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November 21, 2019

**Delivered by Email, RESS and Courier**

Ms. Christine Long, Registrar and Board Secretary
Ontario Energy Board
P.O. Box 2319, 27th Floor
2300 Yonge Street
Toronto, ON M4P 1E4

Dear Ms. Long:

**Re: Application for Review of an Amendment to the Independent Electricity System Operator Market Rules**
**Board File No. EB-2019-0242**
**Kingston CoGen Limited Partnership – Revised Figures to Affidavit Evidence**

Upon subsequent review of the Affidavit of Brian Rivard, filed on November 8, 2019 in the subject proceeding, Dr. Rivard noted that there were inadvertent errors in some figures included therein.

In particular, Figures 1 through 4 in the evidence as filed contain the following errors:

- The tables in Figures 1 through 4 refer to “ABC Corp.” and “XYZ Corp.” but should instead refer to “DR Corp.” and “GEN Corp.”, respectively;
- In Figures 3.A and 3.B, GEN Corp’s Marginal Cost in the table “With Generator” is listed as -$380. It should be -$320;
- In Figure 4.B, DR Corp’s Net IESO Settlement is listed as $10,200. It should be -$9,800. This error is carried down in the table “With Generator” for DR Corp. The calculations have been revised accordingly;
- In Figure 4.B, GEN Corp’s Net IESO Settlement is listed as -$200. It should be -$30,200; and
- The numbers in negative are in black. They should be in red, pursuant to paragraph 37.

Please find enclosed the updated Affidavit and a supplementary document containing only the revised figures to reflect these changes.

Yours very truly,

**BORDEN LADNER GERVAIS LLP**

Per:

*Original signed by Ewa Krajewska*

Borden Ladner Gervais

Ewa Krajewska

cc: John Vellone, BLG
John Windsor, Northland Power Inc.
James Hunter, IESO
Colin Anderson, AMPCO
Ian A. Mondrow, Gowling WLG
Michael Bell, OEB Staff
Intervenors of Record

**EB-2019-0242**

**IN THE MATTER OF** the *Ontario Energy Board Act, 1998*, S.O. 1998, c. 15, Sched. B, as amended;

**AND IN THE MATTER OF** an Application by the Association of Major Power Consumers in Ontario, pursuant to section 33 of the *Electricity Act, 1998, S*.O. 1998, c. 15, Sched. A and Rule 17 of the Ontario Energy Board *Rules of Practice and Procedure* for review of amendments to the Independent Electricity System Operator market rules related to the implementation of a Transitional Capacity Auction (MR- 00439-R00-R05).

**AND IN THE MATTER OF** a notice of motion by the Association of Major Power Consumers in Ontario, pursuant to section 33 of the *Electricity Act, 1998, S*.O. 1998, c. 15, Sched. A and Rule 17 of the Ontario Energy Board *Rules of Practice and Procedure* to stay the operation of amendments to the Independent Electricity System Operator market rules pending determination of the Application.

**AFFIDAVIT OF**
**Brian Rivard, Adjunct Professor at the Ivey Business School and Research Director of the Energy Policy and Management Centre, Western University**

**November 8, 2019**
**Revised: November 21, 2019**

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| N. | Exhibit “N” | Paper by David Brown and David Sappinton published in the Journal of Regulatory Economics in 2016 |

# TAB 1

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I, Brian Rivard, of the Town of Paris, in the Province of Ontario, MAKE OATH AND SAY AS FOLLOWS:

## A. INTRODUCTION

### *A.1 Q: Please state your name and occupation.*

1. My name is Brian Rivard. I am Adjunct Professor at the Ivey Business School at Western University and the Research Director of the school's Energy Policy and Management Centre.

### *A.2 Q: For whom are you testifying in this proceeding?*

2. I am testifying on behalf of Kingston CoGen Limited Partnership ("KCLP"). Attached hereto as **Exhibit "A"** is a signed copy of Form A pursuant to the Ontario Energy Board's (the "Board") Rules of Practice and Procedure.

### *A.3 Q: What is your educational background?*

3. I hold a Ph.D. and M.A. in Economics from Western University. My field of specialization is industrial organization with an emphasis on the study of competitive markets, economic efficiency, and regulatory economics. I also have a B.A. in Economics from the University of Windsor.

### *A.4 Q: What is your professional background?*

4. A copy of my curriculum vitae is attached hereto as **Exhibit "B"**. I began my career working as an Economist and then as a Senior Economist at the Canadian Competition Bureau. The Competition Bureau is the agency responsible for enforcing the Canadian *Competition Act* and protecting the Canadian economy against anti-competitive business conduct such as collusion or price fixing, abuse of dominant position, and anti-competitive mergers. My primary function as an Economist at the Competition Bureau was to conduct economic analysis in support of the Bureau's various enforcement actions.

5. After briefly working as a Senior Economic Consultant for the economic consulting firm, LECG, I joined the Independent Electricity System Operator ("IESO") (then called the Independent Electricity Market Operator) in 2000 as a Senior Economic Advisor in the Market Assessment and Compliance Division, reporting to the Market Surveillance Panel. Within this role, I was responsible for monitoring the Ontario electricity market for anomalous conduct, including abuses of market power or gaming, and for structural or market design deficiencies.

6. In 2006, I was promoted to Manager of Economics with the responsibility of conducting analysis of the effects of changes in wholesale electricity market design or government policy on the efficient operation of the IESO's wholesale market.

7. In 2010, I assumed the role of Manager of Regulatory Affairs and Sector Policy Analysis. In this role, I represented the IESO on the ISO-RTO Council ("IRC") as a member and Chair of the IRC's Market Committee. The IRC is a member group of North America's competitive wholesale market operators.[1] I was the Chair of the Market Committee at the time the United States Federal Energy Regulatory Commission (the "Commission") issued its Final Rule in Docket No. RM10-17-000, Order No. 745, *Demand Response Compensation in Organized Wholesale Energy Markets* ("FERC Order No. 745").[2]

8. In 2013, I was appointed the position of Director of Markets. As Director of Markets, I was responsible for evolving the design of the Ontario electricity market to ensure it operated fairly and efficiently. As Director, I oversaw the transition of the responsibility for administering demand response programs from the Ontario Power Authority

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[1] In addition to the IESO, the IRC includes the Alberta Electric System Operator ("AESO"), the California Independent System Operator Corporation ("CAISO"), the Electric Reliability Council of Texas, Inc., ("ERCOT"), ISO New England, Inc., ("ISO-NE"), the Midcontinent Independent System Operator, Inc. ("MISO"), the New York Independent System Operator, Inc. ("NYISO"), PJM Interconnection, L.L.C., ("PJM") and the Southwest Power Pool ("SPP").

[2] Being Tab 8 to the IESO's Book of Authorities in Response to AMPCO's Request for a Stay, dated November 5, 2019, available online at: http://www.rds.oeb.ca/HPECMWebDrawer/Record/657752/File/document [FERC Order No. 745].

("OPA") to the IESO. I initiated the design and implementation of the IESO Demand Response Auction ("DRA").

9. In 2015, I left the IESO to join Charles River Associates International as a Principal in their Energy Practice. I advised clients on a variety of issues, most notably competitive wholesale market design, market power and market manipulation issues.

### *A.5 Q: What is your current position?*

10. I am Adjunct Professor and Research Director of the Energy Policy and Management Centre for the Ivey Business School at Western University. My primary role at Ivey is to further the mission of the Energy Centre which is to:

    a. Contribute to energy policy-making through the production and dissemination of evidence-based research and analysis on major policy issues affecting the electricity, gas, oil and pipeline sectors in Canada;

    b. Provide a transparent and reliable forum for industry, government, academia, and interested stakeholders to discuss and exchange ideas on energy sector development and policy; and

    c. Educate students, executives, and government officials on national and global energy sector issues.

### *A.6 Q: What other professional experiences do you have?*

11. I serve as a peer reviewer for the Energy Journal. I am a Member of the International Association of Energy Economists. I am an occasional lecturer at Ryerson University and Osgoode Hall Law School.

### *A.7 Q: Have you previously submitted testimony before Board or other regulatory agencies?*

12. I provided oral testimony before the Board on behalf of the IESO in EB-2007-0040 (regarding the 3x Ramp Rate). I provided written and oral testimony before the

Commission on behalf of Shell Energy North America (US), L.P. in Docket No. EL02-71-057.

### *A.8 Q: What is the purpose of your testimony in this proceeding?*

13. I was retained by counsel for KCLP to review the Association of Major Power Consumers of Ontario's ("AMPCO") Notice of Appeal (the "Appeal") to Market Rule Amendments MR-00439-R00-R05 (the "Amendments") and supporting evidence, and to offer my independent views on the economic merit of AMPCO's position in this proceeding.

14. The Amendments enable the evolution of the IESO's DRA into a Transitional Capacity Auction ("TCA") that will allow non-contracted and non-regulated generators ("non-committed dispatchable generators") to participate in future capacity auctions alongside Demand Response ("DR") resources.

15. The focus of the Appeal is the appropriate level of compensation for DR resources. The IESO provides non-committed dispatchable generators an energy payment if / when the generators respond to an IESO instruction to produce energy based upon their offered price. Under the Amendment, DR resources will not receive an energy payment (or "utilization payment") when DR resources respond to an IESO instruction to reduce their energy consumption (an "economic activation").[3] AMPCO claims that this

[3] Application for Review of an Amendment to the Independent Electricity System Operator Market Rules, Notice of Appeal, EB-2019-0242, filed September 26, 2019, available online at: http://www.rds.oeb.ca/HPECMWebDrawer/Record/653723/File/document, at para. 12. The terms "energy payment" and "utilization payment" are used interchangeably in the proceeding material. For clarity, a ***utilization payment*** is a payment made to a demand response market participant that responds to an instruction from the system operator (IESO) to reduce the amount of electricity (energy) that they are consuming. The instruction from the IESO to a demand response resource to reduce energy consumption is referred to as an ***energy activation***. For this reason, utilization payments are sometimes referred to as ***activation payments***. Utilization payments at the wholesale market-clearing price are called ***energy payments***. A DR resource could receive an energy activation instruction from the IESO as part of the IESO's economic dispatch process, called an ***economic activation***, as a test of the DR resources capability, or for reliability or emergency reasons. The issue in the Appeal is compensation for economic activation. The IESO plans to compensate DR resources if the IESO instructs the resource to reduce consumption to test the resources capability or for reliability and emergency reasons.

represents inequitable and unfair treatment of DR resources, places DR resources at a competitive disadvantage to non-committed dispatchable generators in the TCA, and results in a TCA that is unfair and inefficient, and effectively anticompetitive and discriminatory. AMPCO also contends that the Commission, in FERC Order No. 745, has definitively recognized "that failure to compensate DR resources for such services is unjust and unreasonable."[4]

16. Counsel further asked that I address the issue the Board raised in Procedural Order No. 2. The Board stated that "it is particularly interested in receiving evidence that describes the experience with compensation for DR in markets in other relevant jurisdictions, and the extent to which that experience is informative in the context of the Amendments having regard to any pertinent differences such as differences in market design or structure."

17. Specifically, my evidence will:

   a. analyze the economic merit of AMPCO's assertions of inequitable and unfair treatment, competitive disadvantage, and the negative impacts on competition and efficiency; and

   b. identify pertinent similarities or differences between the United States wholesale markets and the Ontario market, such as differences in market design or structure, to inform the Board of the applicability of FERC Order No. 745 to Ontario and in the context of the Amendments.

### *A.9 Q: How is your testimony organized?*

18. The remainder of my testimony consists of three parts. In Part B, I offer my analysis of the economic merit of AMPCO's assertions. In Part C, I summarize the conclusions of FERC Order No. 745 and identify unique aspects of the Ontario market that should

[4] *Ibid* at para. 36.

inform a conclusion on the applicability of the Order to Ontario. In Part D, I provide my summary conclusions.

### *A.10 Q: What are your conclusions?*

19. In my opinion, the Amendments provide an equitable treatment of TCA participants. I give evidence that demonstrates the Amendments afford fair and equitable treatment to TCA participants, do not place DR resources at a competitive disadvantage to non-committed dispatchable generators, and promote fair and efficient competition to the benefit of Ontario consumers. I further conclude that the application of FERC Order No. 745 in Ontario will not achieve the effects the Commission intended when it issued its decision. This is due to several unique aspects of the Ontario electricity market, each of which I will speak to herein.

## B. AMPCO'S ASSERTIONS ARE VOID OF FACTUAL SUPPORT AND LACK ECOMOMIC MERIT

### *B.1 Q: What is your understanding of the basis of AMPCO's appeal?*

20. The basis of AMPCO's appeal is that generators receive a payment for energy services provided (economic activations) but DR resources do not. AMPCO asserts that this represents "an inequity in treatment between generation resources and DR resources."[5] AMPCO further asserts that this unequitable treatment puts "DR resources at a competitive disadvantage to generators"[6] in the TCA and would allow generators to "effectively and unfairly displace"[7] DR resources in the TCA. AMPCO concludes that this would "undermine competition"[8] and is "inimical to the IESO's own objective of

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[5] *Ibid* at para. 4.

[6] *Ibid* at para. 22.

[7] *Ibid* at para. 4.

[8] *Ibid* at para. 14.

enhancing competition for the benefit of consumers."[9] The failure to compensate DR resources for economic activations "would result in a capacity market that is unfair and inefficient, and effectively anticompetitive and discriminatory."[10]

### *B.2 Q: What evidence has AMPCO provided to establish competitive disadvantage?*

21. AMPCO's assertion of competitive disadvantage is articulated in the Affidavit of Mr. Colin Anderson at paragraphs 12 through 19. Mr. Anderson reasons as follows:

   a. In the existing DRA, the only revenue stream available to participants is a capacity payment (called an availability payment). There are currently no payments made for energy activations. If the TCA proceeds in December 2019, non-committed dispatchable generators will qualify for an availability payment and an energy payment when economically activated. DR resources will still only qualify for an availability payment.[11]

   b. Non-committed dispatchable generators will be able to submit a capacity offer into the TCA taking into account their anticipated energy payments. They will be able to set a capacity offer price that is lower by the amount of their anticipated energy payments. DR resources will not have the same opportunity.[12]

   c. DR resources incur "legitimate costs" when they are economically activated to curtail demand. If they do not receive an energy payment, they will not be able to recover these costs.[13]

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[9] *Ibid* at para. 25.

[10] *Ibid* at para. 45.

[11] Affidavit of Colin Anderson, sworn October 11, 2019, available online at: http://www.rds.oeb.ca/HPECMWebDrawer/Record/655144/File/document, at para. 12.

[12] *Ibid* at para. 14

[13] *Ibid* at para. 19.

d. DR resources will have two options on how to deal with this. First, they can include the anticipated cost of activation in their capacity offer price. This would put DR resources at a competitive disadvantage to non-committed dispatchable generators that do not have to include these costs in their capacity offer price. Second, they could omit including the anticipated cost of activation in their capacity offer price, but then risk not recovering these costs when economically activated.[14]

### *B.3 Q: If a market participant cannot recover legitimate cost in the market does that not place it at a competitive disadvantage to others that can recover their cost?*

22. From an economic perspective, if a DR resource incurs a cost when economically activated to curtail demand that it would ***avoid*** if it continued to consume, then it could be competitively disadvantaged by the Amendments. However, AMPCO has provided no factual evidence or even conceptual evidence that explains the nature, magnitude or legitimacy of these ***avoidable*** costs.

23. By contrast, a natural gas fired generator could provide both conceptual and factual evidence that it incurs a fuel cost when economically activated in order to produce energy that it can avoid (save) by not producing. This evidence is readily and publicly available, and is the basis for the energy payments made to these generators.

### *B.4 Q: Why does it make economic sense to pay a generator an energy payment for economic activation?*

24. In order to induce a generator to produce energy, it must receive a payment that allows it to recover its avoidable cost of activation. If it did not receive a payment, it would be in its economic interest not to produce to avoid incurring the fuel cost. To induce efficient energy production, the IESO pays generators the energy market-clearing price to cover these costs.[15] The market-clearing price is designed to reflect the cost to

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[14] *Ibid.*

[15] The IESO currently operates a "two-schedule" pricing and dispatch energy market, which is described in the IESO's "The Single Schedule Market Backgrounder." In the two-schedule system, the physical limitations of the

produce one more MW of electricity (marginal cost), or the value to reduce one more MW of consumption (marginal willingness to pay) on the system. Paying generators this price incentivizes only those generators whose avoidable cost of economic activation is less than the market price. This is how the IESO manages the efficient use of the province's generation assets.

### *B.5 Q: Based on your experience in the electricity industry, what types of costs might a DR resource incur with an economic activation?*

25. To my knowledge, the only cost that a DR resource may incur with an economic activation is the value of lost consumption, or what is sometimes called the value of lost load.[16] The value of lost load is the amount a consumer would be willing to pay to avoid disruption of service (i.e., to maintain its level of consumption). If a DR resource receives an energy activation when its value of lost load is greater than the price it would pay to consume, it would incur a legitimate cost from activation that it could have avoided if it had continued to consume. In this instance, the cost from activation would equal the difference between the value of lost load and the price the DR resource would have paid had it consumed.

### *B.6 Q: Does AMPCO provide evidence that DR resources are at risk of incurring this cost with an economic activation?*

26. No. In fact, the IESO market rules provide DR resources the means to manage this risk. Two types of DR resources can participate in the TCA and the IESO's energy market: dispatchable loads and Hourly Demand Response ("HDR") resources.

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system are ignored in the "pricing" schedule that sets an Ontario-wide market price and establishes the most economic set of resources to meet demand. This requires a second "dispatch" schedule that includes the physical limitations of the system. The result is there are times when resources who cleared the market based on economics are told they cannot proceed, and others that were initially unsuccessful are told they are required to run in order to reliably meet demand. The differences between the two-schedules requires a complex system of out-of-market compensation to some participants.

[16] Navigant's Demand Response Discussion Paper, being Exhibit "I" to the Affidavit of David Short, sworn October 25, 2019, available online at: http://www.rds.oeb.ca/HPECMWebDrawer/Record/656576/File/document ["Navigant Report"]. The Navigant Report considers the costs associated with curtailment of a DR resource. This is the only type of cost they identified.

27. Dispatchable loads submit hourly energy bids to the IESO that define the quantities of energy they are willing to consume at different price levels. They receive dispatch instructions from the IESO every 5-minutes based on these energy bids. When they consume, they pay the market-clearing price (the 5-minute price) for the amount they consume. When the market-clearing price is above the price in their energy bid, they receive an economic activation to reduce their demand as per the amount stated in their energy bid. Dispatchable loads that are successful in the TCA are eligible to receive an availability payment by submitting and maintaining energy bids in the day-ahead through to real-time markets during a defined availability window that changes between the summer and winter months but generally covers the expected peak demand hours on business days. The energy bid prices must be greater than $100/MWh but less than $2,000/MWh, which is the maximum market-clearing price. As long as the price in the dispatchable load's energy bid reflects their value of lost load, they are not at risk of incurring a cost from an economic activation; they will only be economically activated when the market price exceeds their value of lost load.

