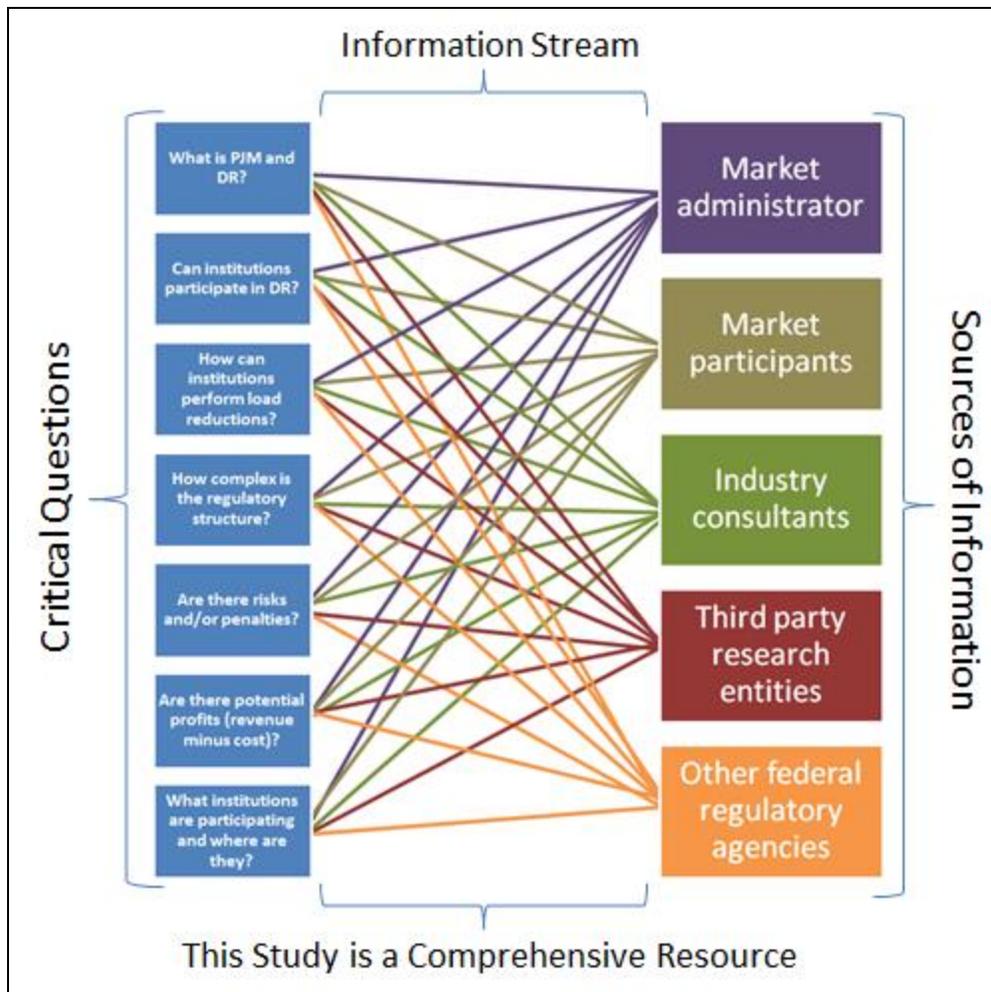


Figure 1: Visual Graphic of Information Stream and this Study's Purpose

3 Methods and Analysis

Upon assessing information available to institutions interested in participating in PJM's DR programs it is clear that while there are a variety of sources producing large quantities of material, this is often incomplete, dispersed, and difficult to grasp for those not familiar with the operations of a wholesale electricity markets. This guide is an effort to produce a comprehensive and easy to read resource for institutions to gain the relevant knowledge needed to become a demand resource in the PJM markets. To this end, two products were produced: (1) a framework of the regulatory structure of the PJM markets and (2) a decision support tool aimed at quantifying the revenue potential of participation in the PJM capacity market -one of the possible markets where DR resources can participate-.

Crafting the framework of the regulatory structure involved an extensive literature review of forty-seven documents to give institutional customers an understanding of DR, wholesale electricity markets, the PJM Interconnection, and the specific Economic and Emergency Load Response Programs. Once all the pertinent information was gathered, it was synthesized into a single-source document to provide an easily understandable outline of the most important material, complemented with bibliographic references for users in need of additional explanation. This synthesis of the regulatory framework is presented in Section 4 of this document.

The second product of this masters project; the decision support tool, involved an assessment of the methods and equations by which PJM establishes supply and demand in the capacity market, as well as how capacity payments are calculated. Further, an assessment of historical market-clearing prices was used to produce a forecast of prices in the demand year 2016 capacity auction. This data was then pulled together to create a *Revenue Calculator* that is capable of estimating the potential revenue any customer could earn from participation in the PJM capacity auction as a DR resource. Section 5 details the decision support tool.

4 Electricity Markets

4.1 Introduction

The purpose of this *Electricity Markets* section is to provide an overview of the regulatory structure of electricity markets, focusing on PJM and its programs for DR. In order to gain a comprehensive understanding of how DR functions within PJM, however, it is necessary to begin the assessment by addressing wholesale markets and finally drilling down into a discussion of the DR programs offered by PJM.

4.2 Wholesale Electricity Markets

In a similar fashion to the airline, trucking, telecommunication, and banking industries, deregulation (also referred to as restructuring) has introduced competition into the electricity industry through a series of legislative acts over the course of the last century.¹⁶ Although each of the acts approved over the course of history have played a contributing role to the current state of the electricity industry, many industry professionals agree that Orders 888 and 889 issued by the Federal Energy Regulatory Commission (FERC) set the foundation for creating competitive wholesale power markets.¹⁷ Prior to these FERC Orders, the electricity industry had been stymied by monopolies and wealthy holding companies. As authors Daniel Kirschen and Goran Strbac of *Fundamentals of Power System Economics* point out, “For most of the twentieth century, when consumers wanted to buy electrical energy, they had no choice. They had to buy it from the utility that held the monopoly for the supply of electricity in the area where these consumers were located.”¹⁸ Although some states still regulate traditionally vertically integrated utilities, there are presently multiple wholesale markets for electricity in which participants may be suppliers, consumers, and/or brokers, buy and sell electricity in a market exchange. Figure 2 offers a map of which states are active, suspended, and not active in restructuring their electricity markets.

¹⁶Electric Power Supply Association website: *Electricity Primer - The Basics of Power and Competitive Markets*, February 13, 2013. Source: <http://www.epsa.org/industry/primer/?fa=wholesaleMarket>

¹⁷Energy Information Administration: *The Changing Structure of the Electric Power Industry 2000: An Update*. October 2000. Section 7: *Wholesale Power Markets and Restructuring the U.S. Power Transmission System*, Page 61.

¹⁸Daniel Kirschen and Goran Strbac: *Fundamentals of Power System Economics*. 2004. Introduction: Section 1.1 *Why Competition*, Page 1.

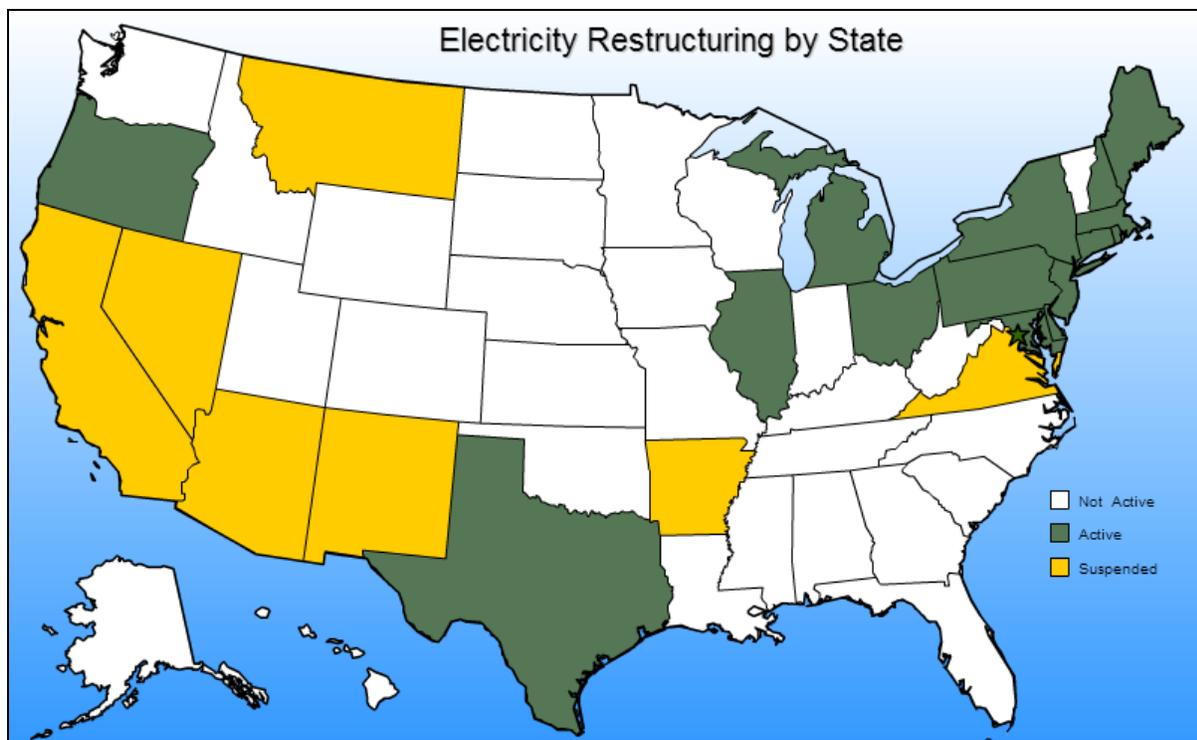


Figure 2: Map of Electricity Restructuring¹⁹

The introduction of competition in electricity markets; along with the continued support of the FERC has led to the formation of Independent System Operators and Regional Transmission Organizations (ISOs/RTOs).²⁰ More specifically, FERC issued Order 2000 in December 1999 calling for the voluntary creation of ISOs/RTOs throughout the United States.²¹ The establishment of ISOs/RTOs was to bolster the continued movement towards greater competition, while ensuring efficiency, reliability, and security within the industry. As shown by Figure 3, there are currently ten ISOs/RTOs serving two-thirds of electricity consumers in the North America²², six of which are regulated by the FERC.

¹⁹U.S. Energy Information Administration website: *Status of Electricity Restructuring by State*. Source: http://www.eia.gov/cneaf/electricity/page/restructuring/restructure_elect.html

²⁰U.S. Energy Information Administration: *The Changing Structure of the Electric Power Industry 2000: An Update*. October 2000. Section 7: *Wholesale Power Markets and Restructuring the U.S. Power Transmission System*, Page 62.

²¹Energy Information Administration: *The Changing Structure of the Electric Power Industry 2000: An Update*, October 2000. Section 7: *Wholesale Power Markets and Restructuring the U.S. Power Transmission System*, Page 67.

²²ISO/RTO website. *The ISO/RTO Council*. Source: <http://www.isorto.org/site/c.jhKQIZPBIImE/b.2603295/k.BEAD/Home.htm>

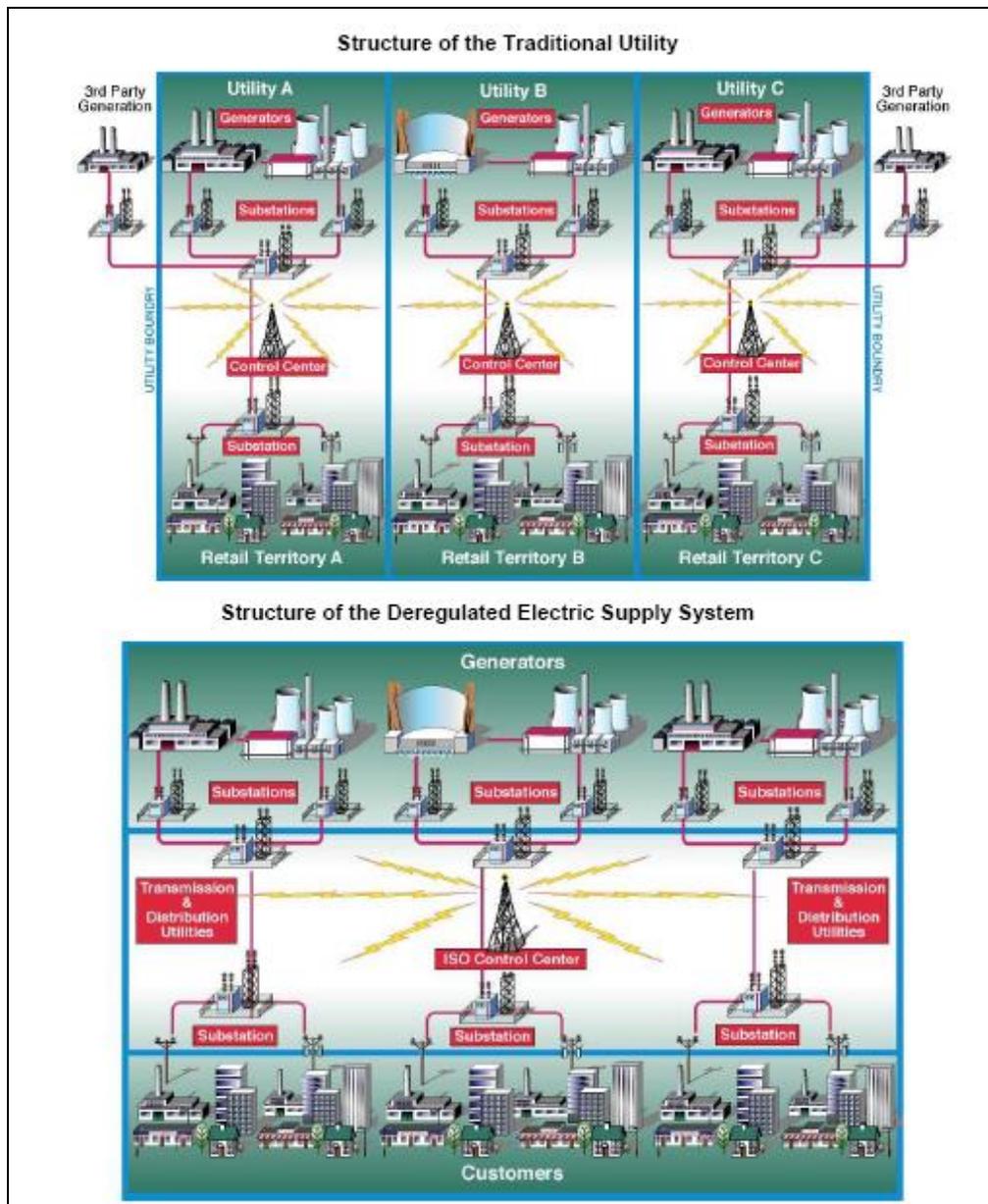


Figure 4: Regulated vs. Deregulated Electricity Industry Structure²⁵

This new framework has resulted in the creation of distinct Wholesale and Retail markets (see Figure 5). The market for the bulk sale of electricity, known as the Wholesale Market, encompasses generation and transmission of bulk electricity. On the other hand, the market for distribution and sale to end-use customers is known as the Retail Market. Both the Wholesale and Retail markets operate within the territory of the ISO/RTO.

²⁵U.S. Department of Energy: *A Primer on Electric Utilities, Deregulation, and Restructuring of U.S. Electricity Markets*, May 2002. Page 59. Source: <http://www1.eere.energy.gov/femp/pdfs/primer.pdf>

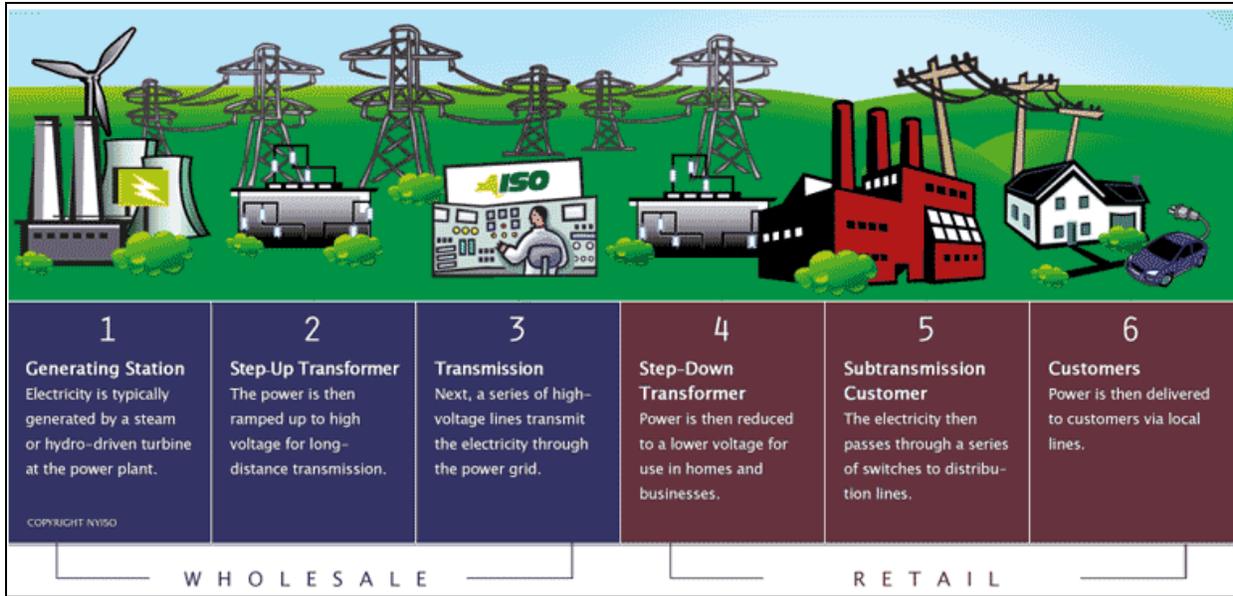


Figure 5: Wholesale vs. Retail Electricity Markets²⁶

4.3 Market Structures

Through the issuances of FERC Orders 888, 889 and 2000, ISOs/RTOs were created on a voluntary basis. As a result of this balkanized effort to create regional electricity markets, each ISO/RTO is unique in their policies, procedures, and market operations. The similarities and differences, as pointed out by FERC, are highlighted in Table 1.

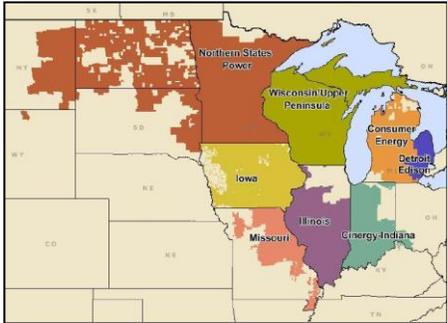
Table 1: Description of U.S. Based ISOs/RTOs

Name of ISO/RTO:	States Covered:	Market Options:
California (CAISO) 	California	“CAISO’s Energy Market is a three settlement (day-ahead, hour-ahead, and real-time) Spot Market that uses locational marginal pricing. Additionally there are programs for Ancillary services, and Financial Transmission Rights market.” ²⁷

²⁶NYISO website: *Wholesale vs. Retail Electricity*. Source:

http://www.nyiso.com/public/about_nyiso/understanding_the_markets/wholesale_retail/index.jsp

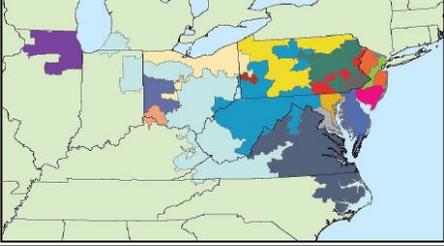
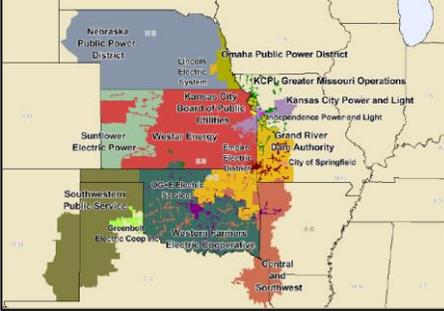
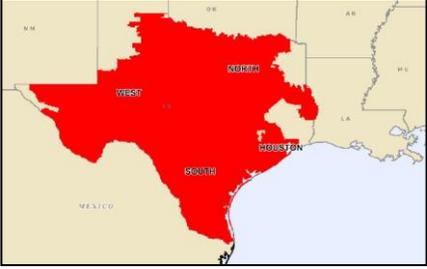
²⁷FERC website: *Electric Power Markets: National Overview*. Source: <http://ferc.gov/market-oversight/mkt-electric/overview.asp>

<p>Midwest (MISO)</p> 	<p>All or most of North Dakota, South Dakota, Nebraska, Minnesota, Iowa, Wisconsin, Illinois, Indiana, Michigan and parts of Montana, Missouri, Kentucky, and Ohio.</p>	<p>“MISO administers a two-settlement (day-ahead and real-time) Energy Market known as the Day-2 market. It produces hourly LMPs that are rolled up into 5 regional hub prices. MISO also administers a monthly Financial Transmission Rights allocation and auction. Moreover, Midwest bilateral trading is active on the Intercontinental Exchange at the Cinergy Hub and Northern Illinois Hub.”²⁸</p>
<p>New England (ISO-NE)</p> 	<p>Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont.</p>	<p>“Within ISO-NE the Energy Market is a two-settlement (day-ahead and real-time) spot market with locational marginal pricing (an internal hub, eight load zones and more than 500 nodes). There is a Capacity Market, Forward Reserves Market, Regulation Market, and Financial Transmission Rights market.”²⁹</p>
<p>New York (NYISO)</p> 	<p>New York</p>	<p>“NYISO’s Energy Market is a two-settlement (day-ahead and real-time) spot market with locational marginal pricing. There is a Regional and Locational Capacity Market, and Financial Transmission Rights market.”³⁰</p>
<p>PJM Interconnection LLC (PJM)</p>	<p>Delaware, District of Columbia, Maryland, New Jersey, Ohio, Pennsylvania,</p>	<p>“PJM’s Energy Market is a two-settlement (day-ahead and real-time) spot market with locational marginal pricing. There is a Capacity Market, Ancillary Services Markets, and Financial</p>

²⁸FERC website: *Electric Power Markets: National Overview*. Source: <http://ferc.gov/market-oversight/mkt-electric/overview.asp>

²⁹FERC website: *Electric Power Markets: National Overview*. Source: <http://ferc.gov/market-oversight/mkt-electric/overview.asp>

³⁰FERC website: *Electric Power Markets: National Overview*. Source: <http://ferc.gov/market-oversight/mkt-electric/overview.asp>

	<p>Virginia and West Virginia. Parts of Indiana, Illinois, Kentucky, Michigan, North Carolina and Tennessee.</p>	<p>Transmission Rights Market. Energy and capacity in the region are also traded bilaterally through brokers and the Intercontinental Exchange.”³¹</p>
<p>Southwest Power Pool (SPP)</p> 	<p>Kansas, Oklahoma, most of Nebraska, and parts of New Mexico, Texas, Louisiana, Missouri, Mississippi and Arkansas.</p>	<p>“SPP provides transmission service on the transmission facilities owned by its members and operates the region's real-time energy imbalance service market. Market participants trade physical electricity bilaterally, either directly or through brokers, and through the EIS market.”³²</p>
<p>Texas (ERCOT)</p> 	<p>Texas</p>	<p>“ERCOT schedules and centrally dispatches the grid within a single control area, ensures transmission reliability and wholesale open access, and manages financial settlement in the wholesale power market. It also administers the Texas competitive retail market, including customer switching. ERCOT operates wholesale markets for Balancing Energy, Ancillary service markets with zonal congestion management. Market participants trade electricity bilaterally directly, through brokers and through the Intercontinental Exchange. Physical products predominantly use the ERCOT hub pricing point, but physical and financial products priced at the four ERCOT zones are also traded.”³³</p>

According to the ISO/RTO Council, an industry organization consisting of representatives from the North American ISOs/RTOs, many of the benefits from organized wholesale electricity markets are derived from two key features of ISO/RTO operation: (1) Security-constrained economic dispatch in which all

³¹FERC website: *Electric Power Markets: National Overview*. Source: <http://ferc.gov/market-oversight/mkt-electric/overview.asp>

³²FERC website: *Electric Power Markets: National Overview*. Source: <http://ferc.gov/market-oversight/mkt-electric/overview.asp>

³³FERC website: *Electric Power Markets: National Overview*. Source: <http://ferc.gov/market-oversight/mkt-electric/overview.asp>

wholesale market participants can participate; and (2) An associated spot market in which these entities can buy and sell power, typically at locational marginal prices (LMPs). Security-constrained economic dispatch and open access to the spot market can provide substantial benefits by allowing market participants to procure generation in forward capacity markets or by buying power on the spot market to meet imbalances; this efficiency reduces cost and improves reliability.³⁴ The PJM Interconnection LLC is one of the six FERC regulated whole electricity markets and is the chosen market of interest for this report.

4.4 PJM Interconnection LLC

The formation of PJM Interconnection LLC (PJM) began in 1927, but the transition to becoming an RTO began in 1993 when the PJM Interconnection Association was formed to administer a power pool. By 2001 the organization became the nation's first fully functioning RTO (a timeline of PJM's history can be found in Appendix C).³⁵ As a non-for-profit entity, the responsibility of an RTO is to balance supply and demand while ensuring system reliability. PJM acts as the grid operator (the entity responsible for running the wholesale electricity market) for more than 51 million people in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia (as shown in Figure 6).³⁶

³⁴ISO/RTO Council: *2009 State of the Markets Report*. Page 6. Source:

<http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/2009%20IRC%20State%20of%20Markets%20Report.pdf>

³⁵ PJM website: *PJM History*. Source: <http://pjm.com/about-pjm/who-we-are/pjm-history.aspx>

³⁶ ISO/RTO Council: *2010 ISO/RTO Metrics Report*. Page 261. Source:

<http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/2010%20ISO-RTO%20Metrics%20Report.pdf>

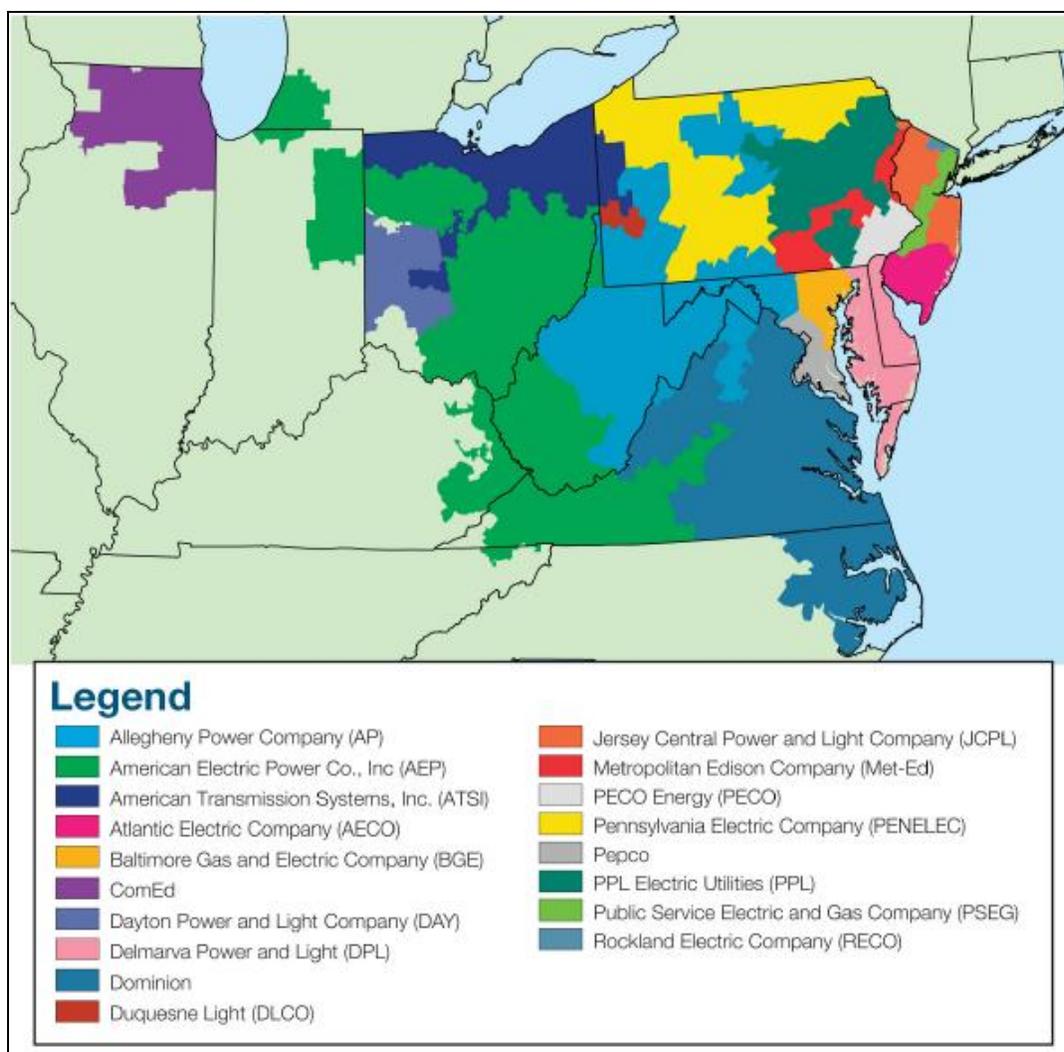


Figure 6: Map of PJM's Territory³⁷

PJM boasts several impressive statistics relating to Generating Capacity, Peak Demand, and Population Served that are the highest amongst all the competitive markets.³⁸ Table 2 offers a summary of those data points.

Table 2: PJM Statistics³⁹

Memberships	750
Generating Capacity	185,600 MW
Peak Demand	158,448 MW

³⁷ Monitoring Analytics, LLC: *State of the Market Report for PJM*. March 3, 2012, Page 2. Source: <http://pjm.com/documents/reports/state-of-market-reports/~media/documents/reports/state-of-market/2011/2011-som-pjm-volume1.ashx>

³⁸ ISO/RTO Council website: *IRC Members*. Source: <http://www.isorto.org/site/c,jhKQIZPBIImE/b.2604455/k.C323/Members.htm>

³⁹ PJM: *PJM 2011 Annual Report*. Page 29. Source: <http://pjm.com/~media/about-pjm/newsroom/annual-reports/2011-annual-report.ashx>

Miles of Transmission Lines	65,441
Gigawatt-hours or Annual Energy	778,000
Annual Billings	\$35.9 billion
Square Miles	214,000
Population Served	60 million

4.5 PJM’s Market Structure: An Overview

Presently, PJM’s electricity market structure consists of the following four segments: (1) Energy Market, (2) Capacity Market, (3) Ancillary Services Market, and (4) Financial Transmission Rights (FTR) Market. As shown in Figure 7, Bilateral Agreements, which constitute sales and deliveries of services, are conducted in both the Energy and Capacity Markets. What’s more, the programs for Demand Response (discussed in greater detail below) function through the structures of the Energy Market, Capacity Market, and Ancillary Services Market.

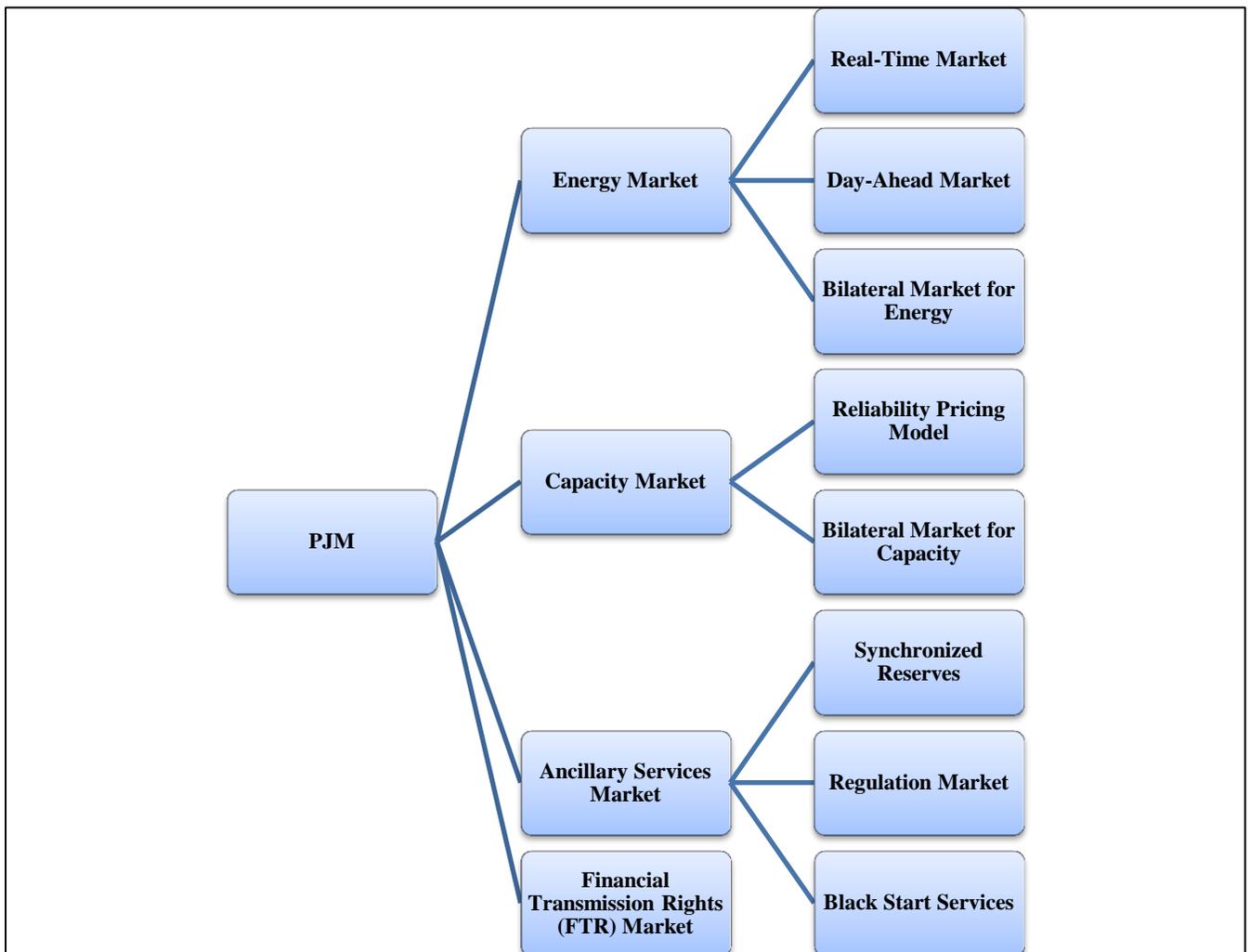


Figure 7: PJM Market Overview

4.5.1 PJM's Energy Market: An Overview

PJM's Energy Market is comprised of two markets (also referred to as settlement periods): the Day-Ahead Market and the Real-Time Market. According to PJM Manual 11: *Energy & Ancillary Services Market Operations*, "The Day-Ahead Market is a forward market in which hourly clearing prices are calculated for each hour of the next operating day. The balancing market is the Real-Time energy market in which the clearing prices are calculated every five minutes."⁴⁰ Electricity price calculations and settlements in both the Day-Ahead Market and the Real-Time Market are determined using Locational Marginal Prices (LMPs); the Day-Ahead Market uses Day-Ahead LMPs and the Real-Time Market uses Real-Time LMPs. Market participants within the Energy Market also have the option to procure Bilateral Agreements (Appendix A provides a graphical illustration of time timing and structure of PJM's Energy Market). Finally, demand response resources can participate in both the Day-Ahead Market and the Real-Time Market as each market has its own Economic Load Response Program (discussed in greater detail below).

4.5.2 PJM's Capacity Market: An Overview

The Capacity Market in PJM is more formally known as the Reliability Pricing Model (RPM). Initiated in 2007, the RPM is composed of a series of auctions, starting with the Base Residual Auction (BRA), that occur during a three year period before the actual delivery of electricity is performed. The RPM can also be referred to as a Forward Capacity Market (vernacular used across all ISOs/RTOs with capacity markets), because its purpose is to give long-term price signals to retain and attract investment in generation within PJM's region.⁴¹ As stated by PJM's Manual 18: *PJM Capacity Market*, "The goal of RPM is to align capacity pricing with system reliability requirements and to provide transparent information to all market participants far enough in advance for actionable response to the information."⁴²

The RPM consists of multiple auctions happening over the three year period before the participating entities are expected to deliver their committed capacity resources. For instance, the Base Residual Auction (BRA) for Delivery Year June 1, 2015 to May 31, 2016 was initiated in May of 2012. The design of the RPM is to ensure sufficient procurement of resources to satisfy PJM reliability criterion. It manages to accomplish this task through several sequential market mechanisms. The first is the BRA which helps to balance long-term supply and demand such that a market clearing house price for capacity commitments can be determined (see Figure 8 for a graphical representation of the BRA results for Delivery Year 2012/2013).

⁴⁰ PJM Manual 11: *Energy & Ancillary Services Market Operations*. Revision: 56, Effective Date: November 29, 2012. Section 2: *Overview of the PJM Energy Markets*, Page 16.

⁴¹ PJM website: *Reliability Pricing Model*. Source: <http://www.pjm.com/markets-and-operations/rpm.aspx>

⁴² PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 1: *Overview of the PJM Capacity Market*, Page 3.

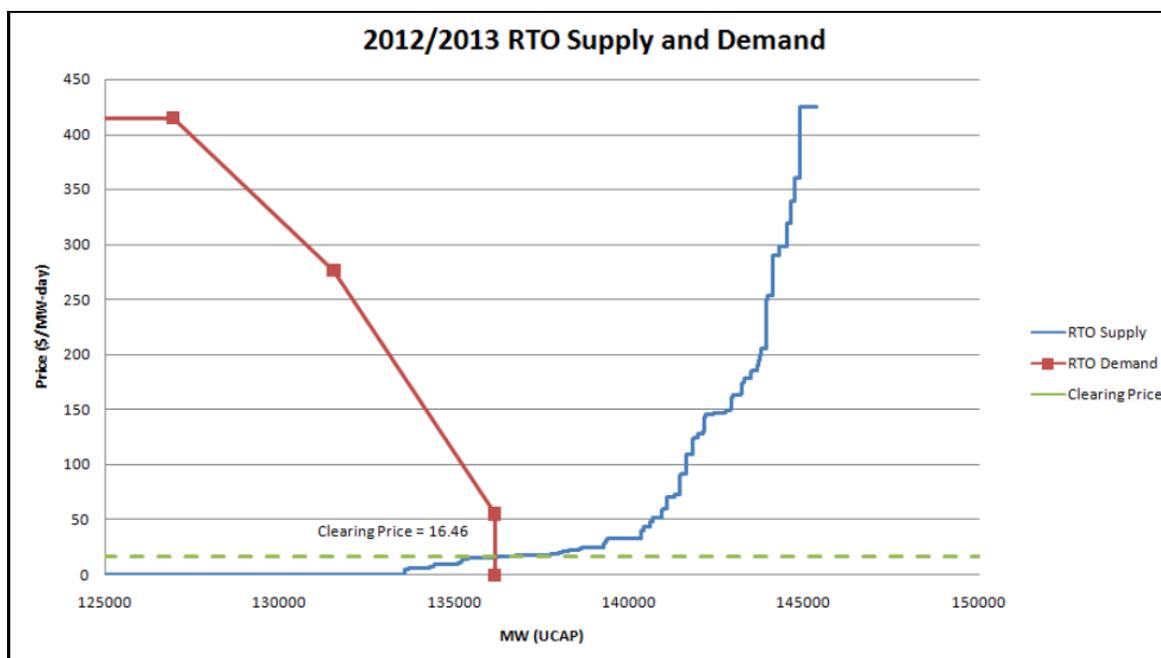


Figure 8: Graphical Illustration of BRA Results Delivery Year 2012/2013⁴³

After the BRA there are three Incremental Auctions to allow load-serving entities to secure additional capacity commitments needed to protect themselves from potential changes in market (Appendix B provides a graphical illustration of time timing and structure of PJM’s RPM). Additionally, the RPM allows for Bilateral Agreements to be made in the Bilateral Market, which provides load-serving entities an opportunity to sign contractual agreements for capacity commitments outside of the auction. Furthermore, the Bilateral Market affords load serving entities the opportunity to hedge against the resulting clearinghouse prices from the auctions.⁴⁴

4.5.3 PJM’s Ancillary Services Market: An Overview

PJM’s market for Ancillary Services is composed of three services: Synchronized Reserve, Regulation, and Black Start. These market services help to support the reliable operation of PJM’s transmission grid, and each is addressed individually in this section.

Synchronized Reserves are resources that provide power to the grid if there is an unexpected generation shortage or other short-term disruption in supply. Typically this service is provided by generators or loads that are already providing service to the grid and have the capability to ramp up/down quickly to help bring the grid back into balance.⁴⁵ The Market for Synchronized Reserves provides the mechanism for PJM participants to buy and sell available ancillary services. This market has two settlement periods: Real-Time and Day-Ahead Scheduling Reserves. PJM takes offers from both of these settlement periods together with energy offers and resource schedules to calculate hourly Synchronized Reserve Market

⁴³PJM website: *Reliability Pricing Model RPM Auctions*. 10/29/2012, Page 41. Source:

<http://www.pjm.com/~media/training/core-curriculum/ip-rpm/rpm-training-section-d-auctions.ashx>

⁴⁴ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 5.1: *Overview of RPM Auctions*, Page 77.