28. HDR resources also submit hourly energy bids. When they consume, HDR resources pay the Hourly Ontario Energy Price ("HOEP"). In order to receive an availability payment, HDR resources must submit energy offers within the hours of availability. HDR resources receive a "standby report" in advance of a potential economic activation between 15:00 EST of the day ahead until 07:00 EST on the dispatch day, if the IESO's pre-dispatch schedules signal they could be curtailed for the hours of availability. In this instance, HDR resources must continue to submit energy bids for the dispatch day consistent with their capacity obligation. HDR resources are economically activated when the pre-dispatch 3-hour ahead price is greater than their energy bid price. The HDR resource is notified that they will be economically activated by receiving an Activation Notice approximately 2.5 hours before the start of the first dispatch hour to which it relates. HDR resources may be activated once per day for up to four consecutive hours. Attached hereto as **Exhibit "C"** is a copy of IESO Market Manual 4, which sets out the rules for activating HDR resources at section 7.2. Like dispatchable loads, HDR resources can manage the risk of incurring a cost associated with lost load from an

economic dispatch through their energy price bid. As the IESO evidence indicates, HDR resources have been economically activated on only one occasion since the implementation of the DRA.

***B.7 Q: In response to Board Staff Interrogatory question 1, AMPCO provided a list of costs related to curtailment. What are your views on the nature of these costs?***

29. AMPCO identified two types of costs related to economic activation under the heading “Cost per Curtailment.” AMPCO called the first set of costs “lost opportunity”. These costs all influence the price the DR resource is willing to pay to consume, i.e. the value of lost load. AMPCO indicates that there are several things to consider in establishing the value of lost load for a DR resource, and these things vary over time, even day to day and hour to hour. However, these costs all should be captured in the DR resource’s energy bid price. As discussed above, the DR resource can avoid incurring a lost opportunity cost by properly estimating its value of lost load and using this estimated value for its energy bid price. This is not to say that it is easy to estimate the value of lost load, and that there is not a risk that the estimate is wrong and that there is ex post regret that they bid too low or too high. This is possible in the same way it is possible that when a generator submits an energy offer with an expectation of its fuel costs and operating conditions: they guess wrong and fail to recover some costs.

30. AMCPO calls the second set of costs “semi-variable costs,” which included labour cost and other overhead costs for the production facility. These costs are costs that the DR resource must incur to ensure that they are available as a capacity resource to respond to an economic dispatch. These costs are not avoided if the DR resource is not economically activated. These are costs that can be avoided only if the DR resource chooses not to be available. I would call these costs fixed avoidable costs. For example, if they wanted to operate as a non-dispatchable load, they may require fewer staff on shift to monitor for dispatch instructions from the IESO. These costs should be recovered through the availability payment and not through an energy payment. This is no different than the types of costs that a non-committed generator may incur to make

sure a generator is available to respond to an IESO dispatch. Non-committed dispatchable generators would also need to recover these types of fixed avoidable costs if they choose to sell capacity and be available for dispatch by the IESO. They would include these costs in their capacity offer price, not in their energy offer price.

***B.8 Q: If a generator receives an energy payment for balancing supply and demand, but a DR resource does not, is this not inequitable treatment, and does it not place the DR resource at a competitive disadvantage?***

31. Contrary to AMPCO's assertion, I contend that *providing* DR resources an energy payment for economic activations would represent *inequitable treatment* and afford DR resources a *competitive advantage* over non-committed dispatchable generators in the TCA. I come to this conclusion by applying the concept of horizontal equity and by way of example.

***B.9 Q: What is horizontal equity?***

32. *Horizontal equity* requires that people who are alike in all relevant respect be treated the same. It corresponds to common notions of fair play and non-discrimination. For example, if two people have the same pre-tax income, they would have equal after-tax incomes. *Vertical equity* holds that people who differ in relevant respects should often be treated differently. This notion of equity is more contentious. Vertical equity is typically concerned with the "preferred" distribution of wealth in society. What represents the "preferred" distribution of wealth is a normative question that requires a value judgement. For example, it can be argued that those who earn higher pre-tax income *should* pay higher taxes.

***B.10 Q: How does this concept of equity draw you to conclude that providing DR resources an energy payment would be inequitable?***

33. I come to this conclusion through an example. The example is an adaptation of the example the IESO presented to stakeholders in the Demand Response Working Group

on March 11, 2018 to elicit views on the issue of the equal treatment of "negawatts and megawatts."[17]

34. Consider two companies, DR Corp. and GEN Corp. DR Corp. consumes 6 MW of electricity. Its value of lost load is $10,000/MWh. DR Corp. also owns a behind-the-meter generator. The generator has a capacity of 4 MW. It incurs a cost of $100/MWh to generate electricity. DR Corp. also incurs a fixed cost of $1,000 to staff and maintain the generator so that it is available to produce electricity when needed. If DR Corp. chose not to maintain the generator to be available to produce electricity, it would avoid incurring this cost. This makes the $1,000 a fixed avoidable cost. GEN Corp. is exactly the same as DR Corp. with one arbitrary exception: GEN Corp. is electrically connected to the IESO market metered separately as a load and a generator, while DR Corp. is connected by meter to the IESO market as a load with its generator operating behind the meter. Figure 1 depicts the situation for both companies.

35. To simplify the discussion, assume there is just one hour in the year and based on the prevailing supply and demand conditions, the two companies expect the energy market price to be $100/MWh. Both companies plan to compete in the IESO TCA. DR Corp., because it is metered with the IESO as a load, competes as a DR resource and can offer 4 MW of capacity (the amount of net-metered load it is capable of decreasing through use of its behind-the meter generator). If successful in the TCA, DR Corp. will be obligated to submit an energy bid in the IESO's energy market for 4 MW. The energy bid price that DR Corp. will submit is equal to $100/MWh as it will be less costly to use its generator to self-supply its demand than to buy energy from the IESO energy market at a price higher than $100/MWh. GEN Corp. competes as a non-committed generator and can offer 4 MW of capacity in the TCA. If successful in the TCA, GEN Corp. will

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[17] IESO Presentation to Demand Response Working Group on Utilization Payments Discussion, dated March 1, 2018, being Exhibit "J" to the Affidavit of David Short, sworn October 25, 2019, available online at: http://www.rds.oeb.ca/HPECMWebDrawer/Record/656576/File/document at 10-14 ["IESO March 1 Presentation"]. A "negawatt" is a unit of energy saved, such as through the curtailment of demand. This issue of whether a "negawatt" and a "megawatt" are functionally and economically equivalent is a contentious issue. The issue was addressed in FERC Order No. 745 where Commissioner Moeller disagreed with the Commission majority that the two were equivalent.

be obligated to submit an energy offer in the IESO's energy market for 4 MW. The energy offer price it will submit is $100/MWh, which is its marginal cost of generation.

36. Assume in the first instance, as per the Amendments, DR resources do not receive an energy payment for an economic activation. What will be the capacity offer price of each company? I answer this with reference to Figure 1.A.

**Figure 1: DR Corp. and GENCorp. are identical in all relevant aspects**

**Figure 1.A: No Energy Payments for DR Resources**

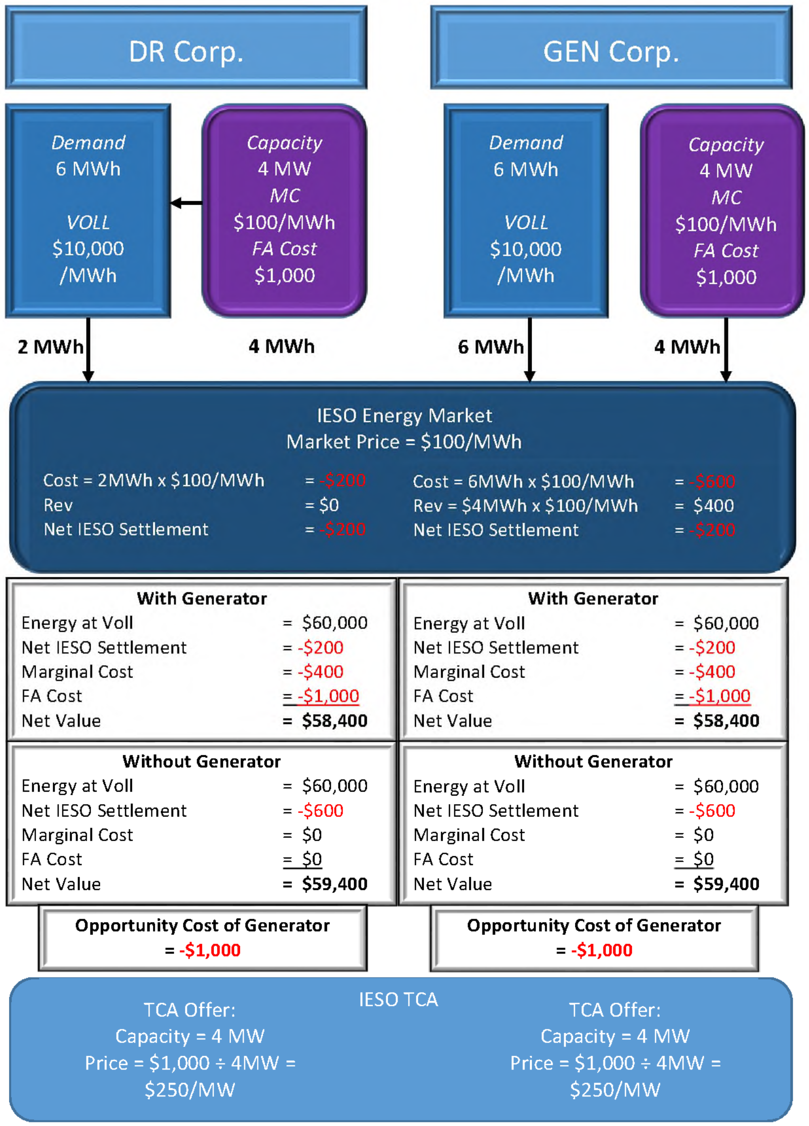
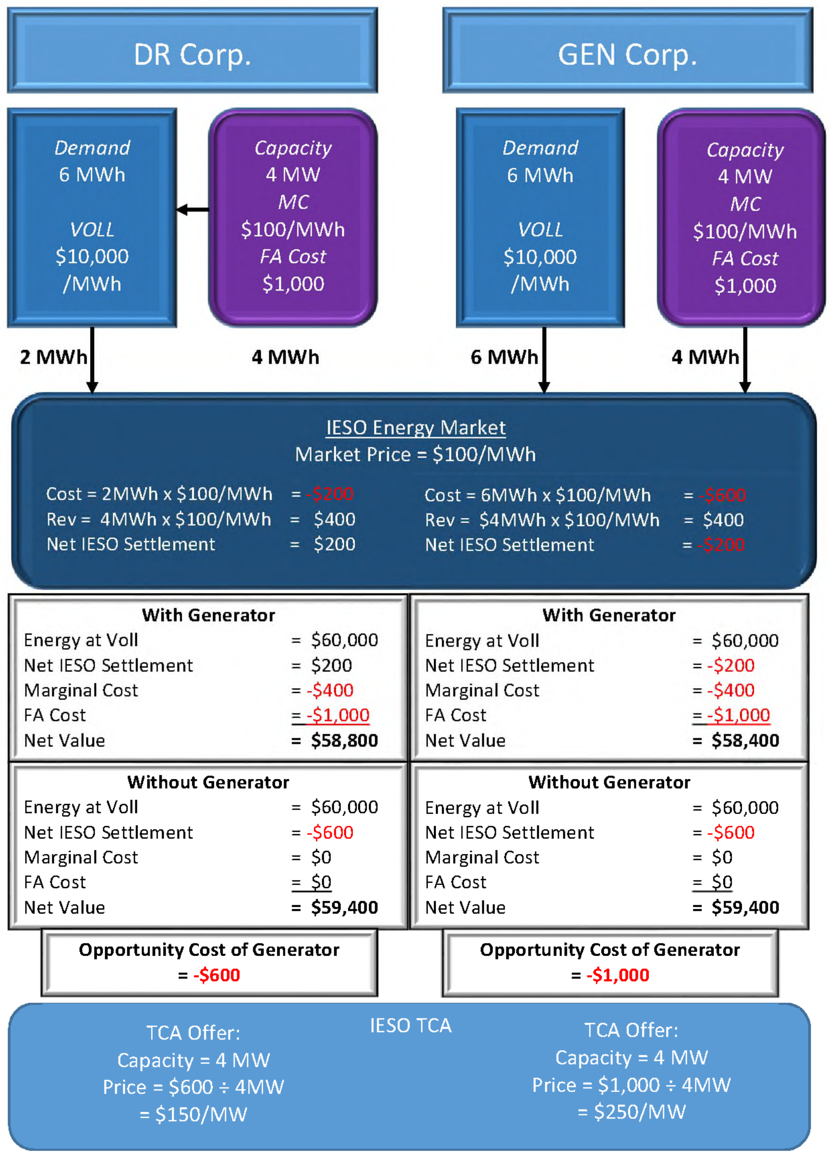


**Figure 1.B: Energy Payments for DR Resources**




37. With an expected market price of $100/MWh, DR Corp. anticipates that it will receive an economic activation to reduce its net-metered load by 4 MWh. It will not receive an energy payment for this activation, so as AMPCO argues, it will not be able to incorporate this revenue in the calculation of its capacity offer price. DR Corp. will make an energy payment to the IESO of $100/MWh x 2 MWh = $200 for its net-metered demand. It will incur a cost of $100/MWh x 4 MWh = $400 to generate electricity to

supply the balance of its 6 MWh of consumption. It will incur the fixed avoidable cost of $1,000 to ensure the generator is available. Overall, DR Corp. will realize a net value of $58,400 for its activities. These calculations are listed in the box for DR Corp. titled "With Generator" in Figure 1.A (numbers in red are negative values).

38. For it to be profitable for DR Corp. to participate in the TCA, the net value it realizes if successful must be greater than the net value it would realize by shutting down its generator and buying all of its electricity from the IESO. This net value is calculated in the box for DR Corp. titled "Without Generator" in Figure 1.A and is equal to $59,400. The net opportunity cost of DR Corp of participating in the TCA is the difference between these two values and is equal to -$1,000. That is, DR Corp. can increase its net value by $1,000 by shutting down its generator and saving the fixed avoided cost of $1,000 to maintain the availability of the generator. Therefore, to keep the generator available, it must recover this amount in the TCA through the availability payment. DR Corp. will submit a capacity offer price of $250/MW for 4 MW of capacity with the hope of recovering the fixed avoided cost of making the generator available. If it is not successful in the TCA, it will shut down the generator.

39. With an expected market price of $100/MWh, GEN Corp. anticipates that it will receive an economic activation to generate 4 MWh of energy. The IESO will pay GEN Corp. the market price per MWh of energy produced for a total energy payment equal to $400. As AMPCO conjectures, GEN Corp. can anticipate earning this energy revenue when calculating its capacity offer price. **<u>However, it costs GEN Corp. $400 to generate the electricity.</u>** What GEN Corp. factors in to its capacity offer price is not the revenue it earns, but the net revenue it earns which is the difference between the energy payment and variable energy cost. This is the "benefit" that GEN Corp. receives by participating in the energy market. As I will discuss more below, it is important to draw the distinction between the energy payment and the net revenue when considering the AMPCO's assertion of competitive advantage. In this case, the market price and GEN Corp.'s marginal cost are equal; GEN Corp. earns zero net revenue. Like DR Corp., GEN Corp. computes its capacity offer price based on the difference between the net value it realizes

from making its generator available and the net value it realizes if it shuts down the generator, which is -$1,000. GEN Corp. submits a capacity offer price in the TCA equal to $250/MW, the same as DR Corp. This is what we might expect given that DR Corp. and GEN Corp. are identical but for the arbitrary physical positioning of their meters.

40. Assume now that contrary to the Amendments, DR resources are paid the market price for an economic activation. How does this affect each company's participation in the TCA and in the energy market? This is presented in Figure 1.B above.

41. First, note that by receiving the market price for an activation, DR Corp. has an incentive to lower its energy bid price. It will be optimal to use its generator to self-supply its demand whenever the market price is greater than half its marginal generation cost (i.e., market price > $50/MWh). To see this, assume the market price is $51/MWh, and DR Corp. does not use its generator to self-supply. DR Corp. pays $51/MWh x 6 MWh = $306 to the IESO. If instead, DR Corp. does use its generator to self-supply, it pays only $51/MWh x 2 MWh = $102 to the IESO to consume, receives an energy payment for economic activation equal to $51/MWh x 4 MWh = $204, and incurs a generation cost of $400 for a net cost of $298. It is better off to self-supply when the energy market price is $51/MWh. By this reasoning, DR Corp.'s net cost of participation in the IESO market if it self-supplies is lower whenever the market price exceeds $50/MWh. As a result, DR Corp. will lower its energy bid price to $50/MWh from $100/MWh.

42. Now assuming that DR Corp.'s lower energy bid price does not result in a lower energy price (which it could), it will now factor this additional energy payment into its capacity offer price calculation. As Figure 1.B demonstrates, the net value to DR Corp. increases when it is eligible for an energy payment for an economic activation. DR Corp. requires a smaller capacity offer price of $150/MW in order to cover its fixed avoided cost of making its generator available. This capacity offer price is lower than the capacity offer price of GEN Corp.

***B.11 Q: Can you summarize what this example demonstrates of AMPCO's assertions of inequality and competitive disadvantage?***

43. Yes. The example shows that AMPCO's assertions are incorrect. In my example, DR Corp. and GEN Corp. are identical but for the physical placement of a meter; an arbitrary and irrelevant difference. Horizontal equity requires like treatment for people (or corporations) that are alike. When DR resources do not receive an energy payment for an economic activation, DR Corp. and GEN Corp., whom are identical, are treated alike for their participation in the IESO markets and realize the same net value for their activities. When DR resources receive an energy payment for an economic activation, DR Corp. avoids the cost of consuming by reducing its net-metered load (a benefit). At the same time, it receives a payment from the IESO to avoid this cost (a second benefit). This amounts to a double benefit for the energy service provided (as evidenced by DR Corp.'s willingness to submit an energy bid price that is half its marginal generation cost). As a result, DR Corp. realizes a higher net value than GEN Corp. for participation in the IESO markets, even though the two companies are identical. The preferential treatment gives DR Corp. a competitive advantage over GEN Corp. in the TCA. What amounts to a double benefit for the energy service allows DR Corp. to cover more of its fixed avoided cost through the energy market. DR Corp requires less in the way of an availability payment to cover these costs and hence they can submit a lower capacity offer price than GEN Corp. in the TCA.