⁴⁵ PJM website: *Synchronized Reserve*. Source: <http://www.pjm.com/markets-and-operations/ancillary-services/synchronized-service.aspx>

Clearing Prices and Day-Ahead Scheduling Reserves Clearing Prices, which are used to determine how many reserves should be procured and how much they should be compensated.⁴⁶

Regulation service acts to provide the grid with greater stability by balancing the frequency at which generation meets load. Once again, this service is typically provided by generators or loads that are already providing service to the grid and can alter their frequency quickly.⁴⁷ In this respect the Market for Regulation provides participants with the mechanism by which they can submit buy and sell offers for regulation resources. In a similar fashion to the Synchronized Reserve, PJM uses the bid price and quantities, along with the energy offers and resource schedules, to calculate a Regulation Market Performance Clearing Price. This price is used to determine the extent of Regulation services needed and how those services will be rewarded.⁴⁸

Black Start services supply the grid with electricity in the unlikely event that the system fails and all power is lost. This service is provided by stand-by generators that can help restore the grid to normal operating conditions.⁴⁹ The Market for Black Start services provides the mechanism by which PJM members can submit bids to provide this service and PJM can dispatch available resources at the least cost.

4.5.4 PJM's Financial Transmission Rights (FTR) Market: An Overview

The purpose of the FTR Market is to aid market participants in evading price risk when delivering electricity to the grid. In essence, FTRs are available for those participants buying and selling electricity wanting to hedge against transmission costs. FTRs can provide market participants with a stream of revenue or charges based on the congestion on the grid. It is important to note that FTR market participants do not need to be buying or selling electricity.⁵⁰

4.6 Demand Response: An Industry Overview

From 2000 to 2008, demand for electricity in the United States grew an average of 0.9 percent per year (as shown by the graphical representation in Figure 9).⁵¹ Historically, utilities and grid operators have been able to meet this continual growth in electricity consumption by building more generation; essentially attacking the challenge from the supply side.

⁴⁶ PJM Manual 11: *Energy & Ancillary Services Market Operations*. Revision: 56, Effective Date: November 29, 2012. Section 4: *Overview of the PJM Synchronized Reserve Market*, Page 67.

⁴⁷ PJM website: *Market-Based Regulation*. Source: <http://www.pjm.com/markets-and-operations/ancillary-services/mkt-based-regulation.aspx>

⁴⁸ PJM Manual 11: *Energy & Ancillary Services Market Operations*. Revision: 56, Effective Date: November 29, 2012. Section 3: *Overview of the PJM Regulation Market*, Page 51.

⁴⁹ PJM website: *Black Start Service*. Source: <http://www.pjm.com/markets-and-operations/ancillary-services/black-start-service.aspx>

⁵⁰ PJM website: *Financial Transmission Rights*. Source: <http://pjm.com/markets-and-operations/fttr.aspx>

⁵¹ U.S. Energy Information Administration: *Annual Energy Outlook*. Page 1. Source: http://www.eia.gov/oiaf/aeo/pdf/trend_3.pdf

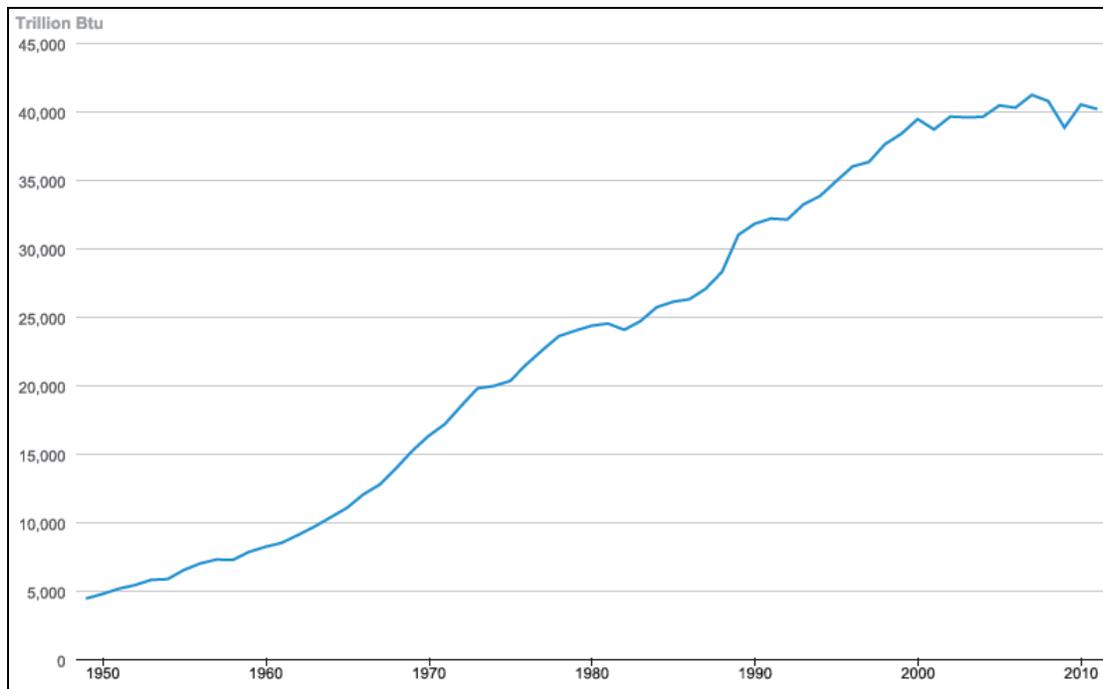


Figure 9: United States Consumption for Electricity Generation (1949-2010)⁵²

Demand Response (DR) offers an alternative method to resolve the continual growth in electricity consumption and moderate investment in new power generation units designed to meet peak loads. In economic terms, DR accomplishes this task by making the demand curve for electricity more elastic; essentially allowing consumers to become more sensitive to prices. As shown in Figure 10, in a market without DR the demand curve (D1) is inelastic, which results in a higher marginal price (P1) because the marginal cost of electricity between quantities Q2 and Q1 increases substantially due to limited supply. On the other hand, when DR is integrated into the market it makes the demand curve more elastic; enabling the demand curve shifts down to D2 as consumers react to high prices. Thus, when prices are at P1 and capacity (supply) is limited, DR can be dispatched to moderate the increase in price; shifting price down to P2.

⁵² U.S. Energy Information Administration: *Annual Energy Review, Table 8.4a Consumption for Electricity Generation by Energy Source: Total (All Sectors), 1949-2011*. Source: <http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0804a>

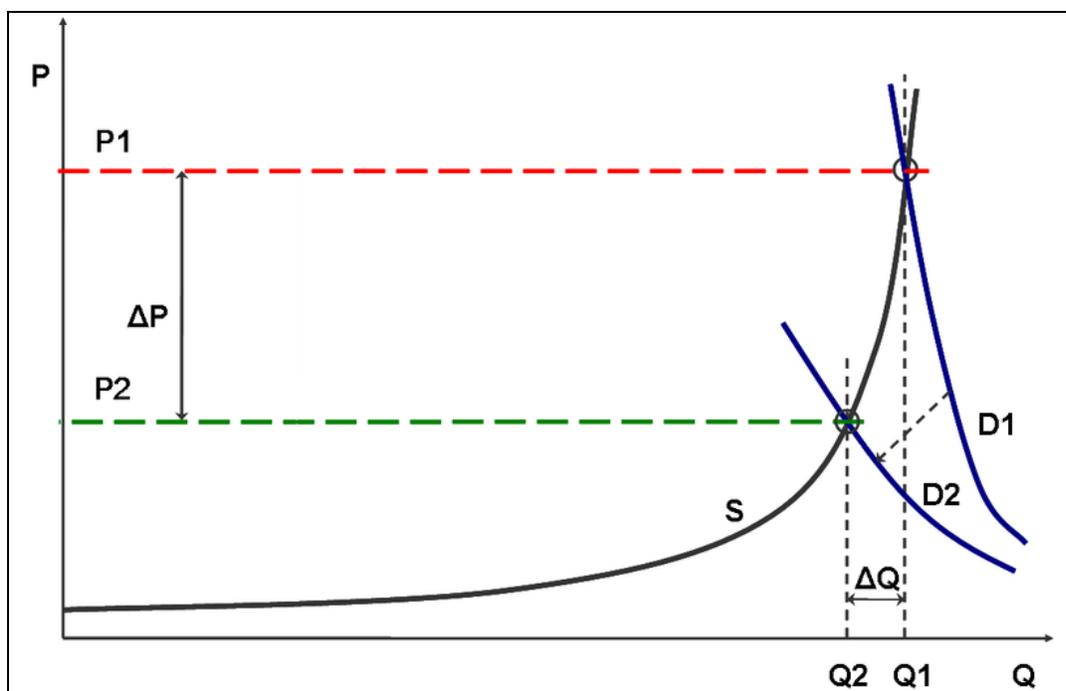


Figure 10: Impacts of Demand Elasticity on Wholesale Price⁵³

According to FERC, DR is defined as: “Changes in electric usage by demand-side resources 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.”⁵⁴ Contrary to the common perception, DR is not a new service; rather it has become more sophisticated with the advancement of technology and the restructuring of electricity markets. In the past, traditional vertically integrated utilities employed interruptible load programs to reduce demand and enhance reliability.⁵⁵ The essential mechanism of these interruptible load programs was utilities calling upon their largest industrial and commercial customers, in an informal fashion, to curtail portions of their load during times of high demand or limited supply. The systems for administrating curtailment were very rudimentary; some utilities offered largest industrial and commercial customers cheaper “interruptible” electric rates in exchange for the option to request curtailment.⁵⁶ However, regardless of the underdeveloped structure, the underlying idea of reducing load at key times in exchange for incentives remains the same today.

Within the last decade DR has developed significantly and taken on many forms amongst the various electricity markets, ranging from programs at the wholesale level to products at the utility and bilateral levels. According to FERC, DR programs can typically be divided into two categories: (1) “Incentive-

⁵³International Energy Agency: *The Power to Choose: Demand Response in Liberalised Electricity Markets*. Source: http://www.schneider-electric.us/documents/solutions1/demand-response-solutions/powertochoose_2003.pdf

⁵⁴FERC website: *Reports on Demand Response & Advanced Metering*. Source: <http://www.ferc.gov/industries/electric/indus-act/demand-response/dem-res-adv-metering.asp>

⁵⁵ ISO/RTO Council: *2009 State of the Markets Report*. Page 6. Source: <http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/2009%20IRC%20State%20of%20Markets%20Report.pdf>

⁵⁶ FacilitiesNet: *Demand-Response Programs: Get Paid To Use Less Energy, The History Of Demand-Response*. Source: <http://www.facilitiesnet.com/facilitiesmanagement/article/The-History-of-DemandResponse--9247>

Based Programs” and (2) “Time Based Programs”.⁵⁷ Thus, as the structures of DR programs have developed, market size and customer class participation have grown. Figure 11 and Figure 12 provide a clear depiction of this development. Figure 11 shows the growth in the total reported potential peak reduction in the 2006 through 2012; which essentially demonstrates that the market for DR has in an overall sense been growing rapidly since 2006.

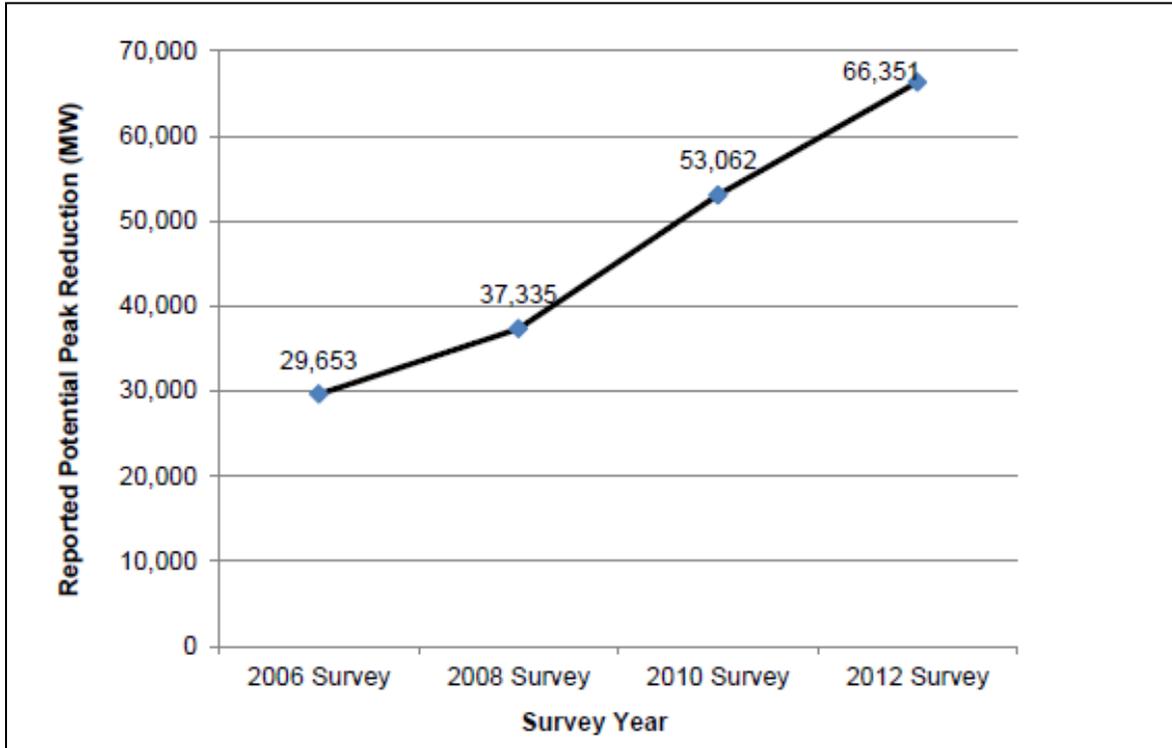


Figure 11: Total Reported Potential Peak Reduction in the 2006 through 2012 FERC Surveys⁵⁸

Figure 12 depicts the reported potential peak reduction by customer class in 2006, 2008, 2010 and 2012 helps to provide an understanding of where that growth is coming from. As illustrated, the growth has been largely due to increased participation from Commercial & Industrial and Wholesale customer classes.

⁵⁷ FERC: *2012 Assessment of Demand Response and Advanced Metering Staff Report*, December 2012, Page 21.

Source: <http://www.ferc.gov/legal/staff-reports/12-20-12-demand-response.pdf>

⁵⁸ FERC: *2012 Assessment of Demand Response and Advanced Metering Staff Report*, December 2012. Page 23.

Source: <http://www.ferc.gov/legal/staff-reports/12-20-12-demand-response.pdf>

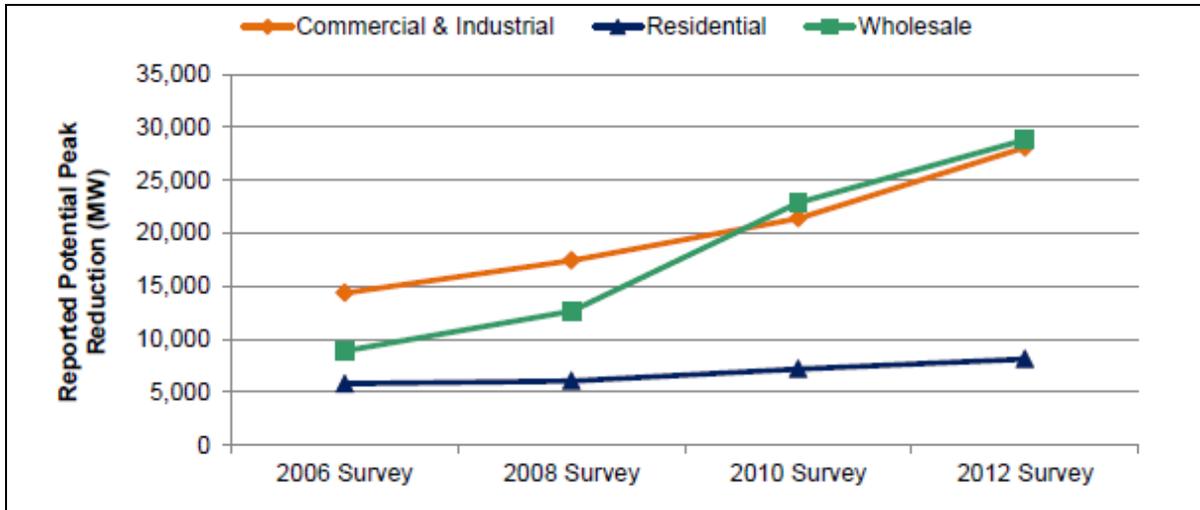


Figure 12: Reported Potential Peak Reduction by Customer Class in 2006, 2008, 2010 and 2012⁵⁹

Lastly, Figure 13 illustrates the reported potential peak reduction by program type and by customer class in 2012 FERC Survey. This chart provides clarity as to which programs are having the biggest impact in terms of peak reduction. As shown the *Load as a Capacity Resource*, *Interruptible Load*, and *Direct Load Control* are the top three programs on the Incentive-Based Programs, whereas Time-of-Use is by far the top program within the realm of Time-Based Programs.

⁵⁹ FERC: *2012 Assessment of Demand Response and Advanced Metering Staff Report*, December 2012. Page 23.
Source: <http://www.ferc.gov/legal/staff-reports/12-20-12-demand-response.pdf>

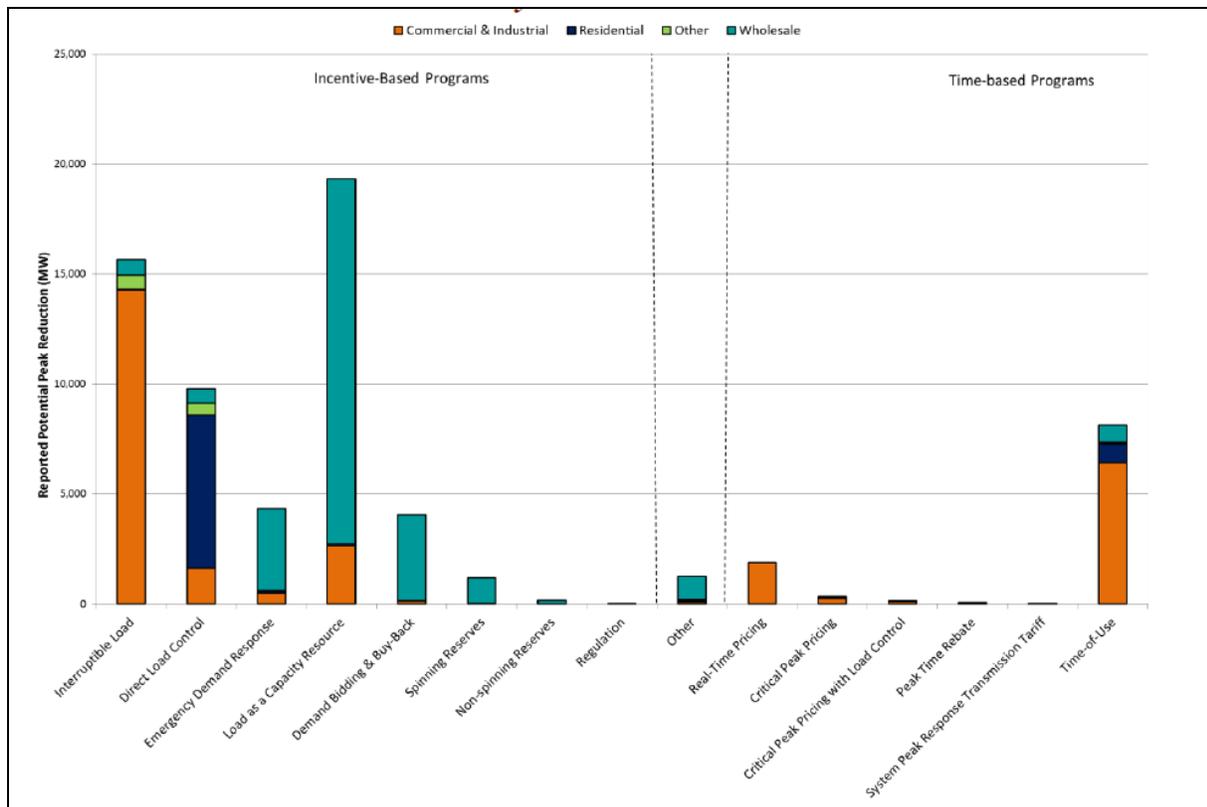


Figure 13: Reported Potential Peak Reduction by Program Type and by Customer Class in 2012 FERC Survey⁶⁰

Demand Response is truly a product of evolution, as it has been an available service to electricity markets for years. Since origination it has taken many forms, ranging from rudimentary to highly sophisticated. It has only been within the last decade, however, that DR has emerged as a truly useful market mechanism. This emergence is attributable to technology innovation, regulatory openings, and the entrance of third-party energy management businesses. PJM is one of the wholesale markets that have embraced DR; having established several strong programs for DR participation, and is reaping substantial benefits from its incorporation.

4.7 Demand Response in PJM

All DR programs in PJM can be grouped into either Economic Load Response or Emergency Load Response. As shown by Figure 14, the Emergency Load Response Program functions within the Capacity Market, while the Economic Load Response Program is divided into programs that operate in the Energy Market as well as the Market for Ancillary Services; each of these programs will be discussed in greater detail in the following sections.⁶¹

⁶⁰ FERC: *2012 Assessment of Demand Response and Advanced Metering Staff Report*, December 2012. Page 116. Source: <http://www.ferc.gov/legal/staff-reports/12-20-12-demand-response.pdf>

⁶¹ ISO/RTO Council website: *North American Wholesale Electricity Demand Response Program Comparison*. January 24, 2012. Source: http://www.isorto.org/site/c.jhKQIZPBIe/b.2604461/k.6151/Documents_and_Issues.htm

The Emergency Load Response Program is based on the commitments from DR resources procured through the forward capacity market to reduce load when PJM’s system is in an emergency condition. Resources within this program are typically referred to as capacity resources.⁶² Alternatively, the Economic Load Response Program operates in the Energy Market and the Market for Ancillary Services and provides the market participants with the opportunity to reduce load in response to an economic price signal.

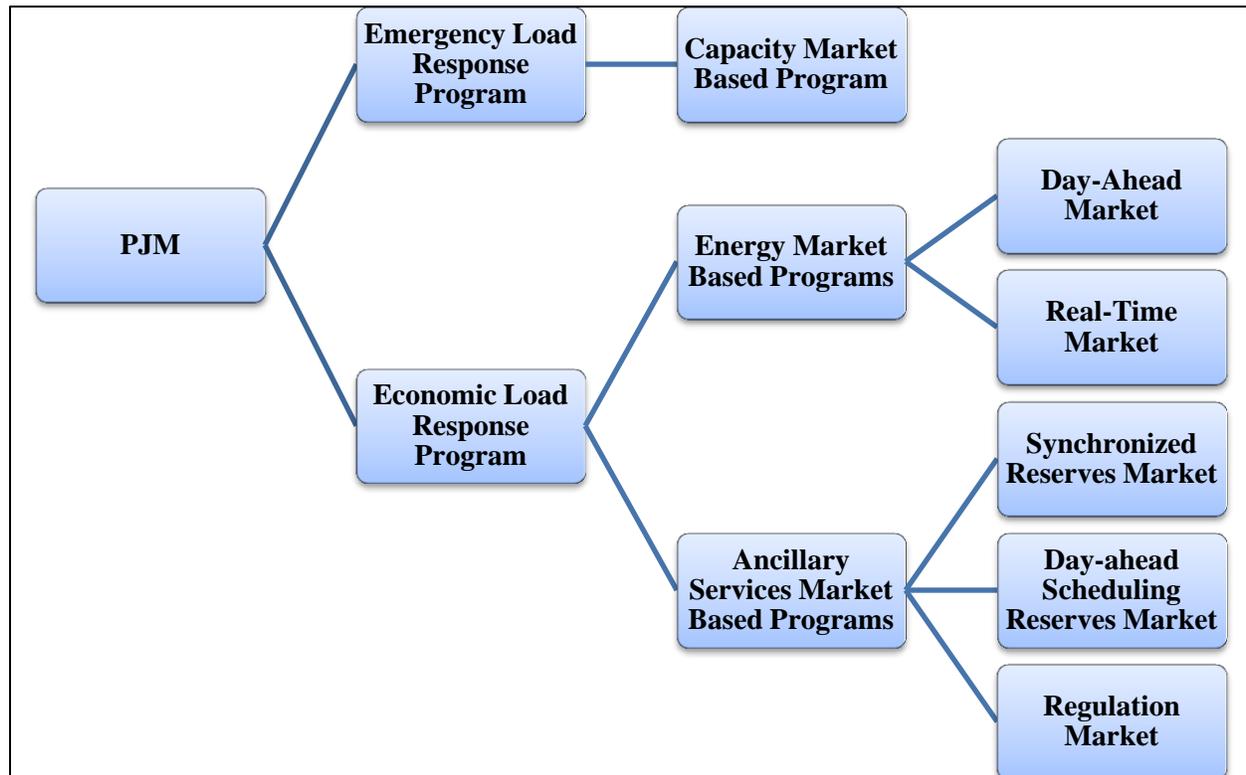


Figure 14: The Structure of PJM’s Demand Response Programs

It is important to make a clear distinction between capacity and energy when thinking about how PJM has structured its DR programs. In short, *capacity* is the willingness and ability to provide electricity in terms of generation or curtailment, while *energy* is the actual amount of electricity generated or curtailed during a particular moment.

4.8 Economic Load Response Program

4.8.1 Program Introduction

The Economic Load Response Program (Economic Program) is designed to enable customers to respond to economic conditions in the wholesale electricity market.⁶³ In this program, participation is voluntary and takes three different forms: DR resources can respond to prices in the Energy Market (Real-Time or Day-Ahead), Synchronized Reserve prices, and/or Day-Ahead Scheduling Reserve prices by reducing

⁶² PJM Manual 35: *Definitions and Acronyms*. Revision: 19, Effective Date: June 24, 2011. Section 2, Page 26.

⁶³ PJM Presentation: *PJM Economic Demand Side Response*. 10/4/2012. Source:

<http://www.pjm.com/training/~media/training/core-curriculum/ip-dsr/economic-demand-side-response-training.ashx>

consumption and receiving a payment for the reduction. Regarding the Regulation Market, demand resources can be compensated for reducing or increasing their load frequency.⁶⁴ The details of participation will be described in more detail in the follow sections.

The structure of the Economic Program is complex as it encompasses DR participation in both the Energy Market and the Market for Ancillary Services. As shown in Figure 15, within each of these markets there are several different options for participating. Within the Energy Market, it is possible for DR resources to participate in the Day-Ahead and Real-Time Markets, which each have their own payment system based on the LMPs that are calculated for those markets. Alternatively, the Market for Ancillary Services offers the possibility to participate in DR as part of the Synchronized Reserve, Day-Ahead Scheduling, and Regulation Markets; these market segments also have their own systems of compensation.

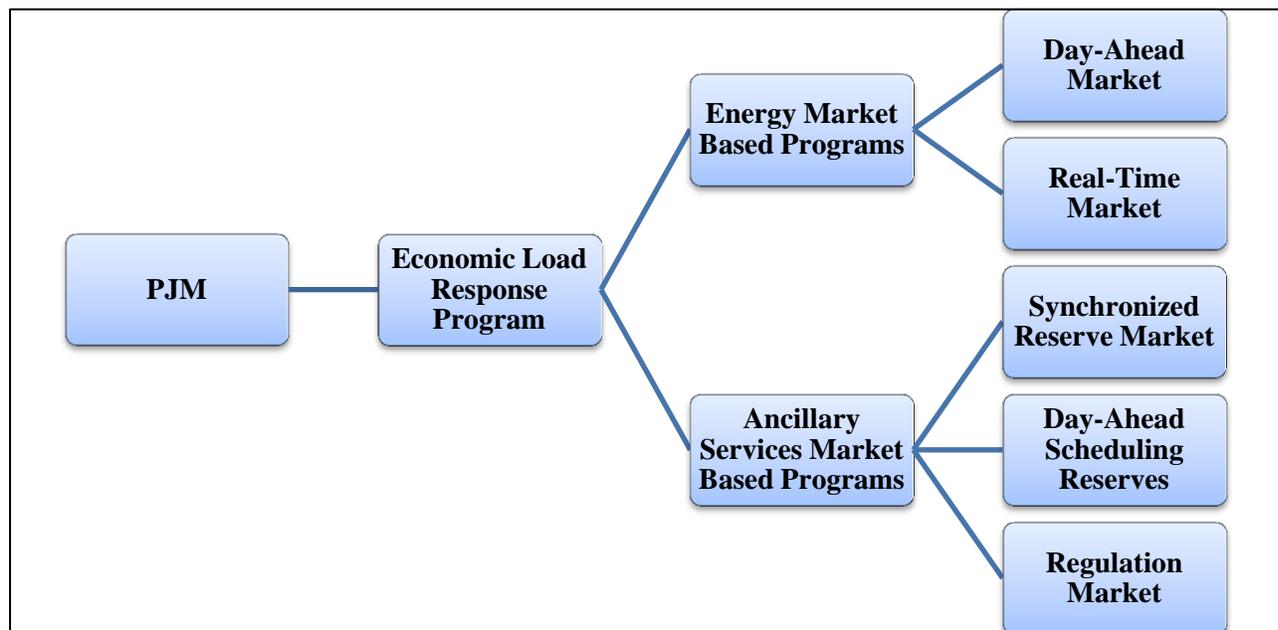


Figure 15: The Structure of the Economic Program⁶⁵

4.8.2 Registration in the Economic Program

All Economic Program registrations, except Economic Regulation Only registrations, must go through the Customer Baseline Load (CBL) certification process. This process determines whether a registration is a Variable or Non-Variable load. The category into which a DR resource is classified is based on hourly load data. Non-Variable Loads are those for which the CBL calculation and adjustment methods result in a relative root mean square hourly error of twenty percent or less compared to the actual hourly loads; all other loads shall be Variable Loads.⁶⁶ A resource should calculate a relative root mean square hourly

⁶⁴ PJM Manual 11: *Energy & Ancillary Services Market Operations*. Revision: 56, Effective Date: November 29, 2012. Section 3: *Overview of the PJM Regulation Market*, Page 51.

⁶⁵ PJM Presentation: *PJM Economic Demand Side Response*. 10/4/2012. Source: <http://www.pjm.com/training/~media/training/core-curriculum/ip-dsr/economic-demand-side-response-training.ashx>

⁶⁶ PJM Manual 11: *Energy & Ancillary Services Market Operations*. Revision: 56, Effective Date: November 29, 2012. Section 10.2: *Demand Resource Registration Requirements*, Page 114.

error for the standard CBL defined in the OATT unless approved to use another method.⁶⁷ Once the necessary calculations have been made, the resulting data must be submitted for review and approval.

Once a resource is enrolled into PJM's Market and has been registered, PJM then has thirty days to review the information that has been submitted.⁶⁸ After this review PJM will inform the resource of its acceptance into the program. Soon after there is a review by the electric distribution company (EDC) and load serving entity (LSE) from where the DR resource is located⁶⁹. Given the approval of PJM and the EDC and/or LSE, the registration is then able to engage in the market.

4.8.3 Market Engagement

Resources within the Economic Program submit bids to the market based on their registrations. For instance, the Day-Ahead Market option provides the mechanism by which a market participant may offer to reduce load ahead of real-time operations in which the resource would then receive payments based on Day-Ahead LMP for the reductions. The Real-Time Market option provides the mechanism by which a market participant may offer to commit to a reduction and receive payments based on real-time LMP for the reductions.⁷⁰

Any resource that plans to participate in either market must submit a bid. Those bid submissions must include specified information.⁷¹ Once this information is submitted into PJM's system, clearing house prices are determined for the Day-Ahead and Real-Time Markets which dictate which demand resources are dispatched and what price is paid.

Similarly to the added complexity in the registration process, DR assets registered in the Ancillary Service Market based programs must submit additional data for participation.⁷²

4.8.4 Metering

DR resources must install and maintain meters that provide integrated hourly kWh data. PJM requires that the metering equipment meet the local EDC standards/requirements for accuracy, or the meter must have a maximum error of two percent over the full range. The hourly load data obtained by the meters must be submitted to PJM within sixty days of the load reduction event, with all the necessary data needed to calculate settlement payments.⁷³ In the case that on-site generation is used to enable the end-use customer to participate in the Economic Load Response Program then the CSP may be requested by

⁶⁷PJM Manual 11: *Energy & Ancillary Services Market Operations*. Revision: 56, Effective Date: November 29, 2012. Section 10.2.5: *CBL Certification Process*, Page 122.

⁶⁸PJM Manual 11: *Energy & Ancillary Services Market Operations*. Revision: 56, Effective Date: November 29, 2012. Section 10.1.1: *Economic Load Response Participant Review Process*, Page 113.

⁶⁹PJM Manual 11: *Energy & Ancillary Services Market Operations*. Revision: 56, Effective Date: November 29, 2012. Section 10.2.4: *Electric Distribution Company ("EDC") and Load Serving Entity ("LSE") activities*, Page 122.

⁷⁰PJM Manual 11: *Energy & Ancillary Services Market Operations*. Revision: 56, Effective Date: November 29, 2012. Section 10.3: *Economic Energy Market Participation*, Page 124.

⁷¹ PJM Manual 11: *Energy & Ancillary Services Market Operations*. Revision: 56, Effective Date: November 29, 2012. Section 10.3: *Economic Energy Market Participation*, Page 124.

⁷² PJM Manual 11: *Energy & Ancillary Services Market Operations*. Revision: 56, Effective Date: November 29, 2012. Section 3.2.1: *Regulation Market Eligibility*, Page 52.

⁷³ Operating Agreement of PJM, Effective Date: 1/17/2013. Section 1.5A.4: *Metering and Electronic Dispatch Signal*, Page 203.

PJM to submit generation meter data. Furthermore, if a market participant intends to use an on-site generation then it must state in writing to PJM that it holds all necessary environmental permits applicable for operation.⁷⁴

Sub-meter load data is only used to support compliance in Regulation Market. According to PJM, a Sub-meter is defined as, “a metering point for electricity consumption that does not include all electricity consumption for the end-use customer as defined by the electric distribution company account number.”⁷⁵ If the DR resource elects to use this method then they must comply with an additional set of specified requirements.⁷⁶ These additional requirements are subject to timely audits by PJM to ensure that the equipment and data is maintained and accurate.

4.8.5 Settlement

Settlement payments for the Economic Program are calculated using a Customer Baseline Load (CBL) calculation. The purpose of the CBL is to calculate what the electricity consumption of a DR resource would have been if no DR event had taken place and/or if the DR resource was not dispatched. In other words, it is a mathematical method for proving that during a DR event the DR resource actually altered their normal consumption pattern. The calculated difference between the CBL and the DR resource’s actual consumption is then used to determine the payment amount.

4.9 Emergency Load Response Program

4.9.1 Program Introduction

The Emergency Load Response Program (Emergency Program) is designed to provide a mechanism by which end-use customers may be compensated by PJM for reducing load during an emergency event.⁷⁷ This program was established in 2007 along with the implementation of the Reliability Pricing Model and is sometimes referred to as PJM’s Load Management Program.⁷⁸ Originally it was divided into two different sets of programs: (1) Interruptible Load for Reliability (ILR) and (2) Demand Resources.⁷⁹ The ILR program, however, was eliminated in 2009.

The current structure of the Emergency Program (shown in Figure 16) is such that it offers market participants two options for engagement; a Full Option Program and an Energy Only Option Program. The nuances of these options are explained in greater detail in the following section.

The Emergency Program necessitates a classification of DR resources. Participants can not only engage in this program through load reduction, but also by incorporating on-site generation. As will be

⁷⁴ Operating Agreement of PJM, Effective Date: 1/17/2013. Section 1.5A.5: *On-Site Generators*, Page 204.

⁷⁵ PJM Manual 11: *Energy & Ancillary Services Market Operations*. Revision: 56, Effective Date: November 29, 2012. Section 10.7: *Use of Sub-meter load data to support demand response regulation compliance*, Page 138.

⁷⁶ PJM Manual 11: *Energy & Ancillary Services Market Operations*. Revision: 56, Effective Date: November 29, 2012. Section 10.7: *Use of Sub-meter load data to support demand response regulation compliance*, Page 138.

⁷⁷ Operating Agreement of PJM, Effective Date: 1/17/2013. Section: *Emergency Load Response Program*, Page 405.

⁷⁸ Monitoring Analytics, LLC: *State of the Market Report for PJM*. March 3, 2012, Page 123. Source: <http://pjm.com/documents/reports/state-of-market-reports/~media/documents/reports/state-of-market/2011/2011-som-pjm-volume1.ashx>

⁷⁹ Monitoring Analytics, LLC: *State of the Market Report for PJM*. March 3, 2012, Page 123. Source: <http://pjm.com/documents/reports/state-of-market-reports/~media/documents/reports/state-of-market/2011/2011-som-pjm-volume1.ashx>

discussed, this capability garners more participation but involves higher regulatory management as there are penalty payments for nonperformance and under-performance. The payment mechanism for the Emergency Program happens through the various auctions in the RPM, with prices varying by auction.

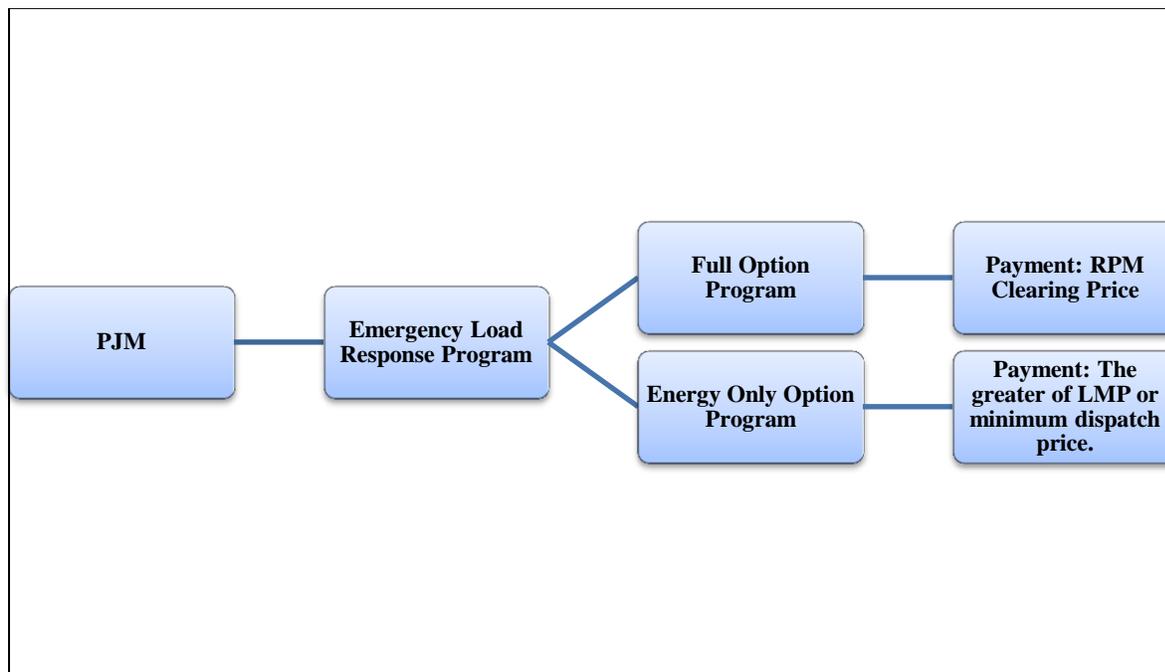


Figure 16: The Structure of Emergency Load Response Program

Since the Emergency Program is based on DR resources curtailing load during an emergency event, it is important to understand how PJM defines this term. According to PJM’s Manual 35: *Definitions and Acronyms*, “An Emergency is an abnormal system condition requiring manual or automatic action to maintain system frequency, or to prevent loss of firm load, equipment damage, or tripping of system elements that could adversely affect the reliability of an electric system or the safety of persons or property; a fuel shortage requiring departure from normal operating procedures in order to minimize the use of such scarce fuel; or a condition that requires implementation of emergency procedures as defined in the PJM Manuals.”⁸⁰ Any of the aforementioned emergencies can trigger an emergency in which the resources within the Emergency Program can be dispatched to curtail.

Figure 17 depicts the sources and business segments for DR activity in the Emergency Program for Delivery Year 2012/2013. The top three sources for DR in PJM are manufacturing, HVAC, and on-site generation. Additionally, the business segment chart shows that the majority of the DR activity is coming from Industrial/Manufacturing facilities, and only seven percent coming from schools and institutional facilities.

⁸⁰ PJM Manual 35: *Definitions and Acronyms*. Revision: 19, Effective Date: June 24, 2011. Section 2, Page 26.