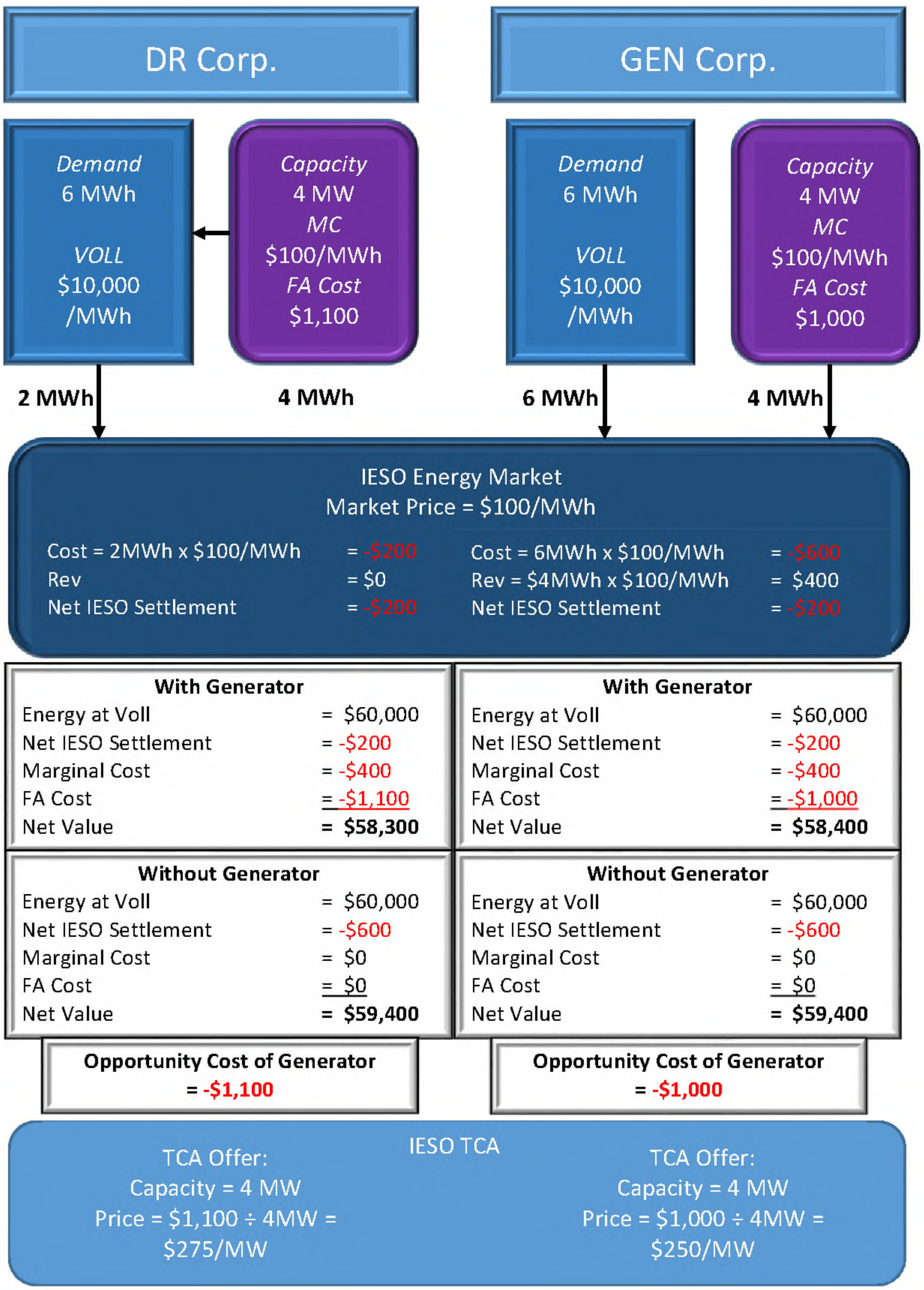
***B.12 Q: What other conclusion do you draw through this example?***

44. Through this example, I can demonstrate that contrary to AMPCO's assertions, paying DR resources an energy payment for economic activations would harm fair and efficient competition. With only slight modifications to the example I described above, I can show that providing DR resources an energy payment for economic activations can lead to more expensive resources being selected before less expensive resources in the TCA and more expensive resources being dispatched ahead of less expensive resources in the energy market.

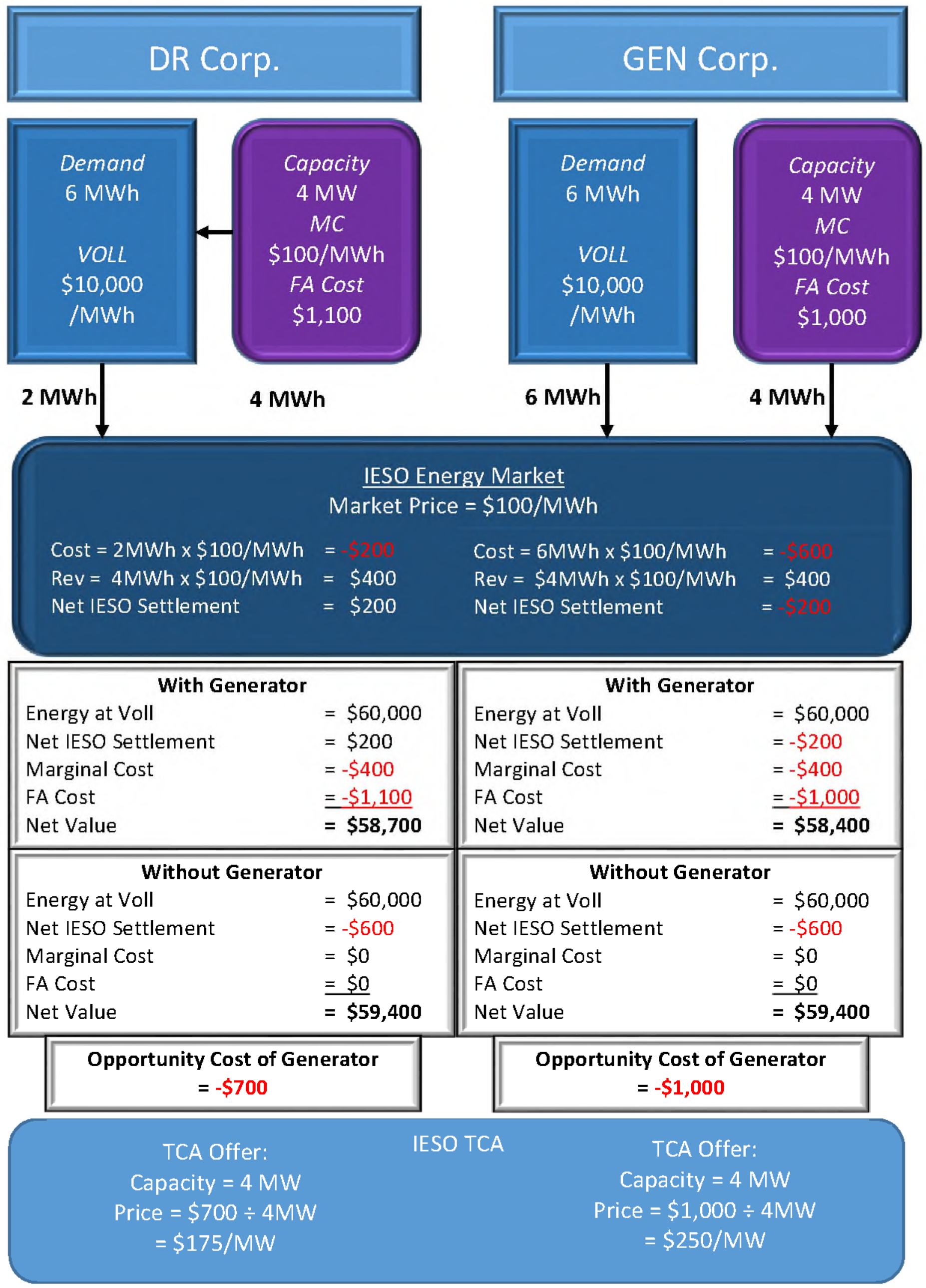
45. In Figure 2, I assume DR Corp. incurs a fixed avoided cost of $1,100 to staff and maintain its generator to ensure it is available to produce electricity, which is $100 higher than the previous example. DR Corp. is now a higher cost capacity resource than GEN Corp. DR Corp. will have to recover $100 more in the TCA than GEN. If as per the Amendments, DR resources do not receive an energy payment for economic activations, DR Corp. will submit a capacity offer price of $275/MWh in the TCA. It has less chance of success in the TCA than GEN Corp. From the perspective of promoting fair and efficient competition, this is the desired outcome; the least cost capacity resource is selected ahead of the higher cost resource. If in the alternative, DR resources are provided an energy payment for economic activations, DR Corp. can anticipate a benefit of reducing its energy payment to the IESO and receiving an energy payment from the IESO for doing so, (i.e., a double benefit). This reduces the amount of fixed avoided cost that it must recover through the TCA by $400. DR Corp. is now able to reduce its capacity offer price to $175/MW, which is lower than GEN Corp.'s capacity offer price of $250/MW. DR Corp. now has an advantage over GEN Corp. in the TCA, even though it is the higher cost capacity resource. As a result, it is possible that DR Corp. is successful in the TCA and GEN Corp. is not. GEN Corp. would be forced to shut down its generator. This would be a wasteful and inefficient use of the province's resources. Providing DR resources an energy payment for economic activations would be harmful to fair and efficient competition.

**Figure 2: DR Corp. has a higher fixed avoided cost**

**Figure 2.A: No Energy Payments for DR Resources**



## Figure 2.B: Energy Payments for DR Resources



## Figure 3: GEN Corp. has a lower marginal generation cost

### Figure 3.A: No Energy Payments for DR Resources

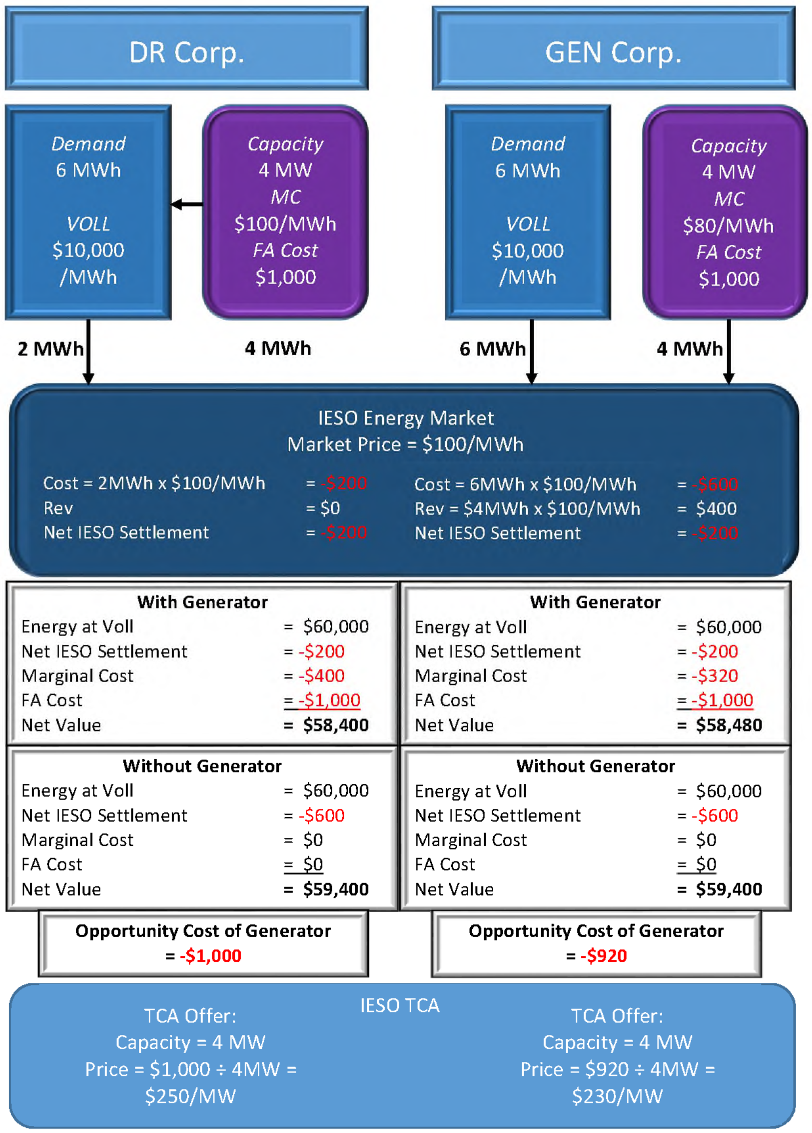
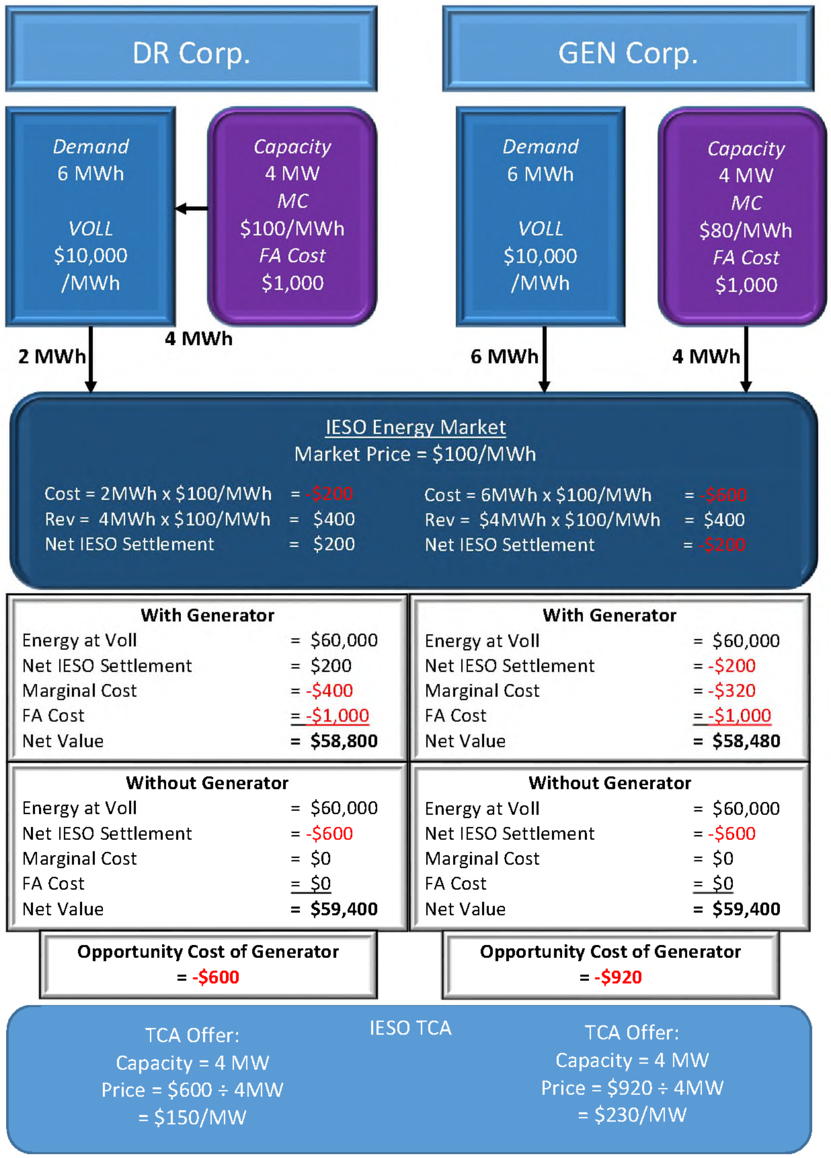


**Figure 3.B: Energy Payments for DR Resources**




46. In Figure 3, I modify the original example by assuming GEN Corp. has a marginal generation cost of $80/MWh, which is lower than the $100/MWh marginal generation cost of DR Corp. In this case, GEN Corp earns a net revenue equal to the difference between the energy market price of $100/MWh and its marginal generation cost of $80/MWh; a benefit of $20/MWh that it can contribute to the recovery of its fixed avoided cost of making the generator available. It can factor this amount into its capacity offer price. Again, I draw a distinction between the net revenue and the full energy

payment; GEN Corp. will factor only the net revenue into its capacity price calculation as this is the only true benefit it receives from the energy market.

47. If DR resources are provided an energy payment for economic activations, Figure 3 illustrates that DR Corp. will submit a lower capacity offer price than GEN Corp. That is, because of the double benefit DR. Corp. receives from activation (a benefit for the energy payment it avoids and a benefit for the energy payment it receives) it has a competitive advantage over GEN Corp. It is also the case that because DR Corp. lowers its energy bid to $50/MWh, (half of its marginal generation cost) it will be dispatched ahead of GEN Corp. for energy. This is not only harmful to fair and efficient competition in the TCA, it leads to the inefficient dispatch of the province's generation resources, which is in conflict with the IESO's least cost dispatch objective.

***B.13 Q: In your examples, you did not consider the effects of the Global Adjustment. How does the Global Adjustment affect your conclusions?***

48. The manner in which consumers are charged the Global Adjustment will also provide certain DR resources a competitive advantage in the TCA over non-committed dispatchable generators, even if DR resources are not provided energy payments for an economic activation as per the Amendments.

49. The Global Adjustment is an accounting mechanism through which the fixed costs to build and maintain generation assets in the province and to deliver Ontario's conservation programs are recovered from Ontario electricity consumers. It is, at a high level, calculated as the differences between payments made to generators at the wholesale market price and payments made through regulation or contract that differ from the market price. The Global Adjustment was established in 2005 as a means to attract private investment in new generation capacity and to offer Ontario consumers price stability. The Global Adjustment has become the largest component of an average consumer's electricity cost, representing between 45 to 60 percent of a typical electricity bill. Attached hereto as **Exhibit "D"** is a copy of a policy brief I authored on this subject.

50. The Industrial Conservation Initiative ("ICI") is a government policy that defines how the costs in the Global Adjustment are allocated to different classes of consumers. Large consumers, known as Class A consumers, are charged global adjustment on the basis of their share of the total system demand during the highest five peak hours of the year. Class A consumers include consumers with an average monthly peak demand greater than 1 MW and consumers in certain manufacturing and industrial sectors, including greenhouses with an average monthly demand greater than 500 kilowatts (kW). Smaller consumers, known as Class B consumers, pay Global Adjustment as a monthly fee based on the kilowatt-hours of electricity they consume in the month, or as part of their regulated time of use prices. I understand that most AMPCO members qualify as a Class A consumer.