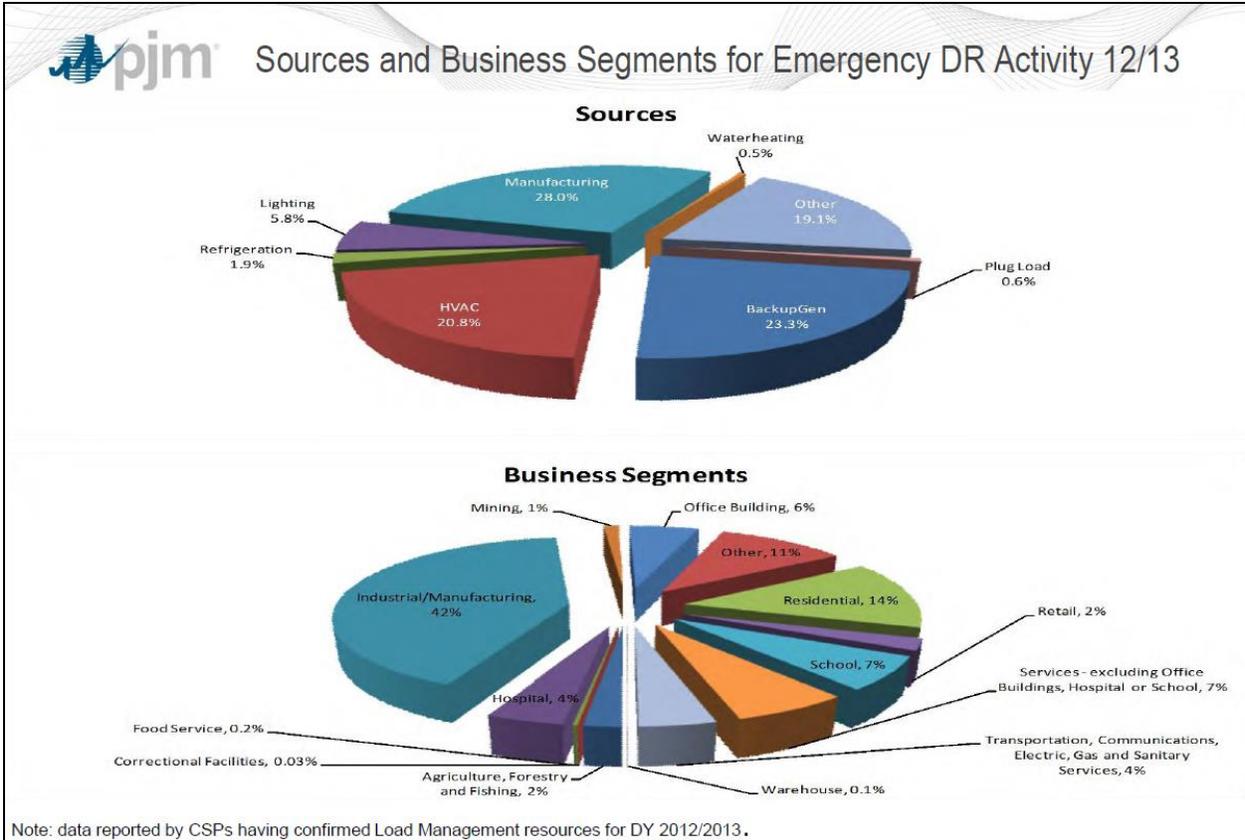


Figure 17: Sources and Business Segments for Emergency DR Activity for Delivery Year 2012/2013⁸¹

4.9.2 Registration in the Emergency Program

In order to enroll DR assets into the RPM, there are a series of general criteria that DR resources must be in compliance with. These requirements relate to the ability of a resource to reliably administer and manage their assets in the Emergency Program. Those general requirements are summarized in Table 3.

Table 3: General Requirements for Demand Response Resources in the RPM

“Demand response resources must be able to reduce at least a 100kW of load.” ⁸²
“Demand response resources must have the capability to retrieve electronic messages from PJM which notify CSPs of emergency events.” ⁸³
“Demand response resources must provide (or contract with another party to provide) supplemental status reports during the Delivery Year, detailing availability of the load management resource, as requested by PJM System Operations.” ⁸⁴

⁸¹ PJM Presentation: *Load Response Activity Report January 2013*, January 14, 2013. Source:

<http://www.pjm.com/~media/markets-ops/dsr/2012-dsr-activity-report-20130118.ashx>

⁸² PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.1: *Requirements of Load Management Products in RPM*, Page 48.

⁸³ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.1: *Requirements of Load Management Products in RPM*, Page 48.

“Demand response resources must provide (or contract with another party to provide) customer-specific compliance and verification information within 45 days after the end of the month in which a PJM-initiated Load Management event occurred.” ⁸⁵
“Demand response resources must provide load drop estimates for all emergency events in which they were dispatched.”
“Demand response resources must have availability for PJM-initiated interruptions in accordance with the availability requirements of the demand resource product type (i.e. Limited DR, Extended Summer DR, or Annual DR).” ⁸⁶
“Demand response resources must be able to respond within two hours of notification to the resource provider of a PJM-initiated emergency event.” ⁸⁷
“Initiation of load interruptions upon request of PJM must be within the authority of the resource provider dispatcher without any additional approvals being required.” ⁸⁸
“Providers of Planned Demand Resources must provide a timeline including the milestones, which demonstrates to PJM’s satisfaction that the Planned Demand Resources will be available for the start of the Delivery Year, 15 business days prior to an RPM Auction. PJM may verify the provider’s adherence to the timetable at any time including, but not limited to, 30 days prior to an Incremental Auction.” ⁸⁹

Once compliance with the general requirements is determined, DR resources registering into the Emergency Program then must select the option of program that best suits their asset’s load profile and capability. The registration must be completed one day before the tenth business day preceding the relevant delivery year. This time period is to allow for the associated EDC and/or LSE to review the application for participation in the program. All registrations that have not been approved on or before May 31st preceding the relevant delivery year shall be rejected.⁹⁰ The two options within the Emergency Program that resources are able to select described in Table 4.

Table 4: Emergency Program Enrollment Options

Option Name:	Description:
The Energy Only Program	“This option restricts end-use customers to receive energy payments only for load reductions during an emergency event. ⁹¹ Participation is voluntary. Participants submit a minimum dispatch price for load reductions during emergency events,

⁸⁴ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.1: *Requirements of Load Management Products in RPM*, Page 48.

⁸⁵ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.1: *Requirements of Load Management Products in RPM*, Page 48.

⁸⁶ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.1: *Requirements of Load Management Products in RPM*, Page 48.

⁸⁷ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.1: *Requirements of Load Management Products in RPM*, Page 48.

⁸⁸ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.1: *Requirements of Load Management Products in RPM*, Page 48.

⁸⁹ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.1: *Requirements of Load Management Products in RPM*, Page 48.

⁹⁰ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.7: *Emergency Load Response Registration*, Page 52.

⁹¹ Operating Agreement of PJM, Effective Date: 1/17/2013. Section: *Emergency Load Response Program*, Page 405.

	which include shutdown costs and a minimum duration. This option of the Emergency Program is similar to the Economic Program in that it provides only energy payments and all participation is voluntary. However, compensation differs significantly between the two programs as Energy Only participants in the Emergency Program receive the greater of LMP or the value of the submitted minimum dispatch price, including shutdown, for the duration of the emergency reduction.” ⁹²
The Full Option Program	“This option allows participants to receive energy payments for load reductions during emergency events as well as capacity payments for participating in the Reliability Pricing Model (PJM’s Forward Capacity Market). Participation is mandatory and failure to reduce will result in a compliance test failure charge. Similar to the Energy Only option, participants in the Full Emergency option submit minimum dispatch prices associated with reductions during emergency events.” ⁹³

Within each of these program enrollment options, DR resources (those assets for which registrations are created) are classified as either On-Site Generator or Load Reduction (see Table 5).

Table 5: Demand Response Asset Classification for Emergency Program

Asset Classification:	Description:
On-Site Generator	“A generator (including Behind The Meter Generation) can be either synchronized or non-synchronized to the grid. Capacity Resources are not eligible for compensation under this program. Injections into the grid by local generators also will not be eligible for compensation under this program.” ⁹⁴
Load Reduction	“A participant that has the ability to reduce a measurable and verifiable portion of its load, as metered on an EDC account basis.” ⁹⁵

For those DR resources that intend to use on-site generation for the purpose of participating in the Emergency Program, it must hold all applicable environmental and use permits for running the generator. These can include but are not limited to federal, state, and local permitting and licensing. On a forward going basis, participation in this program by a DR resource with on-site generation is determined by the resource’s ability to continue operating the on-site generating unit in accordance with this program, and in compliance with all applicable permits, including any emissions, run-time limit or other constraint on plant operations that may be imposed by such permits.⁹⁶ Once the participant has selected the enrollment options and asset classifications for its DR resources, then it is time to elect the load management program (outlined in Table 6).

⁹² Monitoring Analytics, LLC: *State of the Market Report for PJM*. March 3, 2012, Page 124. Source: <http://pjm.com/documents/reports/state-of-market-reports/~media/documents/reports/state-of-market/2011/2011-som-pjm-volume1.ashx>

⁹³ Monitoring Analytics, LLC: *State of the Market Report for PJM*. March 3, 2012, Page 124. Source: <http://pjm.com/documents/reports/state-of-market-reports/~media/documents/reports/state-of-market/2011/2011-som-pjm-volume1.ashx>

⁹⁴ Operating Agreement of PJM, Effective Date: 1/17/2013. Section: *Emergency Load Response Program, Participant Qualifications*, Page 406.

⁹⁵ Operating Agreement of PJM, Effective Date: 1/17/2013. Section: *Emergency Load Response Program, Participant Qualifications*, Page 406.

⁹⁶ Operating Agreement of PJM, Effective Date: 1/17/2013. Section: *Emergency Load Response Program, Participant Qualifications*, Page 412.

Table 6: Load Management Programs

Acronym:	Name:	Description:
FSL	Firm Service Level	“Load management achieved by a customer reducing its load <i>to</i> a pre-determined level (the Firm Service Level), upon notification from the resource provider’s market operations center or its agent.” ⁹⁷
DLC	Direct Load Control	“Load management that is initiated directly by the resource provider’s market operations center or its agent, employing a communication signal to cycle equipment (typically water heaters or central air conditioners).” ⁹⁸
GLD	Guaranteed Load Drop	“Load management achieved by a customer reducing its load <i>by</i> a pre-determined amount (the Guaranteed Load Drop), upon notification from the resource provider’s market operations center or its agent. Typically, the load reduction is achieved through running customer-owned backup generators, or by shutting down process equipment.” ⁹⁹

In addition to selecting the Load Management Program, the resource must register its preferred Product Type. The Product Type provides PJM with sense of a DR resource’s availability, as each Product Type outlines the time windows in which the DR resource should be ready to be notified to curtail. The three product types are summarized in Table 7.

Table 7: Product Types¹⁰⁰

Name:	Description:
Limited DR	“DR resource is available for interruption for at least 10 times during the summer period of June through September in the Delivery Year, and will be capable of maintaining each such interruption for at least a 6-hour duration. At a minimum, the Limited Demand Resource shall be available for such interruptions on weekdays, other than NERC holidays, from 12:00PM to 8:00PM EST.” ¹⁰¹
Extended Summer DR	“DR resource is available for an unlimited number of interruptions during an extended summer period of June through October and the following May, and will be capable of maintaining each such interruption for at least a 10-hour duration between the hours of 10:00AM to 10:00PM EST.” ¹⁰²

⁹⁷ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.2: *Types of Load Management Programs*, Page 49.

⁹⁸ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.2: *Types of Load Management Programs*, Page 49.

⁹⁹ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.2: *Types of Load Management Programs*, Page 49.

¹⁰⁰ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.1: *Requirements of Load Management Products in RPM*, Page 45.

¹⁰¹ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.1: *Requirements of Load Management Products in RPM*, Page 45.

¹⁰² PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.1: *Requirements of Load Management Products in RPM*, Page 45.

Annual DR	“DR resource is available for an unlimited number of interruptions during the Delivery Year, and will be capable of maintaining each such interruption for at least a 10-hour duration between the hours of 10:00AM to 10:00PM EST for the months of June through October and the following May, and 6:00AM through 9:00PM EST for the months of November through April unless there is an Office of the Interconnection approved maintenance outage during October through April.” ¹⁰³
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4.9.3 Market Engagement

In the Energy Only Option Program, participants submit a minimum dispatch price for load reductions during emergency events, which include shutdown costs and a minimum duration time. In this option all participation is voluntary. In this facet, the Energy Only Option Program of the Emergency Load Response Program is very similar to the Economic Program. Compensation, however, differs significantly between the two programs in that Energy Only participants in the Emergency Program receive the greater of the nodal LMP or the value of the submitted minimum dispatch price, including shutdown costs for the duration of the emergency reduction.¹⁰⁴

Participants in the Full Option Program also submit minimum dispatch prices for emergency events, but more importantly these resources are considered committed capacity resources and receive capacity payments. Capacity payments are the reason why this program is more profitable than the Economic Program. Participation during an emergency event or capacity testing is mandatory and failure to reduce will result in a compliance test failure charge.¹⁰⁵

During an emergency event, participants registered in the Full Option Program and the Energy Only Option Program will be paid the higher of the submitted minimum strike price or the zonal real-time LMP for emergency reductions. The minimum dispatch price, which is submitted by the participant, acts as a floor for energy compensation during an emergency event.¹⁰⁶

4.9.4 Metering

DR resources are responsible for ensuring it has metering equipment that provides integrated hourly kWh values. The meters should either meet the standards of the EDC or have a maximum error of two percent over the full range of the metering equipment (these accuracy requirements are same as it is in the Economic Program). The installed metering equipment must be one of the types described in Table 8.

¹⁰³ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.1: *Requirements of Load Management Products in RPM*, Page 45.

¹⁰⁴ Monitoring Analytics, LLC: *State of the Market Report for PJM*. March 3, 2012, Page 124. Source: <http://pjm.com/documents/reports/state-of-market-reports/~media/documents/reports/state-of-market/2011/2011-som-pjm-volume1.ashx>

¹⁰⁵ Monitoring Analytics, LLC: *State of the Market Report for PJM*. March 3, 2012, Page 124. Source: <http://pjm.com/documents/reports/state-of-market-reports/~media/documents/reports/state-of-market/2011/2011-som-pjm-volume1.ashx>

¹⁰⁶ Monitoring Analytics, LLC: *State of the Market Report for PJM*. March 3, 2012, Page 124. Source: <http://pjm.com/documents/reports/state-of-market-reports/~media/documents/reports/state-of-market/2011/2011-som-pjm-volume1.ashx>

Table 8: PJM Metering Equipment Requirements

“Metering equipment used for retail electric service.” ¹⁰⁷
“Customer-owned metering equipment or metering equipment acquired by the Curtailment Service Provider, approved by PJM, that is read electronically by PJM in accordance with the requirements herein and in the PJM Manuals.” ¹⁰⁸
“Customer-owned metering equipment or metering equipment acquired by the Curtailment Service Provider, approved by PJM, that is read by the customer (or the Curtailment Service Provider), and such readings are then forwarded to PJM, in accordance with the requirements set forth herein and in the PJM Manuals.” ¹⁰⁹

Load reduction meter data must be submitted to PJM within sixty days of the event. If meter data is not received by PJM within sixty days, then the CSP will receive no compensation. Meter data must be provided for all relevant hours during the window of an event or performance test. Meter data will be forwarded to the EDC or LSE when it arrives to PJM, and from that time the EDC or LSE has ten business days to provide feedback to PJM.¹¹⁰

4.9.5 Emergency Operations

Emergency Operations are employed whenever pre-scheduled capacity is not sufficient to serve load and maintain reserves or maintain system reliability. PJM initiates an emergency event by sending an electronic message to registered DR resources. When an event has been declared, voluntary resources should perform curtailment if available and if it is deemed profitable; in others words if by shutting down operations, their revenue from DR participation will be greater than their opportunity cost of not curtailing. Committed resources, such as those committed in the capacity market, are expected to curtail in accordance with their registration.

PJM will announce when the event is over with another All-Call communication. Depending on the program, lead time can be as much as two hours before an end-use customer is expected to curtail.¹¹¹ PJM refers to these as Long and Short Lead Times; long meaning between one to two hours and short meaning one-hour notice.

4.9.6 Event Compliance

PJM verifies event compliance on an individual DR resource registration basis by reviewing the submitted data. There is a separate method for assessing compliance for each type of Load Management Program; the details are articulated in Table 9.

¹⁰⁷ Operating Agreement of PJM, Effective Date: 1/17/2013. Section: *Emergency Load Response Program, Metering Requirements*, Page 407.

¹⁰⁸ Operating Agreement of PJM, Effective Date: 1/17/2013. Section: *Emergency Load Response Program, Metering Requirements*, Page 407.

¹⁰⁹ Operating Agreement of PJM, Effective Date: 1/17/2013. Section: *Emergency Load Response Program, Metering Requirements*, Page 407.

¹¹⁰ Operating Agreement of PJM, Effective Date: 1/17/2013. Section: *Emergency Load Response Program, Verification*, Page 415.

¹¹¹ PJM Presentation: *PJM Load Management; PJM State & Member Training*. 1/4/2013. Source: <http://www.pjm.com/training/~media/training/core-curriculum/ip-dsr/load-management-in-rpm.ashx>

Table 9: Compliance Determination by Load Management Program

Name of Load Management Program:	Compliance Determination Description:
Firm Service Level (FSL)	“Determined by comparing actual load during the event to the nominated firm service level. Resource providers must submit load data for all hours of the event and test day and for all days required for PJM to calculate compliance through the Load Response system.” ¹¹²
Direct Load Control (DLC)	“Considers only the transmission of the control signal. CSPs are required to report the time period (during the Load Management event) that the control signal was started and stopped. Failure to start the signal by the start of the event and continue the signal for the duration of the event will result in a deficiency for that end-use customer.” ¹¹³
Guaranteed Load Drop (GLD)	“Determined by comparing actual load dropped during the event to the nominated amount of load drop. Resource providers must submit load data for all hours of the event and test day and for all days required for PJM to calculate compliance.” ¹¹⁴

4.9.7 Settlement

Capacity compliance data must be submitted within forty-five days after the end of the event month, whereas energy settlements must be submitted within sixty days of the event. If no data is submitted in this window then the participant will not receive compensation. Meter data must be provided for all hours of the emergency event or the load management performance test.¹¹⁵

Compensation is made for curtailments in energy consumption during emergency events by Full Program Option participants and Energy Only Option participants regardless of whether the participant’s load during the event exceeds its peak load contribution for the applicable delivery year. Payment is equal to the measured curtailments. DR resources cleared in the capacity market receive the corresponding Capacity Resource Clearing Price as determined in the respective auction.¹¹⁶

4.9.8 Auditing

DR resources will be tested in a zone if PJM has not called an event in that zone by August. The purpose of this auditing exercise is to prove at summer’s end that if there was an event that year, that the DR resource would have had the capability to perform. However, it is important to note that if an event is

¹¹² PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 8.5.1: *Measuring Event Compliance*, Page 134.

¹¹³ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 8.5.1: *Measuring Event Compliance*, Page 134.

¹¹⁴ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 8.5.1: *Measuring Event Compliance*, Page 134.

¹¹⁵ PJM Presentation: *PJM Load Management; PJM State & Member Training*. 1/4/2013. Source: <http://www.pjm.com/training/~media/training/core-curriculum/ip-dsr/load-management-in-rpm.ashx>

¹¹⁶ PJM OATT, Attachment DD: *PROCEDURES FOR DEMAND RESOURCES, ILR, AND ENERGY EFFICIENCY*, Effective Date: 9/17/2010. Page 2532.

called between August 16 and September 30, then no test will be required; meaning that if there was an audit the results are void or if there was no audit then testing is not necessary.¹¹⁷

PJM auditing is based on general parameters that apply to DR resources within the Emergency Program. Those parameters are summarized in Table 10.

Table 10: General Testing Parameters

“All resources in the same zone shall be tested for one hour.” ¹¹⁸
“Test can be conducted between June 1 and September 30 and data must be submitted between October 1 and November 14.” ¹¹⁹
“Notify PJM of intent to test 48 hours in advance.” ¹²⁰
“No limit to the number of tests a CSP can perform.” ¹²¹

Given the general parameters of the testing, there are different methods of assessing compliance for each of the Product Types within the Emergency Program. Those unique methods are summarized in Table 11.

Table 11: Auditing Parameters by Product Type

Product Type:	Description of Auditing Parameters:
Limited Demand Resource	“If a registration for Limited Demand Resource committed to PJM is dispatched by PJM for a PJM Load Management event in a transmission sub-zone between June 1 and September 30 of the 2012/2013 and 2013/2014 Delivery Years and such registration performs at or above the nominated amount of capacity on the registration, no test will be required and no Load Management Test Failure Charges will be assessed for such registrations. If a registration for a certified ILR resource or a committed Limited Demand Resource is dispatched by a PJM-initiated Load Management Event in a zone between June 1 and September 30th of the Delivery Year, load management test compliance will not be evaluated and Load Management Test Failure Charges will not be assessed for such registration.” ¹²²

¹¹⁷PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 8.6: *Load Management Test Compliance*, Page 135.

¹¹⁸PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 8.6: *Load Management Test Compliance*, Page 135.

¹¹⁹PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 8.6: *Load Management Test Compliance*, Page 135.

¹²⁰PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 8.6: *Load Management Test Compliance*, Page 135.

¹²¹PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 8.6: *Load Management Test Compliance*, Page 135.

¹²² PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 8.6: *Load Management Test Compliance*, Page 135.

Annual Demand Resource	“If a registration for a Annual Demand Resource is not dispatched by PJM for a Load Management Event in a Delivery Year, then such registration must demonstrate that it was tested simultaneously with other non-dispatched Annual Demand Resource registrations in the zone for a one-hour period during any hour when a PJM Load Management Event may be called during June through October or the following May of the Delivery Year. If a registration for a Annual Demand Resource is dispatched by PJM for a Load Management Event during the Delivery Year, then no test will be required for such registration and no Load Management Test Failure Charges will be assessed for such registration.” ¹²³
Extended Summer Demand Resource	“If a registration for an Extended Summer Demand Resource is not dispatched by PJM for a Load Management Event during June through October or the following May in a Delivery Year, then such registration must demonstrate that it was tested simultaneously with other non-dispatched Extended Summer Demand Resource registrations in the zone for a one-hour period during any hour when a PJM Load Management Event may be called during June through October or the following May of the Delivery Year. If a registration for an Extended Summer Demand Resource is dispatched by PJM for a Load Management Event during June through October or the following May of the Delivery Year, then no test will be required for such registration and no Load Management Test Failure Charges will be assessed for such registration.” ¹²⁴

DR resource tests are measured in the same fashion as emergency event. A DR resource with a positive net testing shortfall in a zone for a product type will be assessed a Zonal Load Management Test Failure Charge.¹²⁵

4.9.9 Penalties

Participants in the Emergency Program that fail to provide a specified load reduction when dispatched by PJM during emergency events or annual audit event must pay penalties and/or charges for their nonperformance or underperformance. For each type of event, the calculation for assessing the penalty is different, but the methods are similar. It is important to note the nonperformance or underperformance is based from the amount of capacity that was bid into the RPM.

A DR resource Compliance Penalty Charge is assessed to DR resources that under-complied during an event. The Compliance Penalty Charge is the consequence of underperformance. This charge is based on the amount of underperformance (or Under-Compliance Megawatts) times a higher rate than what the CSP would have made in revenue from its DR resources (Load Management Compliance Penalty Rate).¹²⁶

¹²³ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 8.6: *Load Management Test Compliance*, Page 135.

¹²⁴ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 8.6: *Load Management Test Compliance*, Page 135.

¹²⁵ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 8.6: *Load Management Test Compliance*, Page 135.

¹²⁶ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 9.1.9: *Demand Resource and ILR Compliance Penalty Charge*, Page 147.

The Daily Load Management Test Failure Charge which is a penalty payment based on the underperformance of a DR resource during a test event. This charge is equal to the Under-Compliance Megawatts (MWs) in the zone for the product type tested times the LM Test Failure Charge Rate.¹²⁷ In other words, it is the amount of underperformance (MW-day) times a higher rate than what the DR resources would have made in revenue.

5 Decision Support Tool

5.1 Introduction

The preceding sections detail the intricate structure of the PJM markets, the role of demand side resources in those markets, and the complicated process of becoming a PJM member. Given the density of this material it is important for potential market participants to be made aware of the upside of involvement in a clear fashion. Beyond the potentially wide reaching and well understood environmental and economic benefits of demand side management, consumers are likely to be most interested by the revenue potential that market participation represents. Whether it is a CSP attempting to attract a new customer, or an energy manager trying to convince the board that taking part in the PJM DR markets is a worthwhile endeavor; an indication of the potential cash flow is certainly advantageous in drawing attention away from the associated red-tape.

The aim of this portion of the project was to develop an estimate of the revenue that could be earned by a hypothetical demand side resource through participation in the PJM markets. This was accomplished through the creation of a *Revenue Calculator* that provides potential market participants with an estimate of the economic value of their load in the PJM markets. Ultimately, greater insight into the financial benefits available to demand resources should encourage end users to strongly consider participation in DR programs.

5.2 Capacity Market

The variety of markets and multitude of registration options available to demand resources within the PJM RTO/ISO have been described in Section 4.8, but estimations of revenue potential made in this section focus solely on the returns available from participation in PJM's capacity market known as the Reliability Pricing Model. The decision to focus on only this one market was made due to a variety of factors related to creating the most accurate and applicable model possible. These considerations include participation rates, ease of forecasting, and user accessibility.

First, historical data shows that the vast majority of revenue earned by demand resources in PJM markets has come in the form of capacity payments from participation in the RPM (Figure 18). Assuming that this trend continues for CSPs or anyone else interested in garnering greater demand resource participation in the PJM markets would be well served by illustrating the earnings potential of this market.

¹²⁷ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 9.1.7: *Load Management Test Failure Charge*, Page 146.

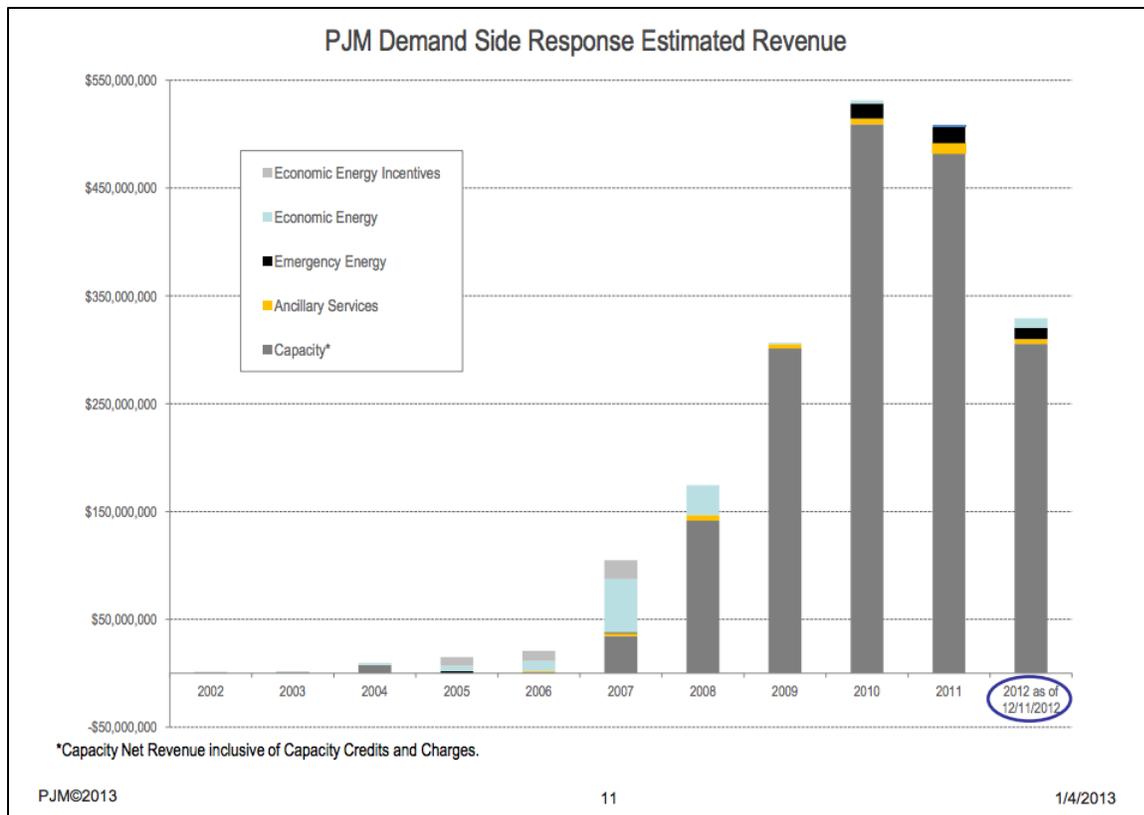


Figure 18: Estimation of Revenue Earned by Demand Resources in PJM Markets¹²⁸

Second, the other markets present distinct challenges in representing theoretical revenue streams. As is detailed in previous sections, load reductions in the energy and ancillary services markets within PJM are entirely voluntary. While this provides the customer with the advantage of being able to self-schedule load reductions, and avoids any penalties associated with non-performance during emergency events, it also presents a variety of modeling challenges associated with the additional scheduling freedom. Customers in those markets have the opportunity to earn arbitrage profits when their marginal costs of making load reductions is less than the locational marginal price in their zone at that time. Thus, an estimation of the potential earnings available in the energy markets would require both a forecast of hourly LMPs, as well as a thorough understanding of the cost to the consumer to make reductions.¹²⁹

Finally, the capacity market offers participants the greatest predictability of payments. With payments based on the results of the BRA and Incremental Auctions, customers can gain an understanding of the revenue they can expect to receive well in advance. Contingent on performance during emergency events, participants earn regular monthly payments during the delivery year.¹³⁰ Thus, forecasting revenue is relatively straightforward in comparison to the other PJM markets, and can be estimated on an annual time scale, which is most meaningful for the majority of consumers.

¹²⁸ PJM Presentation: Load Response Activity Report January 2013, January 14, 2013. Source: <http://www.pjm.com/~media/markets-ops/dsr/2012-dsr-activity-report-20130118.ashx>

¹²⁹ PJM Presentation: *PJM Demand Side Response*. Source: <http://www.pjm.com/~media/training/core-curriculum/ip-dsr/pjm-demand-side-response-slides.ashx>

¹³⁰ PJM Training Materials: *Reliability Pricing Model Training: Demand Response and Energy Efficiency*. Source: <http://www.pjm.com/~media/markets-ops/rpm/20090406-dr-ee-in-rpm-collateral.ashx>

Given that the capacity market represents the greatest potential source of revenue for demand resources, with the most easily forecasted annual payments, this study focused primarily on this option. It is also worth noting that while the energy markets have generated less revenue for demand resources in the past, and are more difficult to model, they also carry less associated risk as there are no non-performance penalties.¹³¹

5.3 Capacity Revenue

As the first ISO, and later the first RTO, approved by the Federal Energy Regulatory Commission, PJM is responsible for operating transmission systems to provide open access for non-utility users. To this end, they are tasked with maintaining the reliability of the electricity grid to the standard set-forth by the Reliability First Corporation (PJM's NERC region) in the Planned Resource Adequacy Assessment. This regulation states that PJM must calculate a reserve margin that results in a probability of being unable to meet the peak load during the demand year of 0.1, or a Loss of Load Expectation of "one day in ten years."¹³²

PJM is thus concerned with attaining an adequate amount of resources to meet the peak demand throughout the year. To this end, PJM has set-up a capacity market known as the Reliability Pricing Model (RPM), which is designed to ensure there are enough resources available to meet peak demand throughout the demand year.¹³³ Due to the fact that demand varies drastically throughout the year, with only a few hours during the summer representing a much higher demand level than the rest of the year, PJM must provide an incentive for additional resources to be available during times of high demand, despite the fact that they will likely only be called upon to operate for a few hours each year. The RPM provides capacity payments throughout the year regardless of whether a resource is called to perform or not, which encourage both the retention of existing resources, and the development of new resources in the PJM region.

5.4 Revenue Calculator

In an effort to make clear the profitability of participating in the RPM as a demand resource, a decision support tool was created to estimate the revenue a particular customer could receive from bidding their load reductions or behind the meter generation into the market. This *Revenue Calculator* utilizes basic customer metrics, product choices, and market defined variables to estimate the potential payout from the RPM. Central to the function of the calculator is a forecast for the market price for capacity based on historical data of RPM clearing prices. This forecast model is described in greater detail below in the "Market Price Estimation" section.

5.4.1 Revenue Calculation

The calculation of payments a demand resource may receive from the RPM is dependent on more than just the market price and quantity of capacity provided. While these are both key components of the calculation, additional considerations are needed to account for the physics behind the transmission of electricity, as well as the performance of a typical demand resource. Table 12 lists the variables that are

¹³¹ PJM Presentation: *Reliability Pricing Model Training: Resource Performance Assessments*. 10/29/2012. <http://www.pjm.com/~media/training/core-curriculum/ip-rpm/rpm-training-section-f-performance-assessment-examples.ashx>

¹³² Reliability First Corporation: BAL-502-RFC-02, *Planned Resource Adequacy Analysis, Assessment and Documentation*, Page 1.

¹³³ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 1.1: *Overview of the PJM Capacity Market*, Page 3.

directly used in the calculation of annual capacity payments, along with a brief description of their purpose within the equation. More detailed descriptions can be found at the provided sources.

Table 12: Variables used in the calculation of capacity payments

Variable	Units	Abbreviation	Definition
Capacity Factor ¹³⁴	-	-	A multiplier used to account for the transmission losses that would occur if electricity had to be provided to the demand resource.
Demand Resource Factor ¹³⁵	-	DR Factor	The percentage of time that a demand resource is expected to be available to perform taking into account outages for maintenance or other shut-downs.
Forecast Pool Requirement ¹³⁶	-	FPR	The amount of unforced capacity needed to meet PJM's reliability criterion.
Installed Capacity ¹³⁷	MW	ICAP	The total available capacity of a demand resource.
Load Under Management	MW	-	The amount of load that a customer is committed to curtailing during an emergency event.
Peak Load Contribution ¹³⁸	MW	PLC	A baseline measure of a customer's peak electricity usage. Defined as the average consumption during the five hours of highest peak during the previous demand year.
Unforced Capacity ¹³⁹	MW	UCAP	The available capacity of a demand resource after taking into account presumed outages.

The essential process of revenue calculation is to determine the amount of usable resource that is being provided to the ISO/RTO and multiply that by the prevailing market price (in dollars per megawatt-day) to generate the resulting capacity payments. Equations 1-4 below details how the above variables are utilized to calculate the annual revenue a demand resource would receive from participation in the RPM.¹⁴⁰ It is important to note that nominated in this context is used to describe the capacity that a

¹³⁴ PJM Manual 13: *Emergency Operations*. Revision: 47, Effective Date: 1/1/2012. Attachment B: *PJM Open Access Transmission Tariff, Emergency Load Response Program*. Page 1696.

¹³⁵ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Attachment A: *Glossary of Terms*, Page 164.

¹³⁶ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 2.1.4: *Forecast Pool Requirement*, Page 9.

¹³⁷ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 2.4: *Reliability Requirements*, Page 12.

¹³⁸ Baltimore Gas and Electric. "Peak Load Contribution (PLC) Overview." Source: https://supplier.bge.com/LoadProfiles_EnergySettlement/plcoverview.htm

¹³⁹ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 2.4: *Reliability Requirements*, Page 12.

¹⁴⁰ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 4.3.7: *Determination of Nominated Value for Load Management*, Page 49.

resource has elected to bid into the market. Also, there are different calculations for each of the three load management options, Firm Service Level (FSL), Guaranteed Load Drop (GLD, and Direct Load Control (DLC), which are described in detail in Table 25.

$$(1) \text{ Nominated } ICAP_{FSL} = \text{Peak Load Contribution} - (\text{Managed Load} * \text{Capacity Loss Factor})$$

$$(2) \text{ Nominated } ICAP_{GLD/DLC} = \text{Managed Load} * \text{Capacity Loss Factor}$$

$$(3) \text{ Nominated } UCAP = \text{Nominated } ICAP * \text{DR Factor} * \text{Forecast Pool Requirement}$$

$$(4) \text{ Annual Revenue} = \text{Nominated } UCAP * \text{Market Price} * \text{Days per Year}$$

5.4.2 Market Price

The market-clearing price for capacity in the RPM is determined in much the same way as in other markets, by the intersection of supply and demand. In this case demand is predetermined by the market operator and is expressed in the form of a downward sloping demand curve that is known as the variable resource requirement (VRR). The VRR is established for the RTO as a whole and for each Locational Delivery Area (LDA) using two specific parameters: the Installed Reserve Margin (IRM), and the cost of New Entry (CONE). Table 13 below gives brief definitions of LDA, IRM, and CONE, with more detailed descriptions given in the related references. In general the VRR curve is set forth by PJM to elicit the correct amount of capacity in a given region at the correct price.

Table 13: Variables used in the determination of market-clearing prices

Variable	Units	Abbreviation	Definition
Cost of New Entry ¹⁴¹	\$/MW-Day	CONE	The estimated cost of bringing a new combustion-turbine online in the specified zone.
Installed Reserve Margin ¹⁴²	%	IRM	A measure used to calculate the amount of installed capacity needed to ensure reliability.
Locational Delivery Area ¹⁴³	-	LDA	A sub-region within PJM that is defined as being constrained by having inadequate transmission or generation to meet the reliability requirement.

5.4.3 Market Price Estimation

Given that the capacity market in PJM has only been in operation since the 2007 demand year, there is only a limited amount of historical data on market-clearing prices. Additionally, PJM's territory has changed since the implementation of the RPM, meaning that some zones have come or gone, leading to further inconsistencies in the data. Thus, the *Revenue Calculator* utilizes a simple historic average of zonal market-clearing prices to forecast the zonal prices in the subsequent auction.

¹⁴¹ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 3.3.1: *Cost of New Entry*, Page 17.

¹⁴² PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 2.1.1: *Installed Reserve Margin*, Page 7.

¹⁴³ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 3.3: *Parameters of the Variable Resource Requirement*, Page 16.

Figure 19 below shows the historical capacity prices in each PJM zone since the market's inception in the 2007 demand year. These prices show clear variability over time, but the market clearing prices in the 2014 and 2015 seem to be converging around the middle of the range of prices. This observation suggests that prices in the RPM are stabilizing.¹⁴⁴

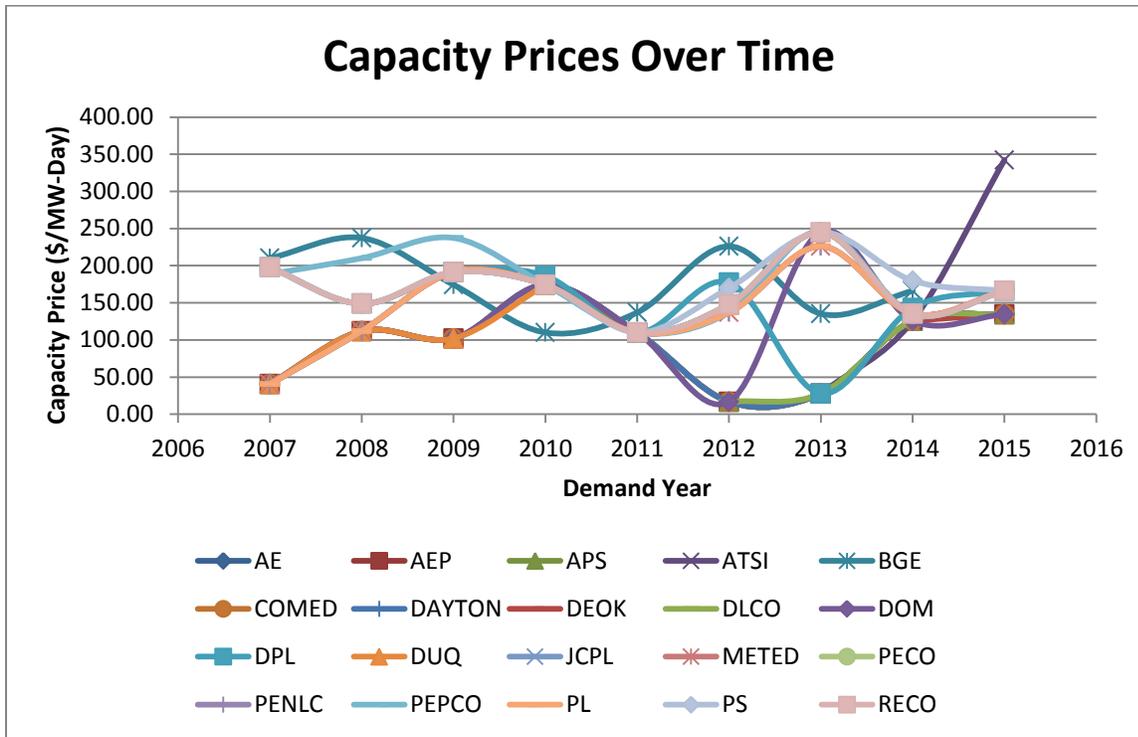


Figure 19: Zonal Capacity Prices Over Time

The *Revenue Calculator* utilizes the above data and the historical average to make a prediction of what the market-clearing price in the RPM will be in the 2016 demand year. Unfortunately, the capacity market in PJM has only been through nine iterations and some zones, such as ATSI, have only been added to the market recently. This means that there is a very limited amount of data on which the price forecasts can be made. For this reason, the forecast for the base market-clearing price in each zone was assumed to be the average of the historical non-LDA prices for that particular zone. This was done to allow for users to select whether their particular zone had been designated as an LDA for the 2016 demand year auction, and thus avoid the assumption that certain zones would remain constrained or non-constrained. Table 14 below shows the statistics of historic zonal market-clearing prices.