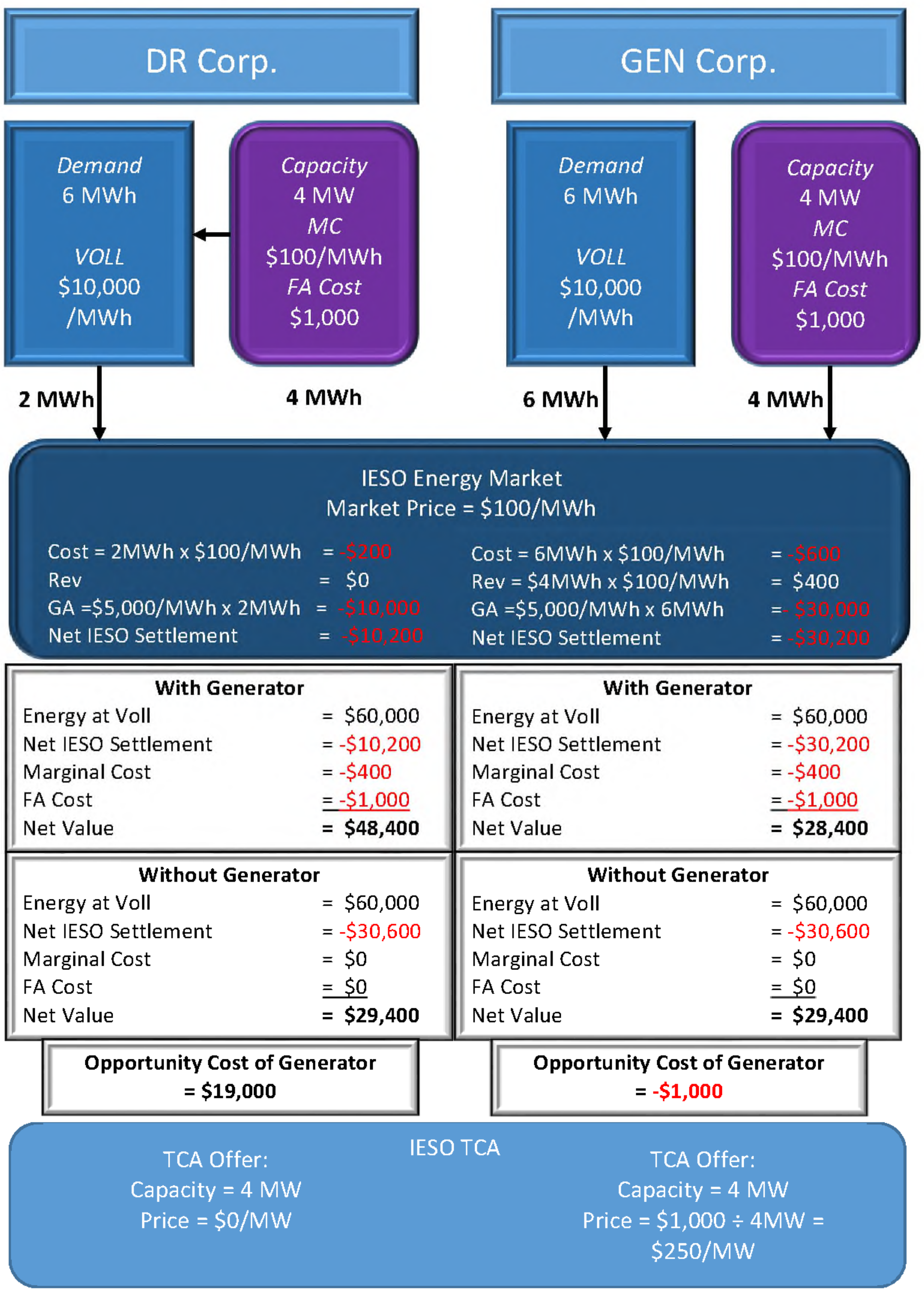
51. The Board's Market Surveillance Panel has shown that the ICI provides Class A consumers with an extreme price incentive to reduce their demand in the expected system peak demand hours to avoid paying the Global Adjustment. This will provide DR resources that are Class A consumers a competitive advantage over non-committed dispatchable generators in the new TCA. I demonstrate this in Figure 4. Attached hereto as **Exhibit "E"** is the Market Surveillance Panel's Report.

52. Figure 4 assumes the same characters for DR Corp. and GEN Corp. as Figure 1, except it also considers the effects of the incentives provided by the ICI. Both DR Corp. and GEN Corp. qualify as a Class A consumer. Assume that both companies anticipate the Global Adjustment charge to be $5,000/MWh. The Global Adjustment is charged based on the metered quantity consumed at the level of the IESO (i.e., based on metered quantities at the transmission level). As a result, DR Corp. can avoid Global Adjustment charges by self-suppling its demand and reducing its net-metered quantity with the IESO to 2MWh. GEN Corp. cannot avoid Global Adjustment by generating. As Figure 4.A demonstrates, even if DR resources are not provided an energy payment for economic activations, DR Corp. has an extreme incentive to generate electricity to avoid $5,000 x 4MWh = $20,000 in Global Adjustment charges. This decreases the opportunity cost of not incurring the fixed avoided cost to maintain the availability of its generator by

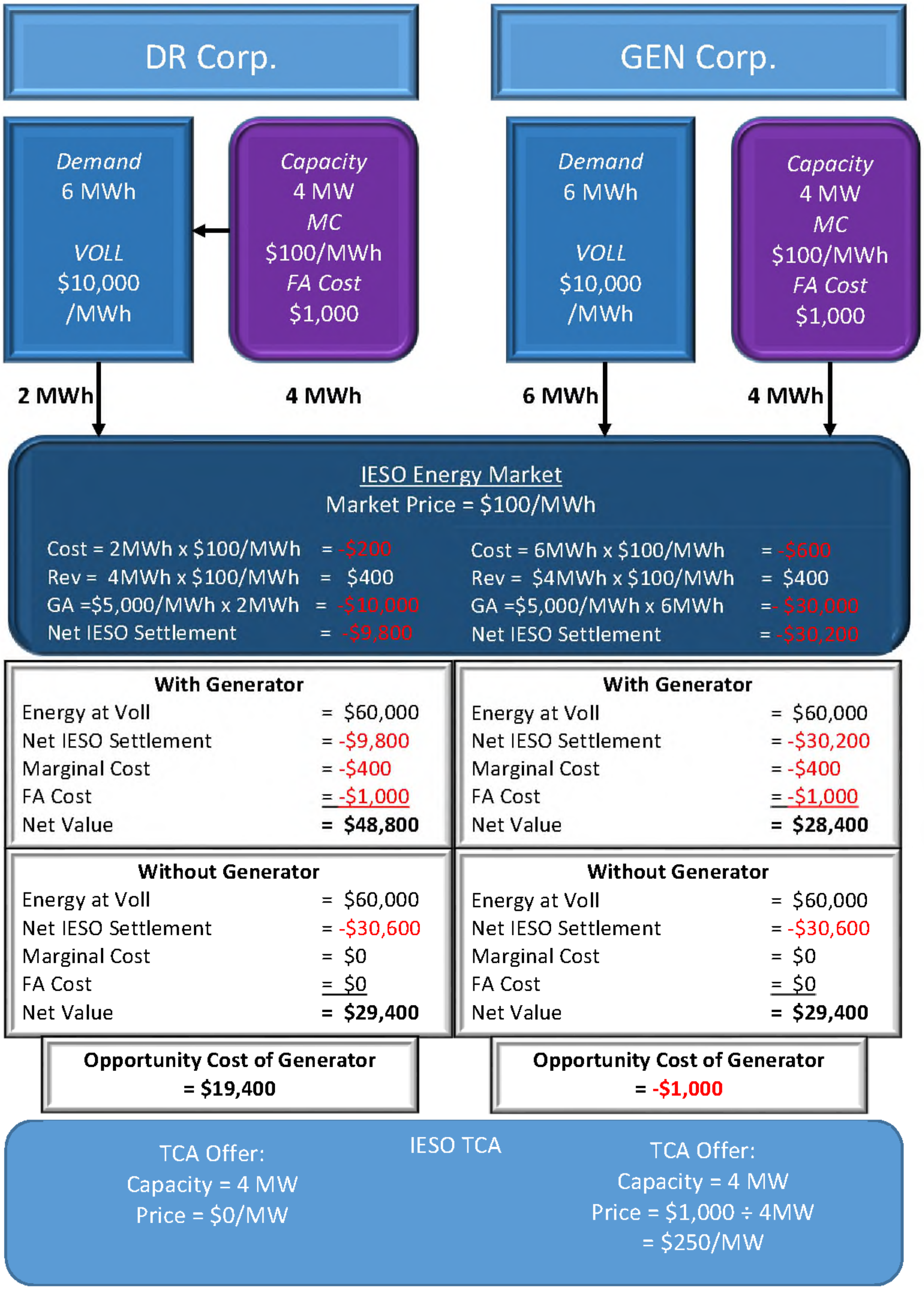
$20,000. DR Corp. is clearly better off by maintaining the availability of its generator; it will do so even if it does not earn an availability payment through the TCA. DR Corp. can offer a capacity price of $0/MWh in the TCA. In effect, the ICI rewards DR resources that are also Class A consumers by compensating them twice for making their generator available; once through the avoidance of the Global Adjustment (which recovers the capacity cost of the committed generator) and once through the availability payment. As Figure 1.B demonstrates, paying DR resources an energy payment for an economic activation would only further DR Corp.'s competitive advantage over the non-committed generator of GEN. Corp.

**Figure 4: Effects of the Global Adjustment**

## Figure 4.A: No Energy Payments for DR Resources



## Figure 4.B: Energy Payments for DR Resources



## C. APPLICATION OF FERC ORDER NO. 745 IN ONTARIO WILL NOT ACHIEVE THE COMMISSION'S INTENDED EFFECTS

### *C.1 Q: Can you briefly describe the conclusions of FERC Order No. 745*

53. Yes. FERC Order No. 745 addressed the issue of compensation of DR resources in Regional Transmission Organization ("RTO") and Independent System Operator ("ISO") organized wholesale energy markets in the United States.[18] The Commission concluded that when a DR resource satisfies two conditions, it "must be compensated for the service it provides to the energy market at the market price for energy, referred to as the locational marginal price (LMP)."[19] ***First,*** the DR resource must have the capability to provide the service, which is described as displacing a generation resource in a manner that serves to balance supply and demand. ***Second***, the payment of the market price to the DR resource for the provision of the service must be "cost-effective" as determined by a "net-benefits test."

### *C.2 Q: What was the basis for the Commissions' conclusion?*

54. The key objective of FERC Order No. 745 was to "remove barriers to participation of demand response resources in organized wholesale electricity markets."[20] FERC Order

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[18] FERC Order No. 745 at para. 9 focused on "customers or aggregators of retail customers providing, through bids or self-schedules, demand response that acts as a resource in organized wholesale energy markets".

[19] *Ibid* at para. 2.

[20] *Ibid* at para. 5. The Commission states this objective is "consistent with national policy requiring facilitation of demand response." It references Energy Policy Act of 2005, Pub. L. No. 109-58, § 1252(f), 119 Stat. 594, 965 (2005):

> "f) FEDERAL ENCOURAGEMENT OF DEMAND RESPONSE DEVICES.—It is the policy of the United States that time-based pricing and other forms of demand response, whereby electricity customers are provided with electricity price signals and the ability to benefit by responding to them, shall be encouraged, the deployment of such technology and devices that enable electricity customers to participate in such pricing and demand response systems shall be facilitated, and unnecessary barriers to demand response participation in energy, capacity and ancillary service markets shall be eliminated. It is further the policy of the United States that the benefits of such demand response that accrue to those not deploying

No. 745 was promulgated on the premise that "active participation by customers in the form of demand response in organized wholesale energy markets helps to increase competition in those markets."[21] Ensuring the competitiveness of organized wholesale energy markets is "integral to the Commission fulfilling its statutory mandate" and to ensuring "just, reasonable, and not unduly discriminatory or preferential rates."[22] The Commission observed that prior to the Order, "the level of compensation for demand response" varied from market to market, and that "some existing, inadequate compensation structures hindered the development and use of demand response." The Commission acknowledged that customers "must have confidence that appropriate price signals will be sustained by stable competitive pricing structures, before they will make an investment in demand response." Attached hereto as **Exhibit "F"** is a copy of the Commission's Notice of Proposed Rule Making in which these observations were made.

***C.3 Q: Did the Commission elaborate on the types of barriers to DR resources that it was concerned with, and how FERC Order No. 745 would eliminate those barriers?***

55. The Commission reasoned that "[d]ue to a variety of factors, demand responsiveness to price changes is relatively inelastic in the electric industry and does not play as significant a role in setting the wholesale energy market price as in other industries."[23] The Commission cited as barriers:

> "the lack of a direct connection between wholesale and retail prices, lack of dynamic retail prices (retail prices that vary with changes in marginal wholesale costs), the lack of real-time information sharing, and the lack of market incentives to invest in enabling technologies that would allow

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such technology and devices, but who are part of the same regional electricity entity, shall be recognized."

[21] *Ibid* at para. 9.

[22] *Ibid* at para. 8.

[23] *Ibid* at para. 57.

> electric customers and aggregators of retail customers to see and respond to changes in marginal costs of providing electric service as those costs change."

The Commission concluded, "paying LMP can address the identified barriers to potential demand response providers."[24]

### *C.4 Q: You indicated that for DR resources to be eligible for compensation it must be cost-effective as determined by the FERC net benefits test. Can you explain this test?*

56. Yes. The Commission recognized that paying DR resources the market price to curtail demand would have two effects. First, paying DR resources the market price would encourage more participation of these resources in the energy market. Their participation would involve an energy bid in the wholesale market. Additional energy bids in the market would lead to a lower wholesale energy price whenever a DR resource's bid was selected in the energy market ahead of a generator offer. All other consumers (non-DR consumers) would realize a benefit from the lower price. Second, these non-DR consumers would have to make an additional payment to the DR resource equal to the market price times the amount of demand curtailed. The net benefits test is satisfied when the savings the non-DR consumers realize from the lower wholesale price are greater than the additional payment they must make to DR resource. FERC Order No. 745 refers to this as the "the billing unit effect of dispatching demand response."[25] In this sense, paying DR resources is deemed cost effective if it leads to lower bills for all non-DR consumers.

### *C.5 Q: Is this how an economist would define "cost-effective"?*

57. No. As many commentators noted in the FERC proceeding, in economics, an outcome would be defined as cost-effective if it leads to society making the best use of its

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[24] *Ibid* at para. 58.

[25] *Ibid* at para. 3.

available resources. Economist call this an allocatively efficient outcome. An allocatively efficient outcome maximizes the benefits to all participants. This is sometimes called "total surplus" which is equal to the sum of consumers' surplus (the difference between what they are willing to pay and the price they pay) and producers' surplus (the difference between the price they receive and avoided variable cost). The IESO's dispatch model seeks to maximize allocative efficiency or total surplus. The net benefits test seeks to maximize the benefit to non-DR participants, or non-DR consumers' surplus and comes at the expense of producers' surplus. Promoting efficiency is also a purpose of the *Electricity Act, 1998*.

### *C.6 Q: Do you see any implications for the IESO or Ontario consumers if the IESO were required to apply a net benefits test in order to pay DR resources the market-clearing price?*

58. Yes. If the intent of the FERC net benefit test is to compensate DR resources only when it results in a reduction in the bills of non-DR consumers (non-DR consumers' surplus), then the IESO would have to take into account the effect of the Global Adjustment in this calculation. This has two implications for the IESO and Ontario consumers. First, it means that (all else held constant) the net benefits test will be satisfied less frequently (if ever) than in the United States markets.[26] Second, it adds additional complications for the IESO in implementing the test that the United States RTO/ISOs did not have to encounter. Furthermore, as several commenters noted in the FERC proceeding, "cost-effective" as defined by the net benefits test, and "allocative efficiency" are different things. An additional implication of Ontario implementing the net benefit test is that it could, if ever satisfied, contribute to a less efficient dispatch of resources and less efficient use of the province's generation resources. This is a point I already established above.

[26] This same point was recognized in Section 3.2 of the "Navigant Report".

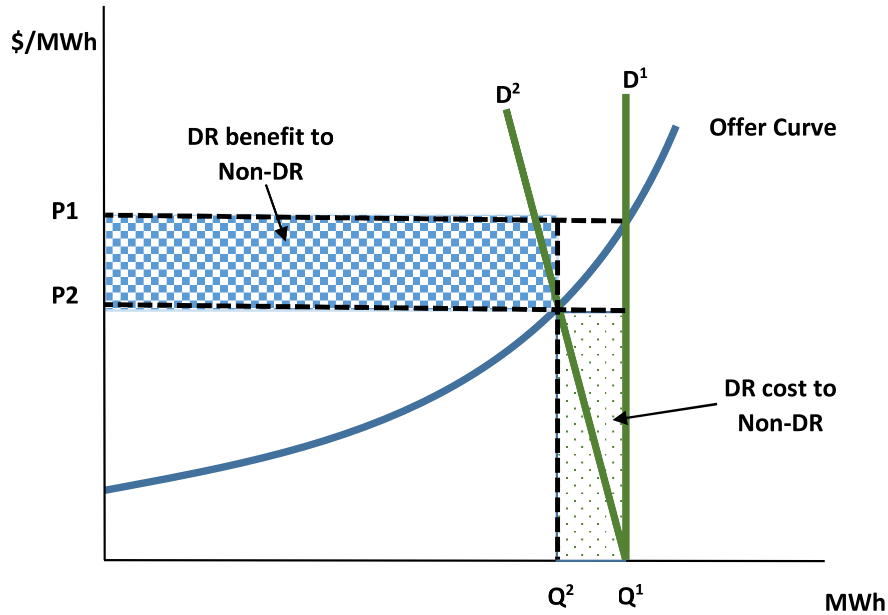
### *C.7 Q: Can you explain why the Global Adjustment means the net benefits test is not likely to be satisfied on Ontario?*

59. Yes. This can be explained with reference to Figure 5. In Figure 5, an hourly offer curve and an hourly demand curve (labeled $D^1$) are drawn. The demand curve $D^1$ is drawn under the assumption that DR resources are not provided an energy payment for an economic activation. The market-clearing price is determined as the intersection of the hourly offer curve and the hourly demand curve, which is $P^1$ in Figure 5. This illustration is based on a figure contained in the Californian ISO's final proposal for implementation of FERC Order No. 745, which is attached hereto as **Exhibit "G".**

60. Paying a DR resource the market-clearing price for an economic activation changes the DR resource's incentives for participation in the market. This was the desired effect of the Commission in FERC Order No. 745. As I outlined above, in the Ontario context, if a DR resource is paid the market price for an economic activation, it will be incentivized to submit a lower energy bid price.[27] This causes the demand curve to become more "elastic" and shift downward. This is represented by the new hourly demand curve $D^2$ in Figure 5. The lower DR resources' energy bids mean that the market clears at the lower price of $P^2$.

[27] This point was discussed in the "IESO March 1 Presentation" at 5.