¹⁴⁴ PJM Auction User Information: *Delivery Year 2007/2008 – 20015/2016*. Source: <http://www.pjm.com/markets-and-operations/rpm/rpm-auction-user-info.aspx>

Table 14: Average, Minimum, Maximum, and Standard Deviation of historical non-LDA capacity prices

Zone	Average Zonal Capacity Price (\$/MW-Day)	Minimum Zonal Capacity Price (\$/MW-Day)	Maximum Zonal Capacity Price (\$/MW-Day)	Standard Deviation Zonal Non-LDA Average Capacity Price (\$/MW-Day)
AE	142.15	110.00	174.29	32.15
AEP	93.79	16.74	174.29	50.50
APS	92.76	16.74	174.29	53.47
ATSI	76.83	27.73	125.94	49.10
BGE	142.15	110.00	174.29	32.15
COMED	93.79	16.74	174.29	50.50
DAYTON	93.79	16.74	174.29	50.50
DEOK	130.28	125.94	134.62	4.34
DLCO	76.26	16.74	134.62	54.25
DOM	117.94	16.74	245.09	63.45
DUQ	129.42	102.04	174.29	31.99
DPL	110.00	110.00	110.00	0.00
JCPL	142.15	110.00	174.29	32.15
METED	109.25	40.80	174.29	47.23
PECO	142.15	110.00	174.29	32.15
PENLC	109.25	40.80	174.29	47.23
PEPCO	157.61	110.00	188.54	34.16
PL	109.25	40.80	174.29	47.23
PS	142.15	110.00	174.29	32.15
RECO	142.15	110.00	174.29	32.15

One of the key determinations of the price that a demand resource could receive for their capacity within the RPM is their location within PJM’s territory. Prior to the auction, PJM designates particular regions as being capacity constrained, meaning that there is either insufficient generation or transmission resources to reliably meet peak demand. The regions are deemed Constrained Locational Delivery Areas or LDAs. In an effort to signal additional resources to these areas, PJM defines individual VRR curves for each of these areas. These curves represent a higher capacity target for the area and thus a higher price for that capacity.¹⁴⁵

As mentioned above, the *Revenue Calculator* uses historic non-LDA prices to create a base market-clearing price forecast each zone. In order to account of the higher prices that are seen in zones located

¹⁴⁵ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 2.3: *Locational Constraints in the Reliability Pricing Model*, Page 10.

within an LDA, an estimate for a price adder was made using a difference of means and confirmed with a one-sided T-Test. Average LDA market-clearing prices were compared with average non-LDA market-clearing prices and determined to be approximately \$69.32 higher. This difference was confirmed to be significant by a one-sided T-Test p-value > 0.01 . Thus, should the Revenue Calculator user indicate that their zone has been defined as an LDA; the forecast market-clearing price will be the base price for that zone plus the \$69.32 LDA adder.

Additionally, beginning in the 2014 demand year auction, demand resources have been given the option to select one of three product types: Limited Summer DR, Extended Summer DR, and Annual DR. These products carry varying hours during which participating resources may be called to perform, with Extended Summer and Annual DR products carrying an increasing number of hours that a resource would be obligated to curtail load should they be called to do so. Accordingly, the Extended Summer and Annual DR are afforded additional payments to Limited DR. The history of these additions, however, is extremely limited and thus it is very difficult to forecast what the price increase associated with selecting these products might be in the future. For the purpose of the Revenue Calculator, the mean of historical prices was used estimate what the prices for Extended Summer and Annual DR products might be.

5.4.4 Inputs

The *Revenue Calculator* was designed to be a user-friendly application for producing a rough estimate of the monetary gains that could be made from participation as a demand resource in PJM's capacity market. To this end, the interface is quite straight-forward, and requires only minimal input from the user regarding the amount of load the user would like to nominate into the auction. Shown below is a screen shot of the user-input screen (Figure 20).

Enter Delivery Year of Auction	
Delivery Year*	2016
<small>*Enter the first calendar year of the delivery period (ie DY 2016/2017 = 2016)</small>	

Enter Your PJM Zone	
COMED	▼

Enter Curtailment Potential	
Peak Load Contribution (MW)**	10
Load To Place Under Management (MW)***	5
<small>*Obtained from you LSE</small>	

Select Load Management Type	
Guaranteed Load Drop	▼

Select Product Type	
Limited DR	▼

Planning Period Parameters***	
Forecast Pool Requirement	1.0902
Demand Resource Factor	0.955
Zone Designated as LDA	Yes ▼
<small>***Planning Period Parameters are available on the PJM website begin Feb. 1 of the auction year</small>	

Figure 20: User input screen of the Revenue Calculator

In this screen the user is prompted to enter basic information needed for revenue calculation, such as their zone within PJM, their peak load contribution, and the amount of load reductions they would like to bid into the auction (see Section 6.2 for a discussion of how they might attain a reasonable estimate of potential load reductions). Further down the screen the user would be prompted to select one of the three load management options mentioned above, as well as the demand response product type they desire. Finally, the user is asked to enter the values for Forecast Pool Requirement and Demand Resource Factor from the Planning Period Parameters, which are released in February prior to the base auction. Direct input of these values allows for a more accurate estimation of revenues and they are readily available to any potential market participant. Also included in these planning period inputs is a drop-down for selecting whether the user's zone has been designated as an LDA for that auction or not.

5.4.5 Outputs

Once the user has input all the relevant information, the *Revenue Calculator* utilizes the equations mentioned in Section 5.4.1 above, along with the appropriate forecasted market price and any appropriate adders for LDA or DR product, to produce an estimate of the revenue potential for a specific demand resource. The user would see displayed this estimation along with brief descriptions of the selected load management type and DR product selected. Additionally, the user is given a simple estimation of costs based on the membership fees associated with participation in the RPM and an assumed \$15,000 in personnel costs necessary to employ someone to manage the logistics of operating as a demand resource. Finally, a bar graph representing the base, high, and low estimates for revenue is produced based on a

75% confidence interval for the appropriate market price. Figure 21 below shows a screen-shot of the outputs interface a user of the Revenue Calculator would be presented with.

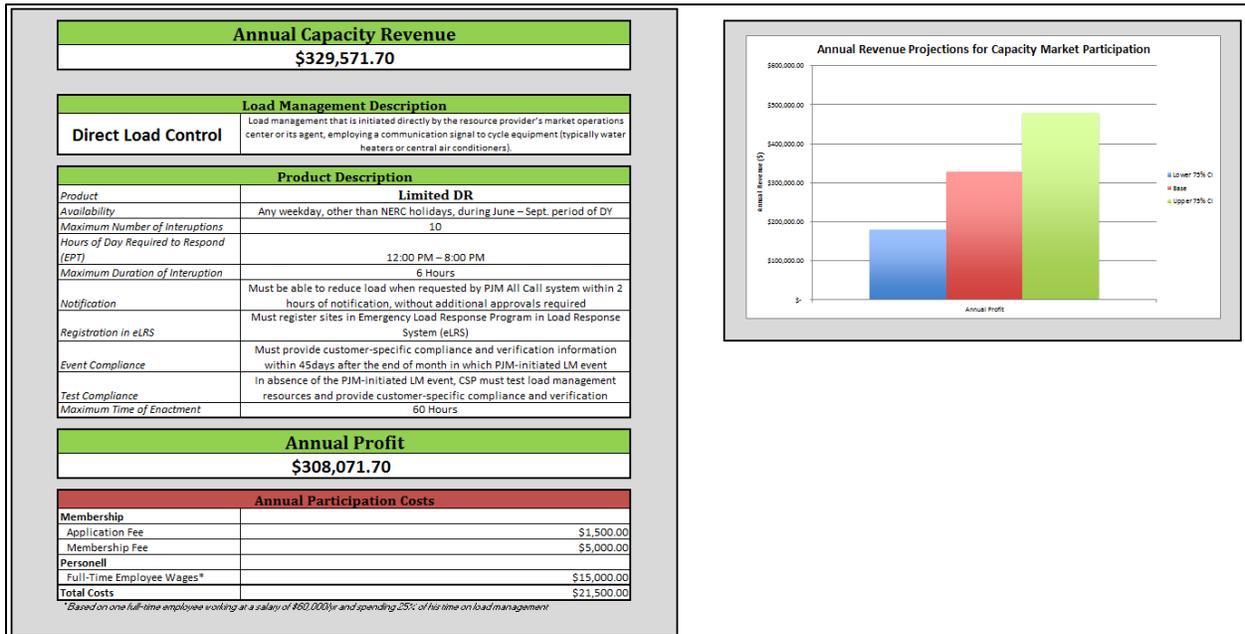


Figure 21: Output screen of the Revenue Calculator

5.4.6 Scenario Analysis

In order to gain additional insights from the Revenue Calculator, a number of unique scenarios were run to determine the changing revenues that a potential consumer might expect. In all cases a representative demand resource was modeled with a peak load contribution of 10MW and varying amounts of load nominated for management from 0.1 to 10MW. Note that revenues level off in the scenarios where the resource has reached its maximum unforced capacity level (in this case approximately 9.3MW).

Figure 22 below shows a comparison of how revenues might differ depending on the user selecting amongst the different demand response products. As might be expected users that allow themselves the possibility of being called upon for a greater number of hours during the year are accordingly compensated to a higher degree.

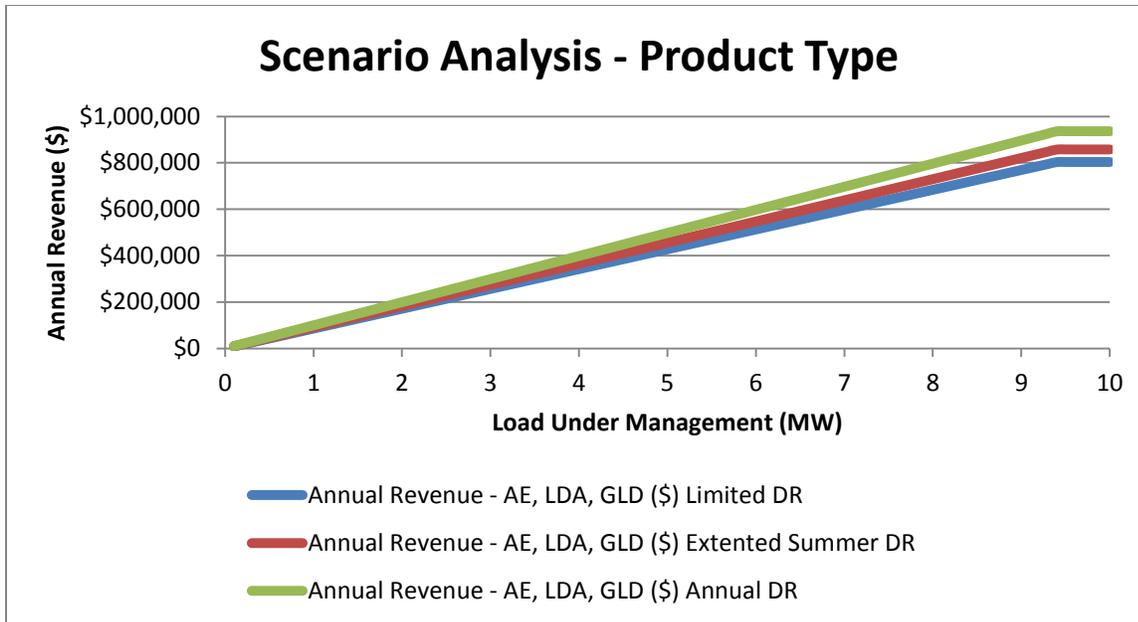


Figure 22: Analysis of the effect of product type on revenue

Additionally, Figure 23 below gives a visual comparison of the revenue increase that a demand resource might expect if it were to be located in a designated LDA zone versus an unconstrained area. Clearly the LDA adder makes revenue potential in these areas significantly higher, with the estimated maximum potential revenue for a 10MW PLC customer being \$936,315 were the AE to be defined as an LDA, versus \$540,174 if that same customer were in an unconstrained zone.

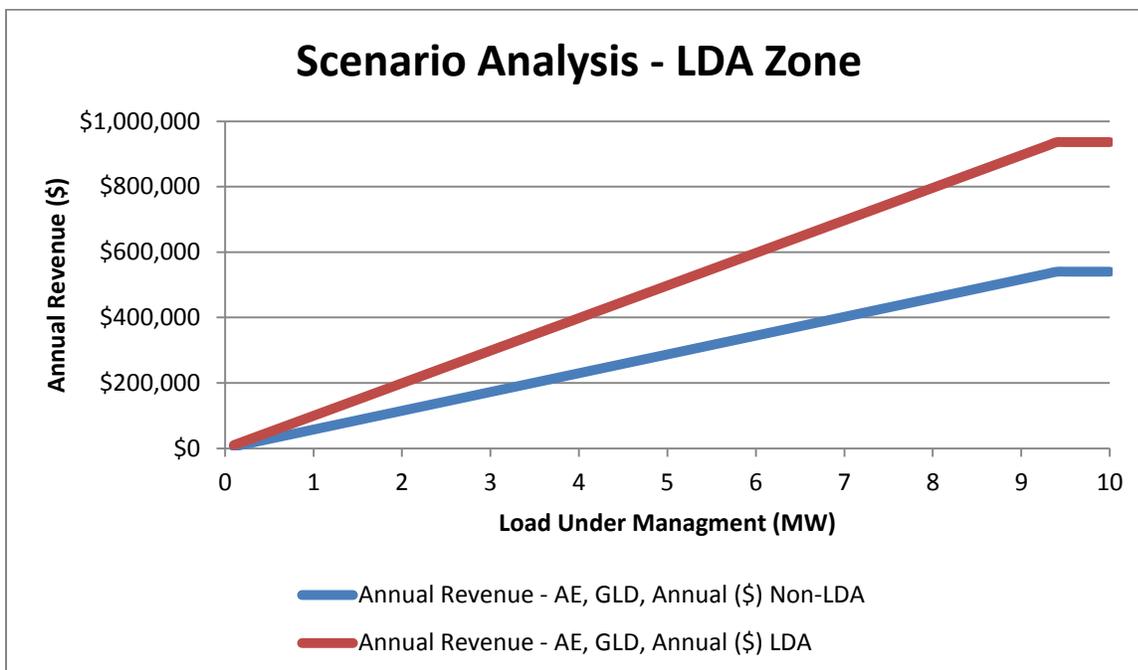


Figure 23: Analysis of the effect of LDA on revenue

Finally, given that revenue estimation in the Revenue Calculator is derived from a forecast model based on historical prices, it is inherently never going to predict the exact market-clearing prices that will

actually occur in the market. For that reason it is worthwhile exploring the best and worst cases of market prices to get an understanding for the complete range of potential revenues. Figure 24 below shows an example of the potential revenue for a hypothetic demand resource given the absolute minimum (corresponding to \$16.74/MW-Day in multiple zones during the 2012 DY) and absolute maximum (corresponding to \$377.23/MW-Day for an Annual DR Resource in ATSI during the 2015 DY) market prices that have been observed in the past.

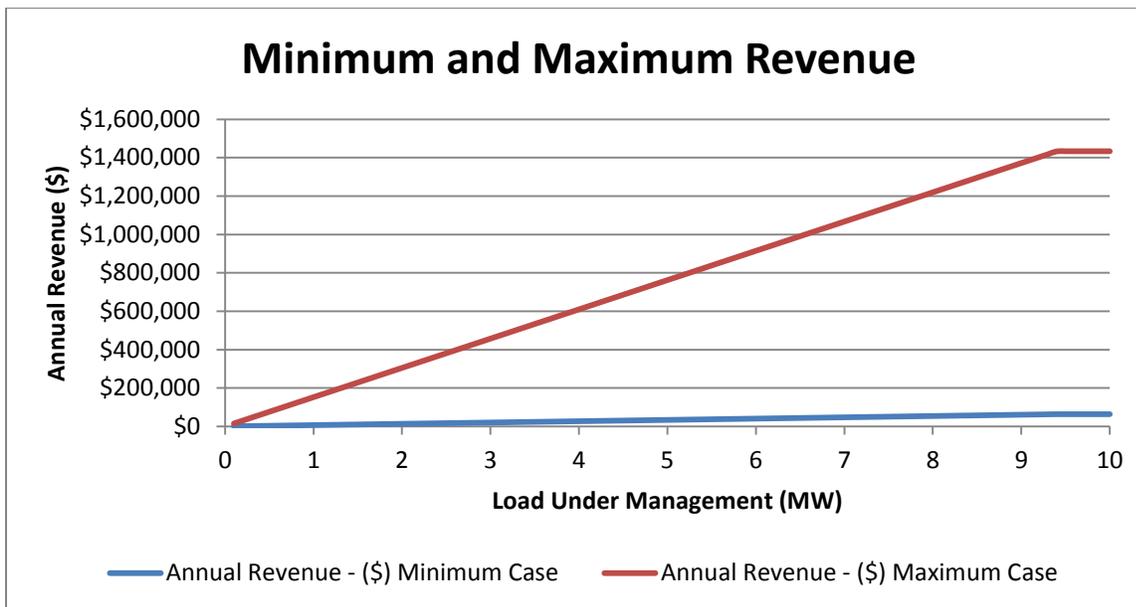


Figure 24: Analysis of minimum and maximum historic capacity prices

5.4.7 Alternative Market Price Estimation

As stated in Section 4.5.2, the purpose of the PJM capacity market is to provide incentives to attract and retain generation to ensure that there are adequate resources available to meet the highest levels of demand while maintaining the reliability criterion of a loss of load expectation of once in ten years.¹⁴⁶ The decision support tool provided in Section 5 offers an estimation of potential revenues for a demand resource participating in this market using a next-year price forecast based on historical data. The *Revenue Calculator* assumes that upfront costs of becoming a demand resource are so low as to be essentially negligible. While this may be a reasonable assumption for the majority of institutions, some others may need to consider significant capital expenditures in order to enable load curtailment. To justify incurring significant capital expenses such institutions will need to forecast long term revenues and therefore may wish to have a deeper understanding of the theory behind the capacity market and the mechanism of capacity payments. This section attempts to provide greater insight into the PJM capacity market and offers an alternative technique for estimating the long-term compensation that a resource might expect.

In order to understand the structure of capacity markets, it is important to remember some of the history of the electric utility industry. From the inception of the industry until the mid-1990s, generating resources were built and owned by utilities best classified as government-regulated monopolies.¹⁴⁷ These

¹⁴⁶ PJM Manual 18: *PJM Capacity Market*. Revision: 17, Effective Date: 12/20/2012. Section 2.3: *Locational Constraints in the Reliability Pricing Model*, Page 10.

¹⁴⁷ Geddes, R. Richard. *A Historical Perspective on Electric Utility Regulation*. CATO Review of Business and Government. 1992.

utilities were allowed to receive compensation from the sale of electricity based only on the variable costs associated with production, and with return for their investment in infrastructure collected through a separate demand charge on customer's bills.¹⁴⁸ As explained earlier in this document, today, electricity markets have been restructured and vertically integrated utilities have given way to an increase in independently owned generation. These generators, however, are still subject to receiving payments based on their marginal costs of producing energy, which is insufficient to cover all the associated capital, financing, and fixed operating and maintenance costs.¹⁴⁹ For this reason, resources wishing to enter the market must rely on capacity payments to supplement their revenues and cover their fixed costs.

PJM attempts to offer resources this "missing money" by allowing them to participate in a forward capacity market. Unfortunately, the current structure of the RPM only provides resources with a price signal for a single year, while investors will be concerned with the payments that they can expect over the lifetime of their asset. Therefore market participants may need to develop a model of the capacity market that allows forecasting long-term price signals. Understanding the RPM market mechanism can facilitate such process.

Like many other markets, prices in RPM are determined by the intersection of supply and demand. PJM determines the market's demand for capacity, or the Variable Resource Requirement (VRR), based on the Cost of New Entry (CONE) and the Installed Reserve Margin (IRM). The CONE value represents an estimate of the levelized capital and fixed operating costs of bringing a new natural gas combustion turbine (NGCT) online within the PJM territory. By subtracting the energy and ancillary services earnings a typical NGCT might expect based on an estimated number of operating hours, the additional revenue required to meet fixed and costs can be calculated. This difference between expected and needed revenues represents the amount that a new generator would need to earn through capacity payments to find the PJM market profitable. Given that the goal of the capacity market is to attract this type of investment, long-term capacity payments can be assumed to roughly equal this additional revenue requirement of a NGCT.¹⁵⁰ Therefore, anyone interested in estimating the long-term capacity revenues would be well served by estimating the costs of associated with NGCT through the use of the Integrated Environmental Control Model¹⁵¹, the U.S. Energy Information Administration's Levelized Cost of New Generation Resources Outlook¹⁵², or the Brattle Group's CONE report.¹⁵³

5.4.8 Environmental Impacts

Recently, colleges and universities have begun to place an increased emphasis on managing their environmental impacts. As a result, they have realized both financial benefits in the form of cost savings, as well as improved public-perception from becoming more environmentally friendly. While the above sections make clear the financial incentives of DR, the environmental benefits available to institutions are less transparent. This section provides a brief analysis of the potential impacts DR could have on the environment in the short and long terms.