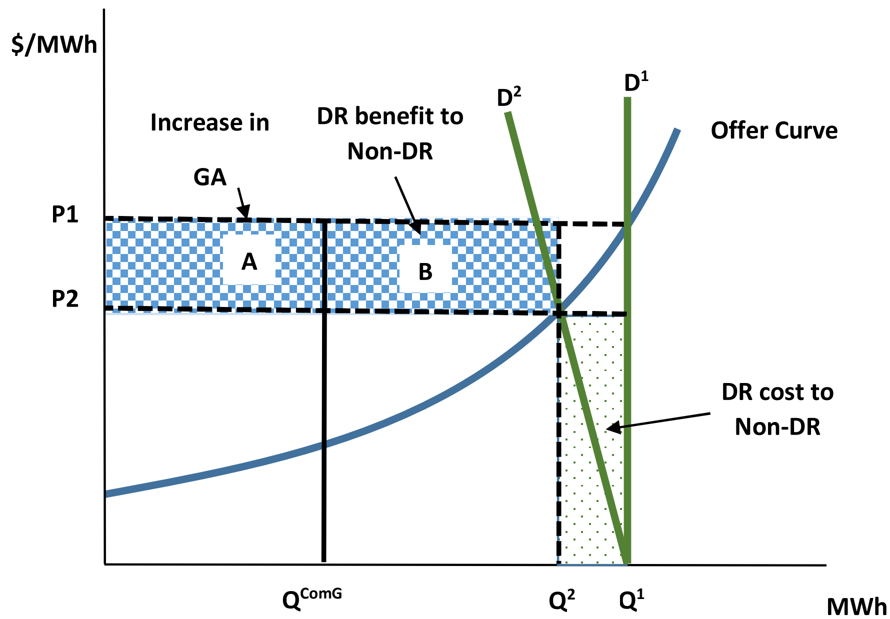
**Figure 5: The Net Benefits Test under FERC Order No. 745**




61. The FERC net benefits test is satisfied if the savings the non-DR consumers realize from the lower wholesale price are greater than the additional payment they must make to DR resources. Under the FERC model, this occurs when the shaded blue area is greater than the shaded green area in Figure 5.

62. If the net benefits test were applied to Ontario, the IESO would have to incorporate the effects of payments made to contracted and regulated ("committed") generators by non-DR consumers through the Global Adjustment. As discussed above, the Global Adjustment includes differences between payments made to generators at the wholesale market price and payments made through regulation or contract that differ from the market price. If providing DR resources an energy payment for economic activations lowers the market-clearing price as the Commission expected in FERC Order No. 745, in Ontario, a portion of the benefit non-DR resources get from the lower energy price will be offset by an increase in the payments the same consumers have to make to committed generators through the Global Adjustment. This means that all else held constant, the net benefits test condition for compensating DR resources will be satisfied less often in Ontario than in the United States. This is illustrated in Figure 6.

**Figure 6: The Net Benefits Test illustrated for Ontario**



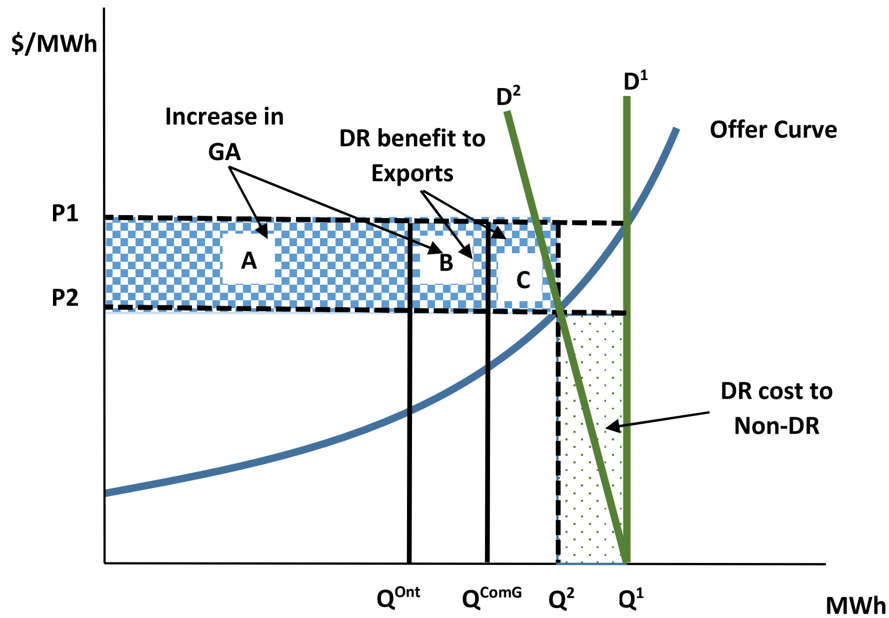

63. In Figure 6, the amount of supply provided by committed generators is $Q^{COMG}$. When lower energy bid prices of DR resources cause the energy market price to fall from $P^1$ to $P^2$, the amount of net revenues earned by the committed generators falls in proportion to the price decrease (the area marked as A in Figure 6). The decline in net revenue is fully offset by higher payments to the committed generators as per their contract terms or regulated rates. Non-DR consumers cover these higher payments through higher Global Adjustment charges. As a result, the benefit that non-DR consumers receive from the lower energy price is reduced by the amount A; they realize the smaller benefit represented by area B. Since the net benefit is smaller in Ontario, it is less likely that the net benefits test condition will be satisfied in Ontario.

### *C.8 Q: Are there conditions in Ontario in which the net benefits test is certain to fail?*

64. Yes. Ontario is a large net exporter. Exporters do not pay the Global Adjustment. In many hours, committed generators are required to produce to meet both the Ontario demand and the export demand. When the amount of energy provided by committed

generators exceeds the Ontario demand, energy price decreases caused by lower DR resource energy bids would lead to an increase in Ontario non-DR consumers' Global Adjustment charges that exceeds benefits they realize from lower energy market prices. That is, exports would realize the benefit of the lower market prices, but because Ontario consumers must cover the higher Global Adjustment charges, they would be worse off, even before paying DR resources not to consume. This is illustrated in Figure 7.

**Figure 7: Sufficient condition for Net Benefits Test failure in Ontario,**



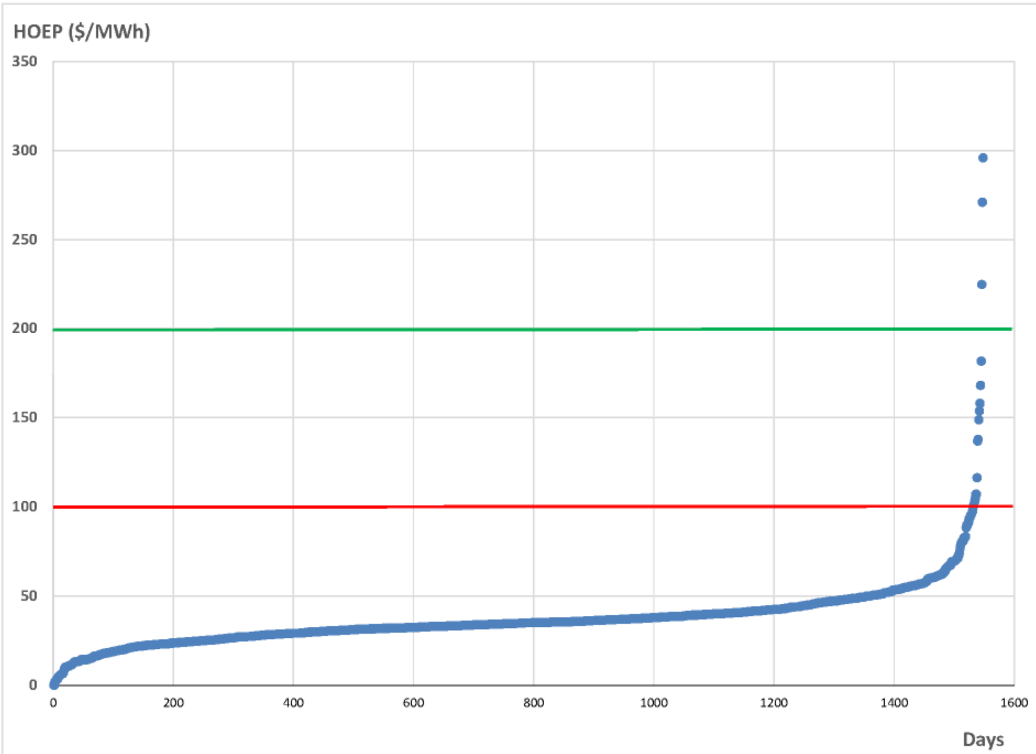

65. In Figure 7, the Ontario non-DR consumers' demand is $Q^{ONT}$. The difference between $Q^2$ and $Q^{ONT}$ is export demand. The amount of energy produced by committed generators is $Q^{COMG}$, which is greater than the Ontario non-DR consumers' demand. The benefit that non-DR consumers realize from the energy price reduction is represented by the area A. However, the amount of Global Adjustment that these consumers will have to pay increases by the area A + B. Ontario non-DR consumers are made strictly worse off by compensating DR resource for economic activations. They are made worse off even before accounting for the amount they have to pay to DR resources for economic activations (the green shaded area).

***C.9 Q: Have you done any analysis that could provide the OEB some guidance on the likelihood that the net benefits test would be satisfied in Ontario?***

66. Yes. The IESO provided me with hourly data for the period January 1, 2018 to October 28, 2019 which is attached hereto as **Exhibit "H"**. The data included hourly HOEP and hourly quantities of Ontario non-dispatchable demand, Ontario dispatchable load demand, committed generation output, non-committed generation output, exports and imports for a total of 15,984 hours. I calculated the number of hours when output from committed generators exceeded Ontario non-dispatchable demand plus dispatchable load demand (the sufficient condition for the net benefits test to fail in Ontario). There were 14,436 hours out of 15,984 hours (90.3% of hours) in which the output of committed generators exceeded the Ontario demand between January 1, 2018 and October 28, 2019. The net benefits test would have failed in these hours.

67. In the remaining 1,548 hours (9.7% or hours) when Ontario demand was greater than the output of committed generators, I considered the likelihood that compensating DR resources for economic activations would lead to sufficient reductions in DR resources' energy bid prices to cause a decrease in the energy market price. If DR resource energy bid prices remain relatively high, then it is not likely a price decrease could occur and hence a net benefit to non-DR consumers is not possible. Figure 8 provides some insights in the number of hours that this might be possible. Figure 8 ranks the 1,548 hours between January 1, 2018 to October 28, 2019, in which Ontario demand exceeded committed generation output, from lowest HOEP to highest HOEP.

**Figure 8: HOEP in hours with Ontario demand greater than committed generation Output, January 1, 2018 to October 28, 2019**




68. First, DR resources must submit energy bid prices that are greater than $100/MWh. Compensating DR resources for economic activations could not have a net benefit in hours when the HOEP was less than $100/MWh because DR resource energy bid reductions could not fall below this price level. HOEP exceeded $100/MWh in only 17 of the 1,548 hours (0.106% of all hours in the data set).

69. IESO analysis found in a presentation to the Demand Response Working Group indicated the following:

> The historical contracting programs required DR energy bids to be priced at $200/MWh. Once the $200 price requirement was removed for HDR resources, the IESO observed that the majority of DR bids were priced by participants much higher than $200/MWh. This implies DR

participant's value of energy consumption is much higher than this level.[28]

70. If we consider prices above $200/MWh as the benchmark for a possible price effect, there were only 3 of the 1,548 hours (0.019% of the total hours in the data set) in which the HOEP exceed this benchmark.

71. Overall, recent historical data suggest that the net benefits test would rarely, if ever, be satisfied in Ontario (0.019% of the time).

***C.10 Q: You also said that there would be additional complications for the IESO to implement the FERC net benefits test. What are the additional complications?***

72. FERC Order No. 745 required the RTO/ISO's "to develop a mechanism as an approximation to determine a price level at which the dispatch of demand response resources will be cost-effective."[29] Essentially, the ISO and RTOs are required to use historic offer data, adjusted to reflect resource availability and fuel costs, to create a representative aggregated supply curve for a trade month.[30] This representative curve is used to determine "the monthly threshold price corresponding to the point along the supply stack beyond which the overall benefit from the reduced LMP resulting from dispatching demand response resources exceeds the cost of dispatching and paying LMP to those resources."[31] The ISO and RTOs must post this threshold price on their website and update it on a monthly basis.

73. As discussed above, the IESO will require additional information to implement the net benefits test in Ontario. They will require a forecast of Ontario non-DR load, the production of committed generation and the amount of net exports. Realistically, these values will change often during the month, which makes the use of a representative

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[28] "IESO March 1 Presentation" at 7.

[29] FERC Order No. 745 at para. 4.

[30] This is described in Exhibit "G".

[31] FERC Order No. 745 at para. 4.

supply stack and a monthly price test less practical. Furthermore, applying a blunt monthly test is more likely to lead to false positives and harm to Ontario consumers given the unique conditions and relative infrequency in which the net benefits test is likely to be satisfied. The IESO would likely have to identify improvements to the way the nets benefits test is implemented in Ontario compared to the United States to limit false positives.

### *C.11 Q: Do you think there are any other aspects of the Ontario market that should inform a decision of whether or not to apply FERC Order No. 745 in Ontario?*

74. Yes. As I outlined above, the key objective of FERC Order No. 745 was to "remove barriers to participation of demand response resources in organized wholesale electricity markets."[32] The Commission stated in its Notice of Proposed Rule Making that:

> "Despite the benefits of demand response and various efforts by the Commission, ISOs and RTOs to address barriers to and compensation for demand response participation, demand response providers collectively play a small role in wholesale markets. After several years of observing demand response participation in ISO and RTO markets with different, and often evolving, demand response compensation structures, the Commission is concerned that some existing, inadequate compensation structures have hindered the development and use of demand response."[33]

75. FERC Order No. 745 further describes the types of barriers to demand response participation that concerned the Commission. These barriers primarily related to the disconnect that existed at the time between wholesale and retail prices and the lack of incentives this created for the investment in the capability to be price responsive.[34]

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[32] *Ibid* at 113.

[33] Exhibit "F" at para. 9.

[34] FERC Order No. 745. This was a point made by Commissioner Moeller on his dissenting opinion: "the lack of dynamic prices at the retail level is the primary barrier to demand response participation."

FERC Order No. 745 sought to remedy these barriers by providing DR resources additional compensation.[35]

76. However, the types of barriers to demand response the Commission was concerned with at the time of FERC Order No. 745 do not seem relevant to present day Ontario. First, as Navigant noted in a report prepared for the IESO:

> "It is important to note that Ontario is different from many U.S. jurisdiction in that many of the DR resources are wholesale market participants or large customers that are exposed to real-time electricity prices as opposed to retail prices. This means that Ontario DR customers avoid the entire real-time electricity price when curtailing and are exposed to high price spikes. When DR providers are only exposed to retail rates as they are in many U.S. jurisdictions, they are unlikely to have the same avoided cost benefit when curtailing during spikes in prices."[36]

77. Second, Ontario has already done a great deal to help DR resources recover the costs of investments needed to enable their participation in wholesale markets. As early as 2007, the IESO (formerly the OPA) recognized the capacity value of DR resources and implemented the DR3 program. The DR3 program procured DR resources through multi-year standard offer contracts that paid DR resources both an availability payment and a utilization payment. The proceeds of the availability payment could contribute in the investment in meters and control systems that would enable price responsiveness. It

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[35] *Ibid.* Commissioner Moeller in his dissenting opinion challenged the majority on this point. Commissioner Moeller stated in his dissent:

> "The Rule [FERC Order No. 745] finds that "greater uniformity in compensating demand response resources" is required and as justification for its action, references the existence of various barriers that limit the participation of demand response in the energy markets. The majority ultimately concludes that these barriers can be removed by better equipping demand response providers with the financial resources to invest in enabling technologies. This is to say that the majority believes that paying demand resources more money will help overcome these barriers and encourage more participation. The Rule, however, never clearly explains how the existence of barriers, in turn, justifies a payment of full LMP to demand resources."

[36] "Navigant Report".

also helped fund investments made by load aggregators to sign-up and compensate consumers that could reduce demand upon an activation from the IESO. In 2015, the former OPA DR3 program was integrated into the IESO-administered market through a program called capacity backed demand response and through the DRA. This provided further learning for the IESO and DR resources on how demand response could respond to economic activations. DR resources were provided availability payments for providing the capacity service, which again could be used to fund investments in the technologies needed to enable demand response. These availability payments were made during a time when Ontario had more than enough capacity to meet its obligations. This means Ontario consumers paid to help remove the barriers to demand response when it did not need the capacity. Arguably, as evidenced by the number of DR resources that now participate in the DRA, Ontario has been successful in removing the types of barriers to demand response participation in the wholesale market that were the focus of FERC Order 745.

78. Third, the ICI has been very effective at stimulating demand response during peak demand periods. The Market Surveillance Panel estimates that "ICI participants reduced their consumption by 42% during peak demand conditions in 2016."[37] They do so to reduce the amount of Global Adjustment that they pay. The Panel "estimates that by reducing consumption by one megawatt during each of the five peak demand hours in 2016, a Class A consumer would have saved approximately $520,000 in Global Adjustment charges."[38] The benefit from reducing peak hour consumption are so significant, it "creates an incentive for Class A consumers to invest in new generating or storage capacity located at their facilities."[39]

[37] Exhibit "E" at 2.

[38] *Ibid* at 8.

[39] *Ibid* at 16.

### *C.12 Q: Are you aware of any research that demonstrates the effect that FERC Order No. 745 has had on the United States wholesale markets?*

79. Yes, in the short time that I had to prepare this testimony, I conducted a non-exhaustive scan of the academic literature and reports prepared by the RTOs, ISOs and their market monitors for empirical evidence on the effects and implications of the implementation of FERC Order No. 745. I was surprised to find only a few reports or academic papers on the topic.

80. Monitoring Analytics LLC, the market monitor for PJM, prepare quarterly and annual reports on the PJM market. They dedicate a section in the reports specifically to demand response. Attached hereto as **Exhibit "I"** and **Exhibit "J"**, are the 2015 and 2019 Quarterly State of the Market Reports. The 2015 report states that FERC Order No. 745 "increased incentives to participate" in the PJM economic demand response program.[40] Figure 6-2 shows a sudden increase in both credits paid to economic demand response and economic MWh reductions starting in April 2012, when PJM implemented the Order No. 745. The 2019 report includes the same Figure 6-2, which shows the elevated levels of credits, and MWh reductions largely continued through 2019 and then subsided, although they are still above the April 2012 levels.[41]

81. The reports also provide the monthly net benefits test threshold prices. Threshold prices have never exceeded $34.07/MWh since April 2012 when PJM implemented Order No. 745.[42]

82. Steve Dahlke and Matt Prorok published a paper in the Energy Journal in 2019 that estimated the consumer savings, $CO_2$ emission reductions, and price effects that *could* be achieved in the MISO electricity market through the removal of regulatory and market rule barriers to market-based deployment of DR. This paper is attached hereto as **Exhibit "K"**. They argue that even after implementation of FERC Order No. 745,

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[40] Exhibit "I" at 213.

[41] Exhibit "J" at 297.

[42] *Ibid* at 300.

there continue to be barriers to DR participation in MISO and that considerable consumer savings and $CO_2$ emissions could be realized through the removal of the barriers. Through their analysis, they uncover a shortcoming of the FERC net benefits test. They note that DR resources that reduce their consumption in a peak hour because of an economic activation often shift their consumption to future off-peak hours. The shift in consumption increases the price in the future hours and reduces some of the benefits to non-DR resources. That is, "deploying demand response resources that pass the net benefits test in the hour they were deployed actually increased overall costs after taking into account the off-peak increase of energy."[43]

83. Kai Van Horn et al, published a paper in the Electricity Journal in October 2013 that also identified shortcomings in the net benefits test and proposed improvements to the test. This paper is attached hereto as **Exhibit "L"**. Van Horn et al, argue the failure of the net benefits tests "to integrated the impacts of transmission is a significant limitation that has unintended consequences for the total benefits which DR resources may bring to the system and for the distribution of those benefits among the buyers in the system."[44]

84. Xu Chen and Andrew N. Kleit published a paper in the Energy Journal in 2016 (attached hereto as **Exhibit "M"**) that provided empirical result to show how incentive-based DR programs can be "manipulated" to inflate customer baseline load measurement. They suggest, "policy makers in FERC, RTOs and states regulatory agencies consider the threat of manipulation when modifying DR market rules following the Supreme Court's recent upholding of the FERC Order 745."[45]

85. Finally, David Brown and David Sappington published a paper in the Journal of Regulatory Economics in 2016 that derives an optimal DR policy and uses the optimal

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[43] Exhibit "K" at 258.

[44] Exhibit "L" at 152.

[45] Exhibit "M" at 201.

policy to estimate the welfare losses that can arise under FERC Order No. 745. This paper is attached hereto as **Exhibit "N"**. They show that the implementation of Order No. 745 overcompensates DR resources and "reduces welfare well below the level secured by the optimal DR policy."[46] They argue that the policy offered by the critiques to FERC Order No. 745, to compensate DR resources the difference between LMP and the retail rate provided higher welfare than compensation at full LMP as per the FERC Order No. 745.

## D. SUMMARY CONCLUSIONS

### *D.1 Q: Can you summarize for the Board the key findings of evidence?*

86. Yes. The evidence in my testimony demonstrates the following.

87. First, the Amendments provide an equitable treatment of TCA participants. Horizontal equity requires that like people be treated alike. I show by way of example, that two identical companies, which differ only by the arbitrary placement of their meters, are treated exactly alike under the Amendment; *horizontal equity*. I then show that compensating DR resources for an economic activation provides preferential treatment to the company that operates a behind-the meter generator; *horizontal inequity*. The company that operates the behind-the-meter generator, DR Corp. is provided preferential treatment because it benefits twice when it reduces its net-demand with the IESO: first, it reduces the energy payment it makes to the IESO, and second, it receives a payment from the IESO for doing so.

88. In my opinion, applying the horizontal equity test is a more accurate way of assessing equitable treatment, than a test of functional equivalence in service provided, which is the test I understand AMPCO has asked the Board to rely on in this matter. As my example demonstrates, both DR Corp. and Gen Corp. are functionally equivalent in terms of their capability of balancing supply and demand on the IESO controlled grid;

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[46] Exhibit "N" at 265.

one by reducing demand and one for producing electricity. Doing so fails to recognize that DR Corp. is effectively compensated twice for reducing demand while GEN Corp. receives no net benefit for producing electricity (i.e., it earns zero net revenue). I argue that when designing fair and efficient electricity markets, it is important to understand the underling incentives of participants.

89. Second, the Amendments do not place DR resources at a competitive disadvantage to non-committed dispatchable generators in the TCA as per AMPCO's assertion. To the contrary, pay DR resources the market price for economic activations would place non-committed-generators at a competitive disadvantage. Through examples, I show that paying DR resources the market price for an economic activation compensates them twice for their demand reduction. This double benefit would allow them to bid lower in the energy market, and offer lower capacity prices in the TCA to the disadvantage of non-committed generators. Furthermore, I demonstrate that DR resources that are Class A consumers already have a competitive advantage over non-committed generators in the TCA since they can avoid paying Global Adjustment as a capacity resource. This later point creates incentives for large-consumers to invest in behind-the-meter generation at a cost greater than the cost to operate and maintain a non-committed generator facility.

90. Third, the Amendment is consistent with the promotion of fair and equitable competition as it provides the proper incentives for DR resources to operate efficiently within the TCA and the IESO's energy market.

91. Fourth, the presence of the Global Adjustment means that the FERC net benefits test will rarely if ever be satisfied in Ontario. Furthermore, there would be significant complications for the IESO to implement the net benefits test in Ontario due to the Global Adjustment. In my opinion, the evidence shows that there is no net benefit to even further studying the merits of the application of the net benefits test in Ontario.

92. Fifth, Ontario has made significant progress towards reducing the types of barriers to DR resources that concerned the Commission at the time of FERC Order No. 745. In

my opinion, providing DR resources energy payments for economic activations is not required to overcome any legitimate barriers to DR resources, to the extent there are any remaining barriers.

93. With this I conclude my testimony.

| | | |
|---|---|---|
| SWORN before me at the Town of Paris, | ) | |
| in the Province of Ontario, | ) | |
| this 21st day of November, 2019 | ) | |
| | ) | |
| | ) | |
| | ) | |
| A Commissioner for Taking Affidavits | ) | **Brian Rivard** |

**Lauren Theresa Daniel, a Commissioner, etc.,
Province of Ontario, while a Student-at-Law.
Expires April 8, 2022.**

# TAB A

This is Exhibit **"A"** referred to in the Revised Affidavit of Brian Rivard sworn before me this 21st day of November, 2019

*A Commissioner for Taking Affidavits*

**Lauren Theresa Daniel, a Commissioner, etc., Province of Ontario, while a Student-at-Law. Expires April 8, 2022.**

**FORM A**

Proceeding: EB-2019-0242

ACKNOWLEDGMENT OF EXPERT'S DUTY

1. My name is Brian Rivard. I live at the Town of Paris, in the Province of Ontario .

2. I have been engaged by or on behalf of Borden Ladner Gervais LLP to provide evidence in relation to the above-noted proceeding before the Ontario Energy Board.

3. I acknowledge that it is my duty to provide evidence in relation to this proceeding as follows:

(a) to provide opinion evidence that is fair, objective and non-partisan;

(b) to provide opinion evidence that is related only to matters that are within my area of expertise; and

(c) to provide such additional assistance as the Board may reasonably require, to determine a matter in issue.

4. I acknowledge that the duty referred to above prevails over any obligation which I may owe to any party by whom or on whose behalf I am engaged.

Date: November 8, 2019

_________________________

*Signature*

# TAB B

This is Exhibit **"B"** referred to in the Revised Affidavit of Brian Rivard sworn before me this 21st day of November, 2019

*A Commissioner for Taking Affidavits*

**Lauren Theresa Daniel, a Commissioner, etc., Province of Ontario, while a Student-at-Law. Expires April 8, 2022.**

**Brian Rivard**
3025 Redstart Dr, Mississauga, Ontario, L5L 2N1
Home: 905-997-6380, Cell: 437-333-4913
brian.rivard27@gmail.com

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## EDUCATION

| | |
|---|---|
| 1996 | Ph.D. in Economics, University of Western Ontario<br>Fields of Concentration: Industrial Organization, Monetary Economics |
| 1990 | Master of Arts in Economics, University of Western Ontario |
| 1989 | Bachelor of Arts in Economics, University of Windsor |

## PROFFESSIONAL HISTORY

### Adjunct Professor and Research Director of the Energy Policy and Management Centre

Richard Ivey School of Business at Western University
May 2018 to Present

- Contribute to energy policy-making through the production and dissemination of evidence-based research and analysis on major policy issues affecting the electricity, gas, oil and pipeline sectors in Canada
- Provide a transparent and reliable forum for industry, government, academia, and interested stakeholders to discuss and exchange ideas on energy sector development and policy
- Educate students, executives, and government officials on national and global energy sector issues.

### Principal

Charles River Associates International
July 2015 to May 2018

- Provide economic and financial consulting services to corporations, law firms and government agencies on energy market issues relating to asset valuation, market strategy and analysis, corporate strategy and contract disputes and litigation
- Lead the Canadian energy practice for CRA, responsible for marketing and client outreach
- Select consulting experiences include:

- For Alberta's Market Surveillance Administrator, co-authored a report with Adonis Yatchew that assessed the integration of different climate policy options in the Alberta wholesale energy market and the potential effects of the large scale deployment of renewables on the ability of the market to continue to function fairly, efficiently and in an openly competitive manner

- Provided economic and regulatory support to EPCOR Utilities Inc, on the competitive implications on distribution franchise arrangement in the Application to the Ontario Energy Board by Union Gas Limited for an Order for Approval of Union Gas Limited's Distribution System Expansion Projects Proposal EB-201500179

- Managed the analysis and co-authored the expert report related to the valuation of a natural gas generation plant in Ontario, post the expiry of its contract with the Independent Electricity System Operator

- Providing expert economic consulting services to the Market Assessment and Compliance Division of the Independent Electricity System Operator on the development of an internal market impact analysis framework

- Providing expert economic opinion to the Market Assessment and Compliance Division of the Independent Electricity System Operator of the market and financial impacts of an alleged breach of the market rules (alleged market manipulation)

- Advised two Ontario wholesale market participants in the development of an internal compliance plan

- With Robert Cary, advising the Independent Electricity System Operator on the implications for the introduction of a Cap and Trade regime on gas generation contracts

- With Christopher Russo, contributed to the preparation of expert testimony for a Quebec based energy trading company on a matter involving breach of contract

- With Seabron Adamson, prepared expert testimony on behalf of three small hydroelectric generators in a Power Purchase Agreement renewal dispute with Hydro-Quebec

- Provided testimony on issues related to market power and market manipulation before the Federal Energy Regulatory Commission, on behalf of a major US energy company

- Provided advice and prepared a report on capacity market design to the Alberta Electricity System Operator

- Prepared report for the Alberta Utilities Commission on the economic fundamentals of capacity markets

- Prepared advice and prepared a report for the Alberta Department of Energy on governance arrangements in jurisdictions with capacity markets

- Conducting a benchmarking study for NextEra of development costs for North American transmission projects comparable to the proposed East-West transmission line

- Providing expert testimony on behalf of the IESO on a litigation matter before the Supreme Court involving the recovery of the Global Adjustment

- Providing expert advice to the IESO  on the interactions between IESO contracts and the Market Renewal Initiatives

## Director, Markets

Independent Electricity System Operator
May 2013 to July 2015

- Responsible for leading the corporate vision on evolution of the Ontario wholesale electricity market
- Led corporate external stakeholder efforts on market-related issues
- Led and mentored a team of 25 market analysts
- Managed $1-million program budget
- Represented the IESO on the IESO Technical Panel

## Manager, Regulatory Affairs and Sector Policy Analysis

Independent Electricity System Operator
April 2010 to May 2013

- Responsible for providing economic analysis of the impacts of changes to the IESO market rules or market design, government policies, and other industry initiatives
- Responsible for representing the corporation’s interest in all regulatory matters
- Led team of 12 regulatory, market and legal analysts
- Represented the IESO on government relations matters

## Manager, Economics

Independent Electricity System Operator
January 2006 to April 2010

- Conducted economic and financial analysis of changes to the Ontario electricity market and government policy

- Provided strategic advice to IESO CEO and Board of Directors on market-related matters

### Director of Economic Analysis
Bell Canada Enterprise
April 2005 to January 2006

- Responsible for economic arguments made in Bell Canada's regulatory filings
- Conducted economic analysis on matters related to product development

### Special Economic Advisor
Independent Electricity System Operator
November 2000 to April 2005

- Conducted analysis of the Ontario electricity market performance and participant behaviour

### Senior Economist
LECG-Navigant Consulting Inc.,
May 1999 to November 2000

- Provided economic consulting services to legal and corporate clients in competition policy matters

### Economist, Senior Economist
Canadian Competition Bureau
August 1993 to May 1999

- Conducted economic analysis of potential violations of the Canadian Competition Act

## Other Professional Experiences

### Part-Time Instructor
Ryerson University and Osgoode Hall Law School

- Offer courses on the law and economics of energy markets

### Journal Referee

- Peer reviewer for the Energy Journal and Guest Editor, International Conference Energy Forum Special Issue

## PAPERS PUBLISHED

"Integration of Renewables into the Ontario Electricity System," (with Adonis Yatchew), *The Energy Journal*, 2016.

"Recent Developments In Competition Policy: The IPEGs," (with Chantale LaCasse), *Canadian Competition Record*, spring of 2001.

"Antitrust Policy Towards EFT Networks: The Canadian Experience in the *Interac* Case," (with R. Anderson), *Antitrust Law Journal*, Vol. 67, issue 2 July 1999.

"Interac, Essential Facilities and Access to Electronic Funds Networks: A Comment on Mathewson and Quigley," (with Roger Ware), *Canadian Competition Record*, Vol. 18, No. 4, winter 1998.

"Monopolistic Competition, Increasing Returns and Self-fulfilling Prophecies," *Journal of Economic Theory*, Vol. 6, No. 2, April 1994.

## CHAPTERS IN BOOKS

"Economic Evidence of Market Power and Market Manipulation in Energy Markets," (with Robin Cohen, David Hunger, and Christopher Russo) in Gordon E. Kaiser (ed.), *The Guide to Energy Market Manipulation* (London: Global Competition Review, La Business Research, 2018).

"Intellectual Property Rights and International Market Segmentation in the North American Free Trade Area," (with R. Anderson, P. Feuer and M. Ronayne) in *Competition Policy and Intellectual Property Rights in the Knowledge-Based Economy.* Edited by R. Anderson and N. Gallini. Calgary: University of Calgary Press, 1998, pp. 397-429.

"The Competition Policy Treatment of Shared EFT Networks: The *Interac* Case," (with R. Anderson) in the Proceedings of 34$^{th}$ Annual Conference on Bank Structure and Competition on *Payments Systems In the Global Economy: Risks and Opportunities*, 1998.

## OTHER PROFESSIONAL ACTIVITY

- Chair, ISO-RTO Council Markets Committee, a ten-member organization of North America's Electricity System Operators
- Graduate of University of Toronto - Rotman School of Management, Advanced Management Program - Change Management 2015

# TAB C

This is Exhibit **"C"** referred to in the Revised Affidavit of Brian Rivard sworn before me this 21st day of November, 2019

*A Commissioner for Taking Affidavits*

**Lauren Theresa Daniel, a Commissioner, etc.,**
**Province of Ontario, while a Student-at-Law.**
**Expires April 8, 2022.**

PUBLIC

IMP_PRO_0034

PROCEDURE

## Market Manual 4: Market Operations

# Part 4.3: Real-Time Scheduling of the Physical Markets

**Issue 56.0**

**This procedure provides guidance to *Market Participants* on the Real-time scheduling process in the *IESO-administered physical markets*.**

## Disclaimer




| | |
|---|---|
| **Document ID** | IMP_PRO_0034 |
| **Document Name** | Part 4.3: Real-Time Scheduling of the Physical Markets |
| **Issue** | Issue 56.0 |
| **Reason for Issue** | Issue released in advance of Baseline 42.1 |
| **Effective Date** | October 15, 2019 |

## Document Change History

| Issue | Reason for Issue | Date |
| --- | --- | --- |
| For history prior to 2011, refer to version 40.0 | | |
| For history prior to December 2014, refer to versions 50.0 and prior | | |
| 40.0 | Issue released in advance of Baseline 33.0 | December 8, 2014 |
| 41.0 | Issue released for Baseline 33.0 | March 4, 2015 |
| 42.0 | Issue released for Baseline 33.1 | June 3, 2015 |
| 43.0 | Issue released for Baseline 34.0 | September 9, 2015 |
| 44.0 | Issue released for Baseline 34.1 | December 2, 2015 |
| 45.0 | Issue released for Baseline 35.0 | March 2, 2016 |
| 46.0 | Issue released in advance of Baseline 36.0 | June 21, 2016 |
| 47.0 | Issue released in advance of Baseline 36.1 | October 26, 2016 |
| 48.0 | Issue released in advance of Baseline 36.1 | December 1, 2016 |
| 49.0 | Issue released for Baseline 37.0 | March 1, 2017 |
| 50.0 | Issue released for Baseline 37.1 | June 7, 2017 |
| 51.0 | Issue released in advance of Baseline 38.0 | August 1, 2017 |
| 52.0 | Issue released for Baseline 38.0 | September 13, 2017 |
| 53.0 | Issue released for Baseline 38.1 | December 6, 2017 |
| 54.0 | Issue released in advance of Baseline 40.1 | November 14, 2018 |
| 55.0 | Issue released in advance of Baseline 41.1 | April 30, 2019 |
| 56.0 | Issue released in advance of Baseline 42.1 | October 15, 2019 |

## Related Documents

| Document ID | Document Title |
| --- | --- |
| MDP_PRO_0027 | Market Manual 4.2: Submission of Dispatch Data in the Real-Time Energy and Operating Reserve Markets |
| PRO-324 | Market Manual 4.6: Real-Time Generation Cost Guarantee Program |

# Table of Contents

# List of Figures



# List of Tables

# Table of Changes

| Reference (Paragraph and Section) | Description of Change |
|---|---|
| Section 5.1.2 | Updated section to reflect the transition from the Demand Response Auction to the Transitional Capacity Auction |
| Section 7.2 | Updated section to reflect the transition from the Demand Response Auction to the Transitional Capacity Auction |

# Market Manuals

The *Market Manuals* consolidate the market procedures and associated forms, standards, and policies that define certain elements relating to the operation of the *IESO-administered markets*. Market procedures provide more detailed descriptions of the requirements for various activities than is specified in the "Market Rules". Where there is a discrepancy between the requirements in a document within a *Market Manual* and the *Market Rules*, the *Market Rules* shall prevail. Standards and policies appended to, or referenced in, these procedures provide a supporting framework.

## Market Procedures

The "Market Operations Manual" is Series 4 of the *Market Manuals*, where this document forms "Part 4.3: Real-Time Scheduling of the Physical Markets".

**– End of Section –**

# 1. Introduction

## 1.1 Purpose

This document provides *market participants* with the information necessary to support the *real-time schedule* for the *physical markets*. The *IESO* determines *dispatch instructions* for each *registered facility*[1] and *boundary entity* as described in this procedure, as the primary means of coordinating the real-time operation of the *physical markets*.

This procedure addresses:

- The release of the real-time schedule to registered market participants that relates to their registered facilities and boundary entities,
- The release of general real-time schedule to all *market participants*,
- The determination and issuance of dispatch instructions for boundary entities, in the form of interchange schedules to control area operators,
- The determination and issuance of dispatch instructions for registered facilities to registered market participants by the *IESO*, and
- The determination and issuance of standby and activation notices for *hourly demand response (HDR)* resources, in the form of standby and activation reports.

## 1.2 Scope

This *market manual* is intended to provide *market participants* with a summary of the steps and interfaces between *market participants*, the *IESO*, and other parties during the process for determining the *real-time schedule* for the *physical markets*. The procedural workflows and steps described in this document serve as a roadmap for *market participants* and the *IESO*, and reflect the requirements set out in the *market rules* and applicable *IESO* policies and standards.

This procedure only addresses the process for determining the *real-time schedule*. This procedure does not address the pre-dispatch process[2] that provides inputs into the process for determining the *real-time schedule*.

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[1] *Facilities* that are registered with the *IESO* as *boundary entities* to import or export electricity are referred to as *boundary entities* in this procedure. The term '*registered facility*' is used to describe those *facilities* within Ontario that have been registered by *market participants* with the *IESO*.