Initially, the dispatch of a demand resource in response to an emergency event means that conventional power generating units are not required to ramp-up or turn-on to match the increased load. Avoiding this

¹⁴⁸ Griffith, Mark. *Capacity Markets Demystified*. Published: October 2008 by Ventyx.

¹⁴⁹ Griffith, Mark. *Capacity Markets Demystified*. Published: October 2008 by Ventyx

¹⁵⁰ Griffith, Mark. *Capacity Markets Demystified*. Published: October 2008 by Ventyx

¹⁵¹ Carnegie Mellon University. *Integrated Environmental Control Model*. Source: <http://www.cmu.edu/epp/iecm/>

¹⁵² U.S. Energy Information Administration. *Levelized Cost of New Generation Resources in the Annual Energy Outlook 2012*.

¹⁵³ The Brattle Group. *Cost of New Entry Estimates for Combustion Turbine and Combined-Cycle Plants in PJM*. 8/14/2011.

peaking generation reduces fuel consumption and consequently also reduces the corresponding air emissions.

Further, because DR can respond quickly to mismatches between electricity supply and demand it will facilitate integrating into the grid variable and intermittent energy resources such as wind and solar. Also, DR may further contribute to integrating these renewable sources and reducing emissions by shifting load from peak hours to the hours of day that these variable energy resources are operating at their highest capacity.¹⁵⁴

In the mid-term, DR reduces the need for additional infrastructure investment to meet increasing demand over time. The peak-reductions afforded by widespread DR negate the need to build either new transmission lines or generators that would only operate during a few of the highest demand hours during the year. These changes lead to reductions in impacts from the procurement of this infrastructure.

Conversely, DR can have some detrimental long-term environmental effects. First, delaying the build-out of new infrastructure postpones the replacement of older, dirtier plants. Also, utilizing DR to meet peak load only affects the generation mix during a few hours during the year, while if a new natural gas combined cycle plant were built, it would likely participate in the energy market and would be called upon to run for a higher percentage of hours, displacing older and dirtier generation.¹⁵⁵

Additionally, it is important to consider the fact that PJM allows demand resources to use behind-the-meter generation, which usually takes the form of emergency diesel generators, to meet load curtailment requirements rather than shedding load. Given the US Environmental Protection Agency's recent decision to increase the annual hours this type of generation is allowed to run, DR may not be producing its anticipated environmental impacts.¹⁵⁶

Finally, it is worth considering the impacts that DR is having on prices and both the positive and negative results. The integration of DR in the PJM capacity market has led to drastic reductions in the market-clearing prices in the past, dropping from \$40.15/kW-yr in 2011/2012 to just \$6/kW-yr in 2012/2013.¹⁵⁷ As mentioned above this discourages the construction of new generation of all kinds. Were a variable resource, such as wind or solar attempt to enter the PJM territory they would likely need to be compensated for more than just the energy they produced, and lower capacity prices would make it more difficult for these projects to become economically viable.

Clearly, there are a variety of factors that will determine the exact effects DR will have on the environment, and in order to ensure that DR achieves its positive potential outcomes additional regulations are going to be required. Closely monitoring the amount of backup generation used to meet curtailment obligations will ensure that DR is truly a clean energy source rather than a marginally less, or even more emitting than the current generation mix. Incorporating strict minimum and maximum bids for capacity will help keep prices in line, and strong air quality standards and aggressive renewable portfolio standards will be required to ensure a more environmentally friendly generation portfolio in the future.

¹⁵⁴ Ruscoe, A.G.; Ault, G. *Supporting High Penetrations of Renewable Generation Via Implementation of Real-Time Electricity Pricing and Demand Response*. IET Renewable Power Generation. 4.4 (2010): 369-382.

¹⁵⁵ Hibbard, Paul. *Reliability and Emission Impacts of Stationary Engine-Backed Demand Response in Regional Power Markets*. Analysis Group. 8/2012.

¹⁵⁶ U.S. Environmental Protection Agency. *National Emissions Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines; New Source Performance Standards for Stationary Internal Combustion Engines*. Federal Register. 1/30/2013

¹⁵⁷ King, Chris. *How Demand Response Cuts Wholesale Power Costs*. E-meter.com. 7/24/2012

6 Conclusion

6.1 General Conclusions

Institutions such as colleges and universities typically have large electricity loads, and some degree of flexibility in their usage patterns. This makes them prime candidates for participation in DR programs. With a large number of institutions located within their territory, and robust markets available to demand resources, the PJM RTO/ISO offers these customers an opportunity to earn incentives and contribute to realization of the environmental and greater economic benefits of demand response. Unfortunately, information about how to participate is difficult to understand for those unfamiliar with wholesale electricity markets. In striving to empower customers with the knowledge of how to get involved in PJM's DR programs and the associated benefits of participation, this project focused on developing a comprehensive resource that offered (1) a framework of the regulatory structure surrounding the PJM markets, and (2) a tool for estimation the revenue potential participating in demand response had for an individual customer. Creation of this guide has yielded insights into both DR in general, as well as its role within the PJM's wholesale electricity markets. Additionally, analysis of revenue potential for a demand resource in the capacity market has produced some conclusions about the economic benefits that an institutional customer may obtain.

DR has clearly evolved significantly since its origins as simple wink-and-nod deals with utilities biggest customers, and has become an integral part of PJM's wholesale electricity markets, providing increased reliability of the transmission network during times of high stress, and helping to lower electricity prices by negating the need for additional generation resources. The importance of DR with PJM can be seen in how it is contributing in all resource categories, from capacity, to real-time energy, to ancillary services.

Additional, it is important to recognize that PJM offers its members a wide variety of registration options designed to accommodate the capabilities of individual demand resources. Thus, a wide range of customers will be able to find a service that they can perform as a demand resource. One major difference that is important for potential demand resources to keep in mind is that enrollment in the Economic program requires only voluntary reductions in load to earn incentives, whereas enrollment in the Emergency program carries the obligation of making specific load reductions when called on to perform. Failure to meet these obligations in the Emergency program carries the repercussion of being forced to pay non-performance penalties. This increased risk exposure in the Emergency program is balanced with generally higher payments than the less-risky Economic program.

Given the plethora of registration options available to demand resources in the PJM markets, and complex nature of participation, enticing institutions towards participation will likely require some determination of the benefits available to them. To this end, the Revenue Calculator created as a part of this study aims to support potential customers in their decision to become a DR resource. Results produced by the Revenue calculator show that participation in PJM's capacity market does indeed result in economic benefits, which corresponded directly to the amount of useful capacity a resource is able to provide. Thus, larger institutions stand to gain greater revenues from the RPM. It is also worth noting that PJM places additional value on resources in constrained areas, and according those resources located in zones that are determined to be Constrained Location Delivery Areas stand to gain increase revenues when compared to unconstrained zones. Additionally, PJM provides greater compensation to those resources that select to be available to perform a greater number of hours during the year by choosing to participate in Extended Summer or Annual DR products. Finally, analysis of market-clearing prices in the RPM shows a high degree of variability historically, but recent auctions suggest that they may be gaining stability. This increased price stability may make it easier for potential demand resources to predict their individual benefits and thus encourage their registration.

6.2 Further Research

While this guide offers institutional electricity customers both a detailed framework of the rules and regulations of PJM's demand response programs, and a user-friendly tool to estimate the revenue potential of participation in the capacity market, it could be further improved to include additional resources. Of particular interest to institutions considering become demand response providers would be a technique for determining what load reductions could be actualized and offered into the markets, as well as a method for assessing the reactions of stakeholders forced to make behavioral changes. Finally, the Revenue Calculator tool could be both expanded to include additional markets, and improved in its abilities to forecast market prices.

Considering that participation in demand response, by definition, requires a customer to draw less electricity from the grid during times when demand is at its highest, an in-depth knowledge of their current energy consumption, as well as an understanding of how and when reductions in that consumption could be made, would be imperative to DR participation. A Curtailment Model would effectively accomplish each of these tasks. Creation of such a model would first require gathering data about the building(s) that a customer would be placing under management. This would include determination of the typical load pattern throughout the day and the year, as well as what operations or equipment was responsible for consuming that load. Production of an energy model using software such as Trace 700 would likely be helpful in making these determinations.¹⁵⁸ Next, an identification of which of loads were non-essential during certain time periods would be necessary in figuring out the extent of the reductions that could be made at any given time. At this point it would be possible to match the load reductions possible at the customer's site with the PJM market and program that best fit their capabilities.

Realization of the load reductions mentioned above without the use to behind the meter generation would likely require significant changes in operations and behaviors for most institutional customers. In considering implementation of a demand response program, most institutions would be well served by assessing how these changes affected the various stakeholders involved. This would entail surveying groups such as students, faculty, facilities and maintenance staff, and administration, to gather information on how these reductions would affect their day-to-day behaviors and whether they would be amenable to such changes. Implementation of a demand response program that had modest returns, but caused major disruptions to primary operation or greatly diminished the quality of life on campus, would likely not be received well nor would it be very successful.

Currently, the Revenue Calculator included in this guide utilizes historical prices to make a forecast for the next market-clearing price in the RPM. While this provides a relatively accurate estimate of what prices can be expected, it is unable to take into account any confounding factors. For example, the prices in demand year 2012 were unusually low likely because of the 2008 economic downturn and subsequent reductions in energy use. Such anomalies will always be problematic for forecasting models, but the estimation of market prices may be improved by accounting for factors outside of the market, such as the state of the economy.

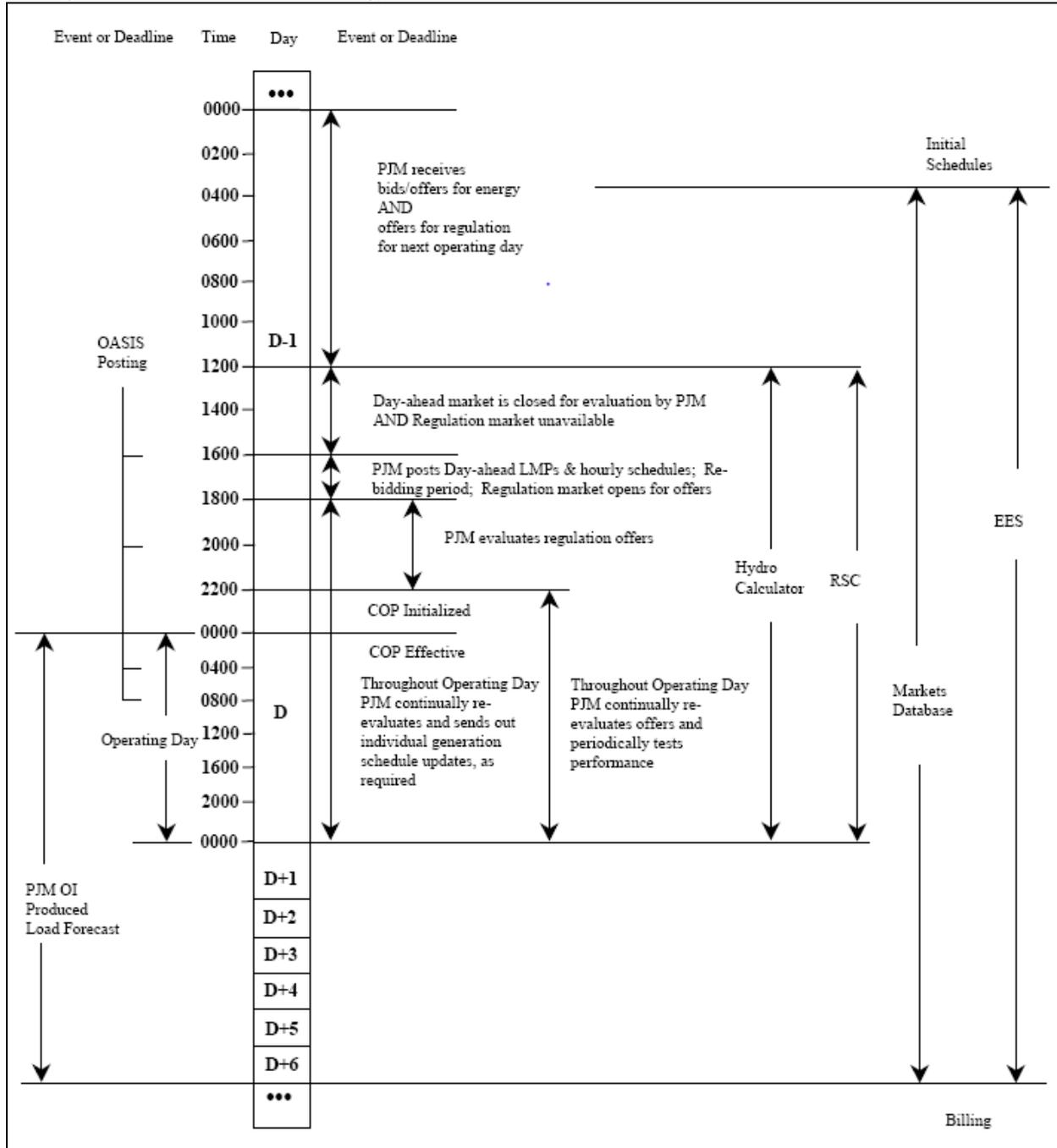
Finally, given that the capacity market has accounted for the vast majority of revenue demand resources have received from PJM in the past, and it continues to gain participation from DR it was the logical choice for initial study. It would, however, be very useful to create a tool that assessed the revenue generation potential of participating in the energy markets and Economic Load Response program. With load curtailments being completely voluntary in these programs and thus carrying no penalties for non-performance, institutions would be exposed to less risk. Additionally, the different registration options available in the Economic program could allow for market participation with little to no up-front costs.

¹⁵⁸ Trane Analysis Tool: *Trace 700*. Source: <http://www.trane.com/Commercial/Dna/View.aspx?i=1136>

Both of these factors may be helpful in encouraging some hesitant institutions to more seriously consider becoming a demand resource. This type of analysis, however, would require a detailed knowledge of the cost to the customer of making load reductions, and comparing those marginal costs of reducing with the hourly LMP in their zone to determine what times it would be economically beneficial for them to make those curtailments.

Appendix A: Timing and Structure of PJM's Energy Market

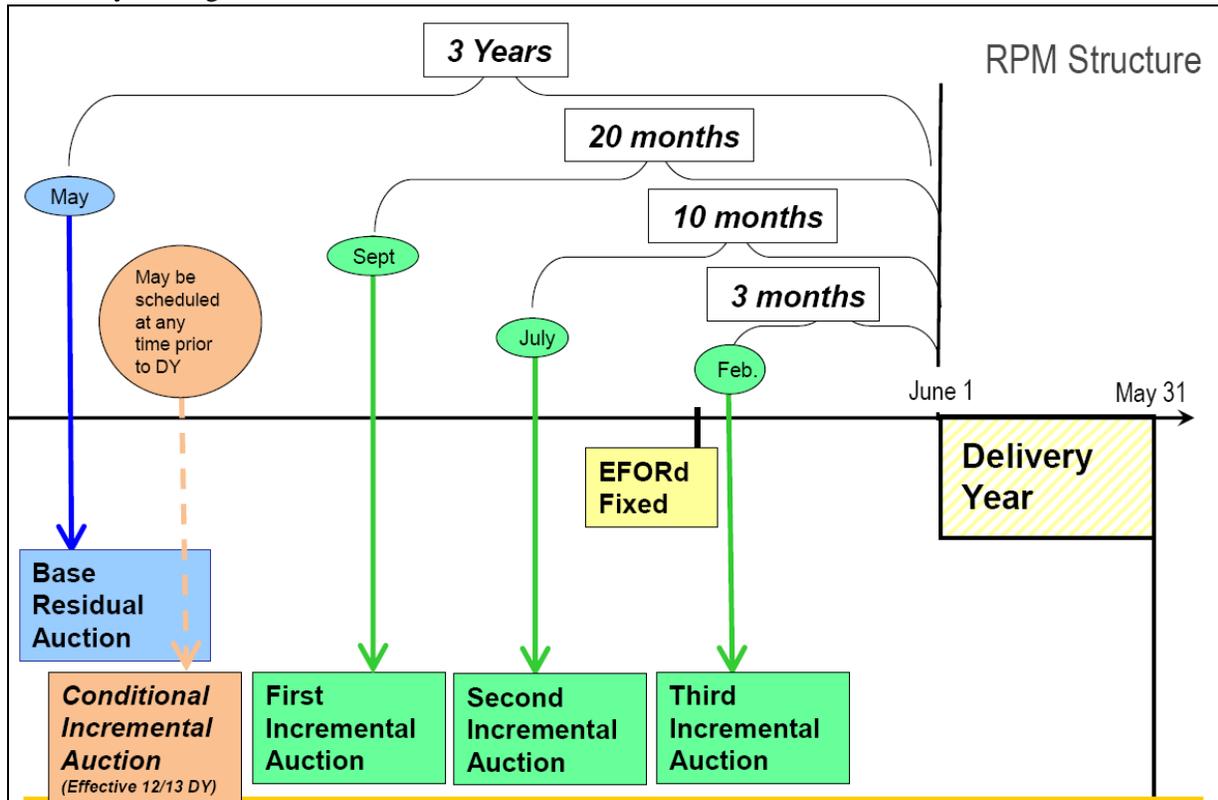
Timing and Structure of PJM's Energy Market:¹⁵⁹



¹⁵⁹ PJM Manual 11: *Energy & Ancillary Services Market Operations*. Revision: 56, Effective Date: November 29, 2012. Section 1: *Overview of Energy & Ancillary Services Market Operations*, Page 11.

Appendix B: Reliability Pricing Model Timeline

Reliability Pricing Model Timeline:¹⁶⁰

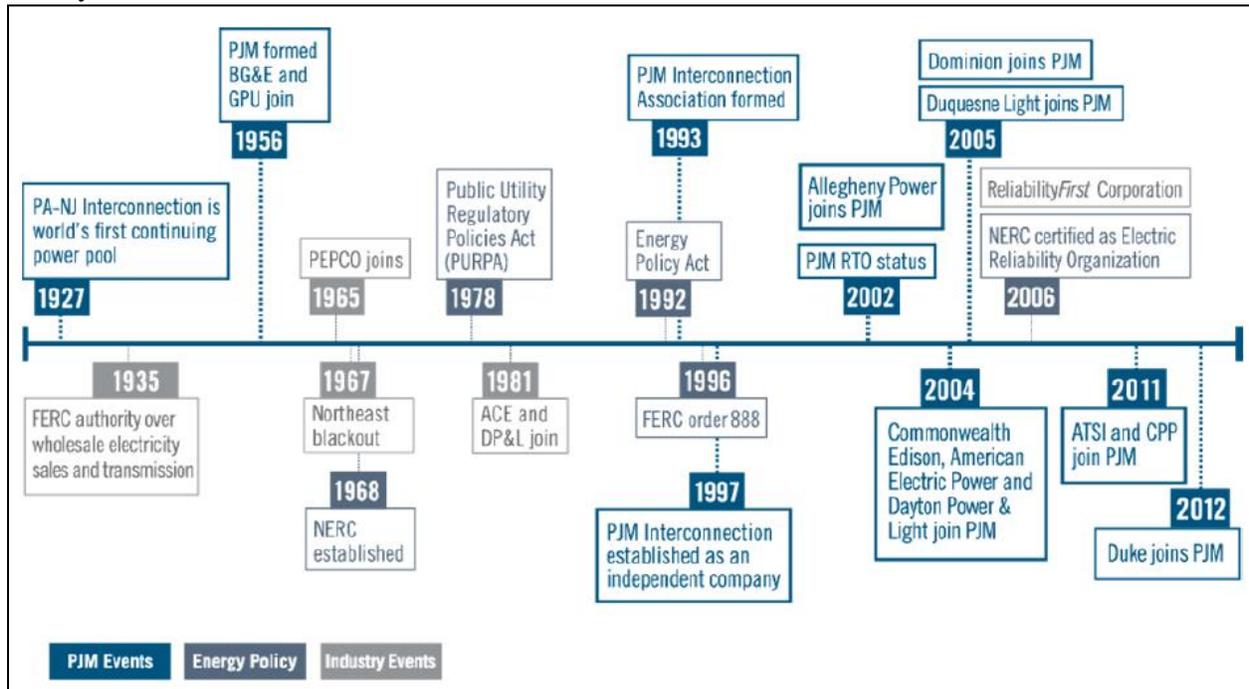


¹⁶⁰PJM Presentation: *Reliability Pricing Model Training*. 10/29/2012. Source:

<http://www.pjm.com/~media/training/core-curriculum/ip-rpm/rpm-training-section-a-c-intro-demand-and-supply-curve.ashx>

Appendix C: History of PJM

History of PJM:¹⁶¹



¹⁶¹ PJM website: *PJM History*. Source: <http://pjm.com/about-pjm/who-we-are/pjm-history.aspx>