[2] For more information on the pre-dispatch process, see Market Manual 4.2: Submission of Dispatch Data for the Real-Time Energy and Operating Reserve Markets.

The *IESO* endeavours to ensure that the correct inputs are provided to the *dispatch algorithm*[3] that calculates the *security*-constrained economic *dispatch* (i.e., the *real-time schedule* of *energy* and *operating reserve*). The *IESO* undertakes regular *security* and *adequacy* assessments:

- To identify events that are likely to occur and adjust the inputs to the *Dispatch* Scheduling and Optimization (DSO) tool so that the resultant set of *dispatch instructions* ensure the *security* and *adequacy* of the *IESO-controlled grid*, and
- To identify events that have occurred to which the routine *dispatch* process will be unable to respond in a manner that continues to ensure the *reliability* of the *IESO-controlled grid*. In such situations, the *IESO* may alter the inputs to the DSO and/or intervene in the routine *dispatch* process by manually altering the *dispatch instructions* to ensure *reliability*. In some extreme cases, the *IESO* may have to suspend normal market operations[4].

## 1.3 Roles and Responsibilities

Responsibility for establishing the *real-time schedule* in the *physical markets* is shared among:

- **Registered Market Participants** having dispatchable generation or load facilities that are responsible for:
  - Accepting or rejecting *dispatch instructions* or *release notifications* issued by the *IESO*,
  - Following accepted *dispatch instructions*, and
  - Notifying the *IESO* as soon as possible of circumstances that will result in its *facility* not following its *dispatch instructions* to an extent that is material (as defined in Market Manual 4.2, Appendix C).
- **Registered Market Participants** having *HDR* resources that are responsible for:
  - Monitoring standby reports to determine if a standby notice is received,
  - Following *dispatch instructions* in the form of activation notices, and
  - Notifying the *IESO* as soon as possible of circumstances that will result in its *facility* not following its *dispatch instructions* to an extent that is material (as defined in Market Manual 4.2, Appendix C).
- **Registered Market Participants** having boundary entities that are responsible for:
  - Revising and re-submitting *dispatch data* for *boundary entities* when quantities scheduled for those transactions by other *control areas* are less than the quantity offered or *bid* into the Ontario market,
  - Creating and submitting e-Tags for their interchange transactions,

[3] The *dispatch algorithm* is run through the *Dispatch* Scheduling and Optimization (DSO) tool operated by the *IESO*.

[4] The process of *market suspension* is set out in Market Manual 4.5: Market Suspension and Resumption.

    - Viewing their *interchange schedules* published by the *IESO* to the *market participant* Interface or verbally confirming *interchange schedules* for a *boundary entity* with the *IESO* where the *interchange schedule* differs from the published schedule,
    - Revising and resubmitting e-Tags when *interchange schedule* quantities differ from the quantity provided on the e-Tag, and
    - Cancelling e-Tags submitted for linked[5] wheeling through transactions whose import and/or export component did not get scheduled for the *dispatch hour*.

- ***Control Area operators*** in areas adjacent to the Ontario *control area* who are responsible for confirming or rejecting the feasibility of *interchange schedules* provided by the *IESO*, and
- The ***IESO*** which is responsible for:
    - Releasing *real-time schedule* information, *market schedule* information, *market prices* and related operational information to *registered market participants*,
    - Publishing dispatch instructions for market participants with boundary entities in the form of interchange schedules,
    - Identifying and removing from schedule linked wheeling through *interchange schedules* whose import and/or export component did not get scheduled for the dispatch hour.
    - Issuing and confirming *dispatch instructions* verbally to *market participants* with *boundary entities* where the *interchange schedule* is different from the published schedule,
    - Issuing dispatch instructions to registered facilities that are not boundary entities,
    - Issuing dispatch advisories, on a reasonable efforts basis, to registered facilities that are not boundary entities, as per *Market Rule* Chapter 7, Section 7.1.6 (*MR* Ch. 7 Sec. 7.1.6).
    - Identifying circumstances where emergency actions are required to maintain the *reliability* of the *IESO-controlled grid*,
    - Informing *market participants*, as soon as practicable, whenever a published *market price* is an administrative price.

## 1.4 Contact Information

Changes to this public *market manual* are managed via the *IESO* Change Management process. Stakeholders are encouraged to participate in the evolution of this *market manual* via this process.

To contact the *IESO*, you can email *IESO* Customer Relations at customer.relations@ieso.ca or use telephone or mail. Telephone numbers and the mailing address can be found on the IESO website (http://www.ieso.ca/corporate-ieso/contact). Customer Relations staff will respond as soon as possible.

**– End of Section –**

[5] Linked wheeling transactions are described in Market Manual 4.2, Section 2.5.4.

# 2. Participant Workstation and Dispatch Workstation

*Market participants* are required to operate a *participant workstation* and a *dispatch workstation* for the purposes of supporting the process of determining the *real-time schedule*. The *participant workstation* is connected to the Participant Network. *Market participants* submit *bids* and *offers* to the *IESO* via the *participant workstation*, as described in Market Manual 4.2. Valid *bids* and *offers* are then passed to the *IESO's* Market Interface System (MIS) for the purposes of determining the *real-time schedule*. *Dispatch instructions* for *boundary entities*, in the form of the *interchange schedule*, are published via the *Market Participant* Interface, a component of the *participant workstation*.

The *dispatch workstation* is connected to the Real-Time Network, which supports real-time operation of the power system. *Dispatch instructions* for *registered facilities* are submitted to *market participants* via their *dispatch workstation*.

For more information on the system and software requirements for the *participant workstation* and the *dispatch workstation*, refer to Market Manual 6: Participant Technical Reference Manual.

**– End of Section –**

# 3. Determining Real-Time Schedules

The *IESO* uses a range of information to determine the *real-time schedules*, including:

- Dispatch data submitted by registered market participants,
- The registered *generation facility's* maximum ramp rate from the IESO Registration Solution,
- The registered *generation facility's* minimum loading point from the IESO Registration Solution (*MR* Ch. 7 Sec. 2.2.6A), and
- The following registered *generation facility's* characteristics from the IESO Registration Solution (*MR* Ch. 7 Sec. 2.2.6A),
    - Forbidden region data, and
    - Period of steady operation data.
- A default value of zero for the minimum loading point, forbidden region and period of steady operation if none has been registered with the *IESO* with respect to this information.
- Predictions of load for the next sixty-minutes, calculated automatically[6] every five-minutes,
- Generator and transmitter outage information provided by market participants,
- Transfer limits for interconnected interties,
- Total *operating reserve* requirements (10-minute spinning, 10-minute non-spinning, 30-minute) determined by the *IESO*,
- *Local area* reserve requirements (if any), determined by the *IESO*,
- Operating *security* and thermal limits on transmission *facilities*,
- Scheduled interchange for the hour, calculated by the last pre-dispatch run of the DSO[7],
- The output level of each *generator* and the withdrawal levels of each *dispatchable load* and *HDR* resource at the beginning of the *dispatch interval* are set at the *IESO's* best estimate of their actual values, as determined from real-time system data and the *real-time schedule* for the preceding *dispatch interval*,
- *Variable generation* five-minute supply forecast, and
- Such other available information as the *IESO* determines appropriate.

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[6] At the discretion of the *IESO,* we may manually adjust the Ontario *demand* forecast to account for limitations of our automated load predictor to accurately forecast expected load profiles.

[7] The DSO is run with a one-hour time-step in pre-dispatch mode for all the remaining hours of today and, from 16:00 EST on, for all the hours of tomorrow. *Interchange scheduled* by the DSO for the next hour is confirmed with adjacent *control areas* and ramped at or near the top of the hour. Scheduled interchange for the hour is provided as an input to the real-time DSO to calculate the five-minute *dispatch instructions* for internal Ontario resources.

The *IESO* uses this information and the *dispatch algorithm*[8] to determine a *security*-constrained economic *dispatch* schedule for each five-minute *dispatch interval and* to determine anticipated schedules for a number of advisory intervals within the study period. Daily *energy* limits are not taken into account in determining *real-time schedules*.

The real-time constrained *dispatch* schedule, only, utilizes a two-step optimization technique to determine a *security*-constrained economic *dispatch* schedule for a number of critical intervals over a forward-looking study period. For each real-time constrained *dispatch* schedule, critical intervals are selected by the *IESO* from the study period based on selection criteria defined in the Multi-Interval Optimization Functional Requirements document.

There are currently up to 11 critical intervals selected within a study period of 55 minutes. The first critical interval is always the *dispatch interval*, and the remaining critical intervals are advisory intervals. Both the length of the study period and the number of advisory intervals are configurable and may be changed by the *IESO* in the event of significant improvement or degradation of either computer software and hardware performance or the accuracy of predicted demand values (*MR* Ch.7, App. 7.5, Sec. 2.11.3*).*

In the event of a malfunction of the multi-interval optimization algorithm the *IESO* may switch to single interval optimization. During such periods new *dispatch* advisory reports will not be issued. The *IESO* will issue a system message to notify *market participants* whenever single interval optimization is being used.

It should be noted that the *dispatch* advisory reports issued to registered dispatchable *market participants* only include the schedules for the advisory intervals and not for the *dispatch interval*.

The *IESO* will review the output from the *dispatch algorithm* and may manually adjust the *real-time schedule* to reflect control actions that are required to address events that the *IESO* assesses:

- Will have a material impact on the *IESO-controlled grid*, and
- Occur in a timeframe in which the *dispatch algorithm* and market mechanisms cannot respond.

Such events may include:

- Unplanned outages of facilities,
- Rapid changes to *security limits*,
- Unexpected *demand* changes,
- Limitations of the load predictor to accurately forecast Ontario *demand* for the next interval,
- Area reserve inadequacies,
- Voltage problems, or
- Variable generation ramp events.

To resolve such problems, the *IESO* may intervene in the routine *dispatch* process, where the *IESO* judges that such intervention is viable. In such situations, the *IESO* will manually adjust the *dispatch instructions* that result from the *real-time schedule* generated through the *dispatch algorithm* and issue these adjusted *dispatch instructions*. Where an assessment determines that such intervention

[8] The real-time DSO uses the *constrained IESO-controlled grid* model.

is not viable, the *IESO* will suspend normal market operations (see Market Manual 4.5: Market Suspension and Resumption).

**– End of Section –**

# 4. Determining Market Information

Within five minutes following the end of each *dispatch interval*, the *IESO* uses the *dispatch algorithm* to determine the *market schedule* and the *market prices* for that *dispatch interval*. For the purpose of determining the *market schedule* and *market prices* for any *dispatch interval*, the *IESO* uses the same information and data that was used to determine the *real-time schedule* for that *dispatch interval*, except that (*MR* Ch. 7, Sec. 6.4):

- The unconstrained *IESO-controlled grid* model is used,
- The initial conditions used for any *dispatch interval* in the *market schedule* are the final conditions of the *market schedule* for the preceding *dispatch interval*,
- The total *demand* (including losses) to be satisfied within a *dispatch interval* in the *market schedule* are set at the *IESO's* best estimate of its actual value, as determined from real-time system data,
- Total system *energy* losses determined in the *real-time schedule* are represented as an increase in *non-dispatchable load* within the *IESO control area*,
- Any *registered facility* in respect of which a *forced outage* has been detected during a *dispatch interval* are recognized by an adjustment to the input data,
- The estimated deviations between scheduled quantities and actual quantities are represented as a change in *non-dispatchable load* in the *IESO control area*[9],
- The *market schedule* reflects *dispatch* adjustments[10] computed using scheduled injections from the constrained schedule, outlined in *MR* Ch. 7, App 7.5, and
- The *demand* in the *market schedule* will be adjusted when the *IESO* initiates a voltage reduction (3% or 5%) and/or *non-dispatchable* load cuts (rotational, *emergency* or manual load shedding), by an amount expected to offset the impact of the control action (*MR* Ch. 7 Sec. 3.2.1.12).

**Note:** When the *IESO* undertakes an emergency control action consisting of a voltage reduction and/or *non-dispatchable* load cuts for local or global reasons, the *IESO* will adjust the *demand* in the *market schedule* as soon as practical, considering the nature of the operating conditions at the time, by an amount expected to offset the impact of the control action. The *IESO* will not consider any action resulting in a *demand* reduction of 50 MW or less as a control action for the purposes of this manual.

**– End of Section –**

[9] Until such time that locational pricing is implemented in the *IESO-administered markets*, in determining the *market schedule* and *market prices* for any *dispatch interval*, the *IESO* shall not have regard to the estimated deviations between scheduled quantities and actual quantities.

[10] These dispatch adjustments will not be considered in determining the *market schedule* and *market prices* for any *dispatch interval* until the date indicated in the previous footnote.

# 5. Releasing Real-Time and Market Information

## 5.1 Publication of Real-Time Schedule Information

The *IESO* releases information in support of the *real-time dispatch process*, including *real-time schedules*, *market schedules* and *market prices*. Information relating to specific *registered facilities*, HDR resources, and *boundary entities* is released to the *registered market participant* for that *facility*. Other information relating to the general status of the system is released to all *market participants*.

### 5.1.1 Registered Facilities (other than boundary entities and HDR resources)

As soon as practical but no later than the start of the *dispatch interval* to which it relates, for each *registered facility* that is a *dispatchable load* or a dispatchable *generator* in respect of which *market participant bid* or *offer* has been submitted for the applicable *dispatch hour*, the *IESO* releases the following information to the *registered market participant* for the *facility:*

- The real-time schedule for that *registered facility*,
- The dispatch advisories for that *registered facility* (*MR* Ch. 7, Sec. 7.1.6), and
- The obligation indicator for any registered *facility* that is a *variable generator*.

The *dispatch* advisory will be issued on a reasonable effort basis and missed *dispatch* advisories will not be re-issued.

Within one hour after each *dispatch hour*, for each *registered facility* that is a *dispatchable load* or a dispatchable *generator* in respect of which a valid *bid* or *offer* has been submitted for the applicable *dispatch hour*, the *IESO* releases the *market schedule*[11] for each *dispatch interval* in the *dispatch hour* to the *registered market participant*.

Additionally, the *IESO* shall *publish* on the *IESO* website:

- The standing *offer* prices and quantities for control action sources of *operating reserve* as determined by the *IESO Board* (*MR* Ch. 5, Sec. 4.5.6A.2), and
- The times and quantities of the voltage reductions and reduction in *thirty-minute operating reserve* when these control action sources of *operating reserve* are scheduled to provide *operating reserve* (*MR* Ch. 5, Sec. 4.5.6A.4).

Also, the *IESO Board* may specify the circumstances under which any one or more of the quantities may either be withdrawn or not introduced, and the manner in which any such withdrawal will be effected and the *publishing* thereof (*MR* Ch.5, Sec. 4.5.6A.3).

[11] This obligation is subject to the provisions of *MR* Ch. 7 Sec. 8.4.

### 5.1.2 Hourly Demand Response (HDR) Resources

The *IESO* releases the *pre-dispatch* schedule for each *registered facility* that is an *HDR* resource as soon as practical[12] (consistent with relevant *reliability standards*).

The *IESO* releases *dispatch instructions,* in the form of an activation notice to the *capacity market participant* (CMP) for each *registered facility* that is an *HDR* resource.

### 5.1.3 Boundary Entities

As soon as practical and consistent with relevant *reliability standards*, but no later than the start of the *dispatch hour* to which it relates[13], for each *registered facility* that is a *boundary entity* in respect of which the *dispatch instructions* for a given *dispatch hour* provides for the *dispatch* of more than 0 MW, the *IESO* releases the following information to the relevant *market participant*:

- The interchange schedule for that registered facility, as found in the relevant pre-dispatch schedule,
- Any request of that registered facility to submit an offer or bid under a reliability must-run contract and the scheduled use of that registered facility under reliability must-run contracts and contracted ancillary services contracts, and
- The projected market schedule for that registered facility.

### 5.1.4 All Market Participants

In the five-minute period after the end of each *dispatch interval*, the *IESO* releases to all *market participants* the uniform *market prices* of *energy* and *operating reserves* related to that *dispatch interval*.

Within one hour after the end of the *dispatch hour*, the *IESO* releases to all *market participants* the following information for each *dispatch interval* of that *dispatch hour*:

- Total system load and total system losses,
- Area *operating reserve* requirements,
- For information purposes only, *energy* prices at each set of transmission nodes identified by the *IESO* for this purpose, decomposed as far as practical into an *energy* component, a loss component and a component for all other transmission and system constraints and the prices of each class of *operating reserve* in each reserve area identified by the *IESO* for this purpose,
- Aggregate reliability must-run resources called upon,
- Any area *operating reserve* shortfalls, and
- A list of network and *security* constraints that affected the *real-time schedule*.

[12] Typically, this will be approximately 2 hours and 30 minutes (but no later than 2 hours) prior to the start of the *dispatch hour* due to the scheduling requirements of *HDR* resources.

[13] Typically, this will be at least 30 minutes prior to the start of the *dispatch hour* due to the requirements to provide e-Tags at least 20 minutes prior to the start of the *dispatch hour*.

The *IESO* also releases the *market schedules* for all *dispatch interval*s in the preceding *dispatch hour* to the *registered market participant*, for each *registered facility*.

In the event of a load *curtailment*, the *IESO* will release to all *market participants* an estimate of aggregate load *curtailed* as soon as practicable following the return to a *normal operating state*.

## 5.2 Publication of Real-Time Dispatch Information

Within one hour after the end of each *dispatch hour*, the *IESO publishes* information regarding the system results and events that occurred during that *dispatch hour*. This information includes:

- Total load met,
- Transmission capacity between the *IESO-controlled grid* and each *intertie zone*,
- Any *outages* of transmission *facilities*,
- Total *operating reserve* scheduled, and total *energy* called from such *operating reserve*, by area,
- The market prices for each dispatch interval, and
- The uniform Hourly Ontario Energy Price (HOEP).

**– End of Section –**

# 6. Determining Dispatch Instructions

## 6.1 Registered Facilities (other than HDR resources and boundary entities)

The *IESO* will seek to ensure that the *dispatch instructions* issued with respect to each *registered facility*, other than a *boundary entity or HDR* resource, closely approximate the most recent *real-time schedule* for that *registered facility* and *dispatch interval* and are within capabilities of the *facility* as registered with the *IESO*. The *IESO* may, however, issue *dispatch instructions* that depart from the *real-time schedule* produced by the DSO if:

- The *security* and *adequacy* of the system would be endangered by implementing the most recent *real-time schedule*,
- The *dispatch algorithm* has failed, or has produced a *real-time schedule* that is clearly and materially in error,
- The *dispatch algorithm* has produced a *real-time schedule* that does not accurately reflect the *minimum run-time* or lockout[14] status of a *facility* due to *dispatch algorithm* limitations,
- Material changes subsequent to determination of the most recent *real-time schedule*, such as failure of an element of a *transmission system* or failure of a *registered facility* to follow *dispatch instructions*, have occurred, or
- The operation of all or part of the *IESO-administered markets* has been suspended[15] (refer to Market Manual 4.5: Market Suspension and Resumption).

Having produced the *real-time schedule*, an under generation condition may prevail. In such circumstances, the *IESO* will declare an *emergency operating state* if observance of *security limits* under a *normal operating state* will require *curtailment* of *non-dispatchable load*. The *IESO* will implement *demand* management and/or load shedding activities[16], as detailed in the Market Manual 7: Systems Operations Overview[17], to resolve the situation.

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[14] The dispatch algorithm does not have the functionality to recognize the operating status of some facilities once they complete dispatch instructions. This is illustrated in, but not limited to, the following examples:

- The dispatch algorithm does not recognize that, once some quick start facilities synchronize, they must remain in service at or above a minimum loading point for a minimum run-time.
- The *dispatch algorithm* does not recognize that, once some *facilities* change their *dispatch* level, they are locked out and cannot change *dispatch* from that level for a specified period of time.

[15] This may occur as a result of one of the preceding bullets.

[16] Implementation of manual load shedding should be preceded by a declaration of an *Emergency Operating State*.

[17] In general, under generation situations should not appear unexpectedly. In most cases, under generation situations should be evident in advance via the Adequacy Report up to 34 days out. These situations may also be identified in an advisory notice – which may include a Maximum Generation Alert, or the outputs of the pre-dispatch run. Control actions to address under generation in these timeframes can include issuance of a

## 6.2 Hourly Demand Response (HDR) Resources

The *IESO* will seek to ensure that the *dispatch instructions*¸ in the form of an activation notice, issued with respect to each *registered facility* that is an *HDR* resource for each *dispatch hour* reflect the *pre-dispatch schedule*[18] used for scheduling that *dispatch hour*. The *IESO* may, however, issue *dispatch instructions* that depart from the *pre-dispatch schedule* if:

- The *security* and *adequacy* of the system (internally or externally) would be endangered by implementing the *pre-dispatch schedule,*
- The *dispatch algorithm* has failed, or has produced a *pre-dispatch schedule* that is clearly and materially in error,
- Material changes subsequent to determination of the *pre-dispatch schedule*, such as failure of an element of a *transmission system* or failure of a *registered facility* to follow *dispatch instructions*, have occurred, or
- The operation of all or part of the *IESO-administered markets* has been suspended. Refer to Market Manual 4.5 for more details on this situation.

## 6.3 Boundary Entities

The *IESO* will seek to ensure that the *dispatch instructions* issued with respect to each *registered facility* that is a *boundary entity* for each *dispatch hour* reflect the *pre-dispatch schedule* used for scheduling that *dispatch hour*. The *IESO* may, however, issue *dispatch instructions* that depart from the *pre-dispatch schedule* if:

- The *security* and *adequacy* of the system (internally or externally) would be endangered by implementing the *pre-dispatch schedule,*
- The *dispatch algorithm* has failed, or has produced a *pre-dispatch schedule* that is clearly and materially in error,
- The *dispatch algorithm* has produced a *real-time schedule* that does not accurately reflect the *minimum run-time* or lockout[19] status of a *facility* due to *dispatch algorithm* limitations,
- Material changes subsequent to determination of the *pre-dispatch schedule*, such as failure of an element of a *transmission system* or failure of a *registered facility* to follow *dispatch instructions*, have occurred,
- In the event of a shortfall in *energy* or *operating reserve*, the output of a *resource* associated with a capacity export is insufficient to support the full export,
- The operation of all or part of the *IESO-administered markets* has been suspended. (Refer to Market Manual 4.5 for more details on this situation.),

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System Advisory for under generation, soliciting *offers* for generation and rejecting, revoking, or recalling *outages*.

[18] For *HDR* resources, the pre-dispatch run occurring three hours in advance of the *dispatch hour* will be used for scheduling demand response during the availability window of the *dispatch day*. A resource will be scheduled for one and up to four consecutive hours when the *pre-dispatch schedule* is less than the resource's total *bid* quantity.

[19] As defined in section 6.1.

- A violation of the net *interchange schedule* limit has occurred,
- Quebec has issued a reliability declaration pursuant to the Amended & Restated IESO-Hydro Quebec Capacity Sharing Agreement, but the *dispatch algorithm* has failed to produce a *pre-dispatch schedule* in accordance with the obligations under the agreement (see Section 6.4), or
- An external jurisdiction has issued a capacity call, but the *dispatch algorithm* has failed to produce a *pre-dispatch schedule* in accordance with the capacity export obligations (see Section 6.7).

In addition, e-Tags and/or *interchange schedules* for *boundary entities* may be required to be changed following *IESO* confirmation of e-Tags and *interchange schedule* with adjacent *control areas* for (e.g., as a result of a failure to successfully navigate the adjacent market). The sequence of this confirmation is as follows:

- The *IESO* validates e-Tags and confirms the *interchange schedules* with the appropriate c*ontrol areas*, prior to five minutes to the start of the *dispatch hour*.

  **Note:** The *IESO* removes interchange *bids* or *offers* from the schedule where e-Tags are missing, late, invalid, and incorrect and/or c*ontrol area* confirmation fails, unless such interchange *bids* or *offers* are required for *reliability* reasons. Refer to Market Manual 4.2: Submission of Dispatch Data in the Real-Time Energy and Operating Reserve Markets**,** Section 2.5.

- The *IESO* confirms the *interchange schedule(s)* MW quantities with the appropriate c*ontrol areas and* quantities are modified prior to the start of the ramp, as necessary, to ensure viable *interchange schedule(s)*. In the event of an *interchange scheduling* disagreement between *control areas*, the lesser quantity shall prevail. Failure to agree to the lesser quantity will result in the *interchange scheduling being reduced to 0 MW*, and
- The *IESO* notifies *market participants* of revised *interchange schedule(s)* MW quantities where quantities have been revised in discussion with other c*ontrol areas*.

## 6.4 Intertie Scheduling Protocols

### 6.4.1 IESO/NYISO Protocol: NY90

In an effort to ensure fair and efficient use of the *IESO*/NYISO *interties*, the *IESO* and the NYISO have agreed to follow a specific *interchange scheduling* protocol for the exchange of *interchange scheduling* information (*MR* Ch. 7 Sec. 1.4.1). On July 29, 2002, the *IESO* and the New York Independent System Operator (NYISO) adopted a scheduling protocol to effectively coordinate *interchange scheduling* between the two jurisdictions. This *interchange scheduling* protocol establishes a timeline that defines when certain *interchange scheduling* checkout activities occur, both within and between the two organizations. Figure 6-1 illustrates this timeline.

The *IESO* will be marking New York *interchange schedules* with either the "**NY90**", “**MrNh**”, “**TLRe**” or "**OTH**" code within the *IESO* systems to reflect schedule check-out activities within the NYISO (see *IESO*-NYISO scheduling protocol below). This approach will result in more accurate and reliable pre-dispatch schedules.

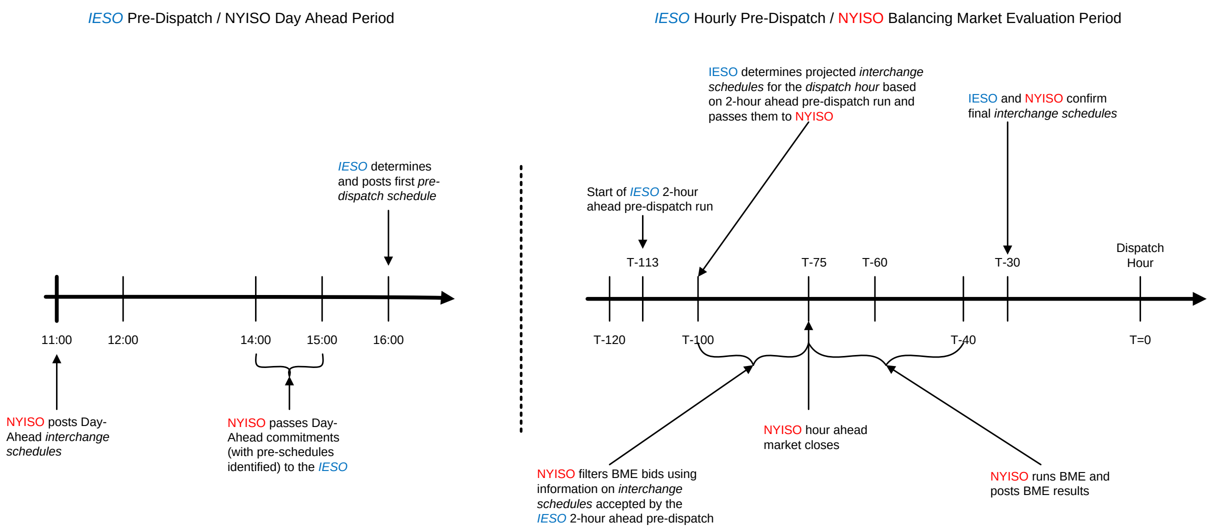


**Figure 6-1: IESO - NYISO Scheduling Protocol**

### Pre-Dispatch Period (*IESO*) and Day-Ahead (NYISO)

| | |
|---|---|
| 11:00 hours (EST) to 12:00 hours | The NYISO posts the Day-Ahead Market schedule |
| 14:00 hours to 15:00 hours | NYISO calls and performs a cursory check on eligible marketers (importers/exporters). |
| 16:00 EST | The *IESO* posts initial *pre-dispatch schedule* for the next 32 hours. |

### Hourly Pre-Dispatch Period (*IESO*) / RTC (NYISO)

| | |
|---|---|
| T-100 minutes | The *IESO* determines projected *interchange schedules* for the *dispatch hour* based on the 2-hour ahead pre-dispatch run, applies the **NY90/Max** code to projected *interchange schedules* and communicates the information to the NYISO. |
| T-100 minutes to T-75 minutes | The NYISO filters the hour ahead Real Time Commitment (RTC) *interchange schedule bids* that affect the *IESO*/NYISO *interties* to include only those *interchange schedules* with *offers*/*bids* accepted by the *IESO's* 2-hour ahead pre-dispatch run. |
| T-75 minutes to T-40 minutes | The NYISO runs the RTC, automatically adjusting e-Tags accordingly based on the RTC results then notifies the *IESO* of those *interchange schedules* that have failed (in whole or part)[20] to navigate the NYISO market and posts the NYISO Hour-Ahead schedule |

[20] The NYISO identifies to the *IESO* those *interchange schedules* not scheduled and partially scheduled by RTC. Those *interchange schedules* scheduled in part by RTC will be scheduled accordingly. Those *interchange schedules* not scheduled will be removed by the *IESO* prior to the *dispatch hour.* In either case the *interchange schedules* will be failed and no CMSC payments will apply.

**Hourly Pre-Dispatch Period (*IESO*) / RTC (NYISO)**

| | |
|---|---|
| T-30 minutes | The *IESO* confirms final *interchange schedules* with the NYISO, making final adjustments to *interchange schedules* accordingly and notifies the *market participant* of the changes by automated e-mail. The NYISO posts RTC results |
| T-100 minutes to T-75 minutes | Where required for *reliability* reasons, the *IESO* may, in economic merit, include *interchange schedules* from the NYISO 2-hour ahead RTC evaluation that failed the *IESO* 2-hour ahead pre-dispatch run, in the short list for evaluation in the final RTC evaluation, or<br>If necessary, in economic merit, constrain on resources irrespective of the *IESO*-NYISO scheduling protocol. |

Revisions and/or additions to *dispatch data* within the two hours prior to the *dispatch hour* are restricted. The *IESO* may accept revisions and/or additions for internal *reliability* reasons. Additionally, at the request of the NYISO, the *IESO* may allow revisions and/or additions during this timeframe if the changes facilitate a solution to NYISO *reliability* concerns. [21]*IESO* / NYISO *interchange schedule* implementation is consistent with the *NERC* transaction ramping default of 10-minutes with the ramp straddling the top of the *dispatch hour*.

### 6.4.2 Curtailed and Failed Interchange Schedules

An *interchange schedule* that has been curtailed during the *dispatch hour* for *reliability* reasons may be reinstated within that *dispatch hour* if the *reliability* condition causing the curtailment is resolved, and the curtailed *interchange schedule(s)* is scheduled in the next *dispatch hour*.

At T-100 minutes, the projected *interchange schedules* for the *dispatch hour* based on the *IESO's* 2-hour ahead pre-dispatch run are considered as at their maximum available for the *dispatch hour* and are "capped" at that value in the constrained schedule using the code **NY90/Max**[22]. This "short list" is forwarded to NYISO for RTC evaluation. CMSC will apply as per the normal scheduling process, provided the "capped" *interchange schedule(s)* clears the NYISO RTC @ T-75 minutes.

Where required for *reliability* reasons, the *IESO* may, include in the short list for evaluation in the final NYISO RTC evaluation, *interchange schedules* from the NYISO 2-hour ahead RTC evaluation that are the next most economically *interchange schedule(s)*, which failed the *IESO* 2-hour ahead pre-dispatch run. The **NY90/Max** code is **not** used for such *interchange schedules* in the pre-dispatch period when the addition to the short list includes a complete *offer* (either the full quantity of the new *interchange schedule* or an existing *interchange schedule* MW is increased to the full quantity offered). However, CMSC or IOG will be applied as appropriate if the *interchange schedule* is dispatched. The **NY90/Max** code is used if the addition to the short list results in a selection of a partial *interchange schedule offer.*

[21] This would not include calls for capacity exports

[22] The schedule is re-evaluated in the 1-hour ahead pre-dispatch run, with the market schedule able to increase or decrease, but the constrained schedule only able to decrease.

At-T-30 minutes, *interchange schedules* that failed the NYISO RTC (all or in part) will be failed by the *IESO* using the code **OTH/Fix,** unless failed as a result of external transmission limitation, in which case the **TLRe** code will be applied. No CMSC payments will apply.

### 6.4.3 IESO/MISO Protocol: MISO Protocol

In an effort to facilitate the release of MISO transmission and ramp the IESO has a unique scheduling protocol for all MISO transactions. At T-90, all e-Tags for transactions on the Michigan, Manitoba or Minnesota interfaces will be reduced to their 2 hour out pre-dispatch schedule. Subsequently, all transactions whose schedule increases from 2 hours out to 1 hour out will be re-loaded to reflect their 1 hour out pre-dispatch schedule.

### 6.4.4 IESO/Hydro-Quebec: Capacity Agreements

The IESO and Hydro-Quebec have capacity agreements. Energy scheduled to satisfy the terms of the agreements will be on the PQ.OUTAOUAIS *boundary entity*. Delivery of firm energy under the agreements is measured as the net schedule on PQ.OUTAOUAIS regardless of the *market participant* responsible for the scheduled transaction (i.e., a Hydro Quebec energy transaction does not have to be scheduled for the sending entity to be meeting its energy obligation, if other transactions deliver an equivalent amount of energy).

Submission of *dispatch data* for transactions associated with the agreements shall adhere to the existing timelines and requirements specified in *Market Manual* 4.2, Section 2.5. The determination of *real-time schedules*, *market schedules*, *market prices*, and *dispatch instructions* for these transactions shall be in accordance with this *market manual*, and as described below.

#### Winter Period (December 1 to March 31)

To call on Ontario capacity, Hydro Quebec TransÉnergie (HQT) shall issue a reliability declaration to the IESO, and Hydro Quebec Energy Marketing (HQEM) shall submit an associated energy export bid (HQEM export). An advisory notice shall be issued notifying market participants. This HQEM export will be scheduled by the *dispatch algorithm* using normal market mechanisms.

To satisfy the terms of the capacity agreements, the *IESO* may take control actions in the pre-dispatch timeframe to increase the net schedule on PQ.OUTAOUAIS to the MW *bid* quantity of the HQEM export if:

- The HQEM export *bid* price is the *maximum market clearing price (MMCP)*
- The net schedule on PQ.OUTAOUAIS is less than the MW *bid* quantity of the HQEM export, and
- There is sufficient transmission capacity on the interface.

To satisfy the terms of the capacity agreements, the IESO may take control actions in real-time to ensure delivery of energy exports associated with the capacity agreements that are scheduled in pre-dispatch.

These control actions will be made in accordance with Market Manual 7.1: IESO-Controlled Grid Operating Procedures, Appendix B.2: Emergency Operating State Control Actions. Constrained-on exports on PQ.OUTAOUAIS shall be applied on a reasonable effort economic basis using the TLRe code (see Table 1-1).

### Summer Period (June 1 to September 30)

To call on Quebec capacity, the IESO shall issue a reliability declaration[23] to HQT and issue an advisory notice to market participants. Following this, HQEM will submit an associated import *offer* (HQEM import). As in the winter period, this HQEM import will be scheduled by the *dispatch algorithm* using normal market mechanisms.

Consistent with Market Manual 7.1, Appendix B.1, the IESO may constrain on import transactions on a reasonable effort economic basis in advance of or during an emergency operating state. This may include import transactions on PQ.OUTAOUAIS associated with the capacity agreements, with no preferential treatment given to the HQEM import. Manual constraints will be applied using either the TRLi or ADQh code for IESO adequacy (see Table 6-1).

## 6.5 Pre-Emptive Curtailments

If the *IESO* determines with reasonable certainty that specific transactions, or a certain volume of transactions, will not be successfully scheduled or will need to be curtailed in real-time due to an internal issue, the *IESO* may remove the affected transactions from the constrained schedule only (using the TLRi code) for future hours.

If the *IESO* determines with reasonable certainty through input from the appropriate scheduling entity that transactions will not be successfully scheduled due to external reliability (security or adequacy), or due to a consistent *market participant* failure (economics or tagging), the *IESO* may remove the anticipated affected transactions from the *IESO* scheduling processes, for future hours and code appropriately.

If an external Reliability Coordinator initiates the *NERC* TLR procedure that has resulted, or is anticipated to result, in transaction failures and it is determined, through input from the appropriate issuing entity, that the TLR will continue for some time into the future, the *IESO* may pre-emptively remove (or reduce to the expected level of delivery) transactions from the applicable pre-dispatch constrained and unconstrained sequences (using the TLRe code). On a reasonable effort basis, the *IESO* will attempt to remove/reduce the transactions as per the IDC process (first by transmission priority bucket, then on a reasonable effort economic basis within the transmission bucket). To prevent an increased schedule to the remaining transactions, the IESO may constrain these transactions to their pre-dispatch value with a TLRe code.

*Market participants* can visit the *NERC* website at www.nerc.com to confirm whether Transmission Loading Relief Procedures have been implemented.

If pre-emptive curtailments are expected to last for multiple hours, an advisory notice shall be issued notifying *market participants* that this practice is occurring. Another advisory notice shall be issued when the pre-emptive curtailments have ended.

In all cases, pre-emptive curtailments will be made to the same transactions that are expected to be curtailed in real-time on a reasonable effort basis (e.g., economics, transmission priority, etc.).

[23] In accordance with Market Manual 7.1: IESO-Controlled Grid Operating Procedures, Appendix B.1 Actions in Advance of and During the IESO Controlled Grid Emergency Operating State.

## 6.6 Transaction Coding

### 6.6.1 Principles of Coding

When altering the *pre-dispatch schedule* issued with respect to each *registered facility* that is a *boundary entity*, the *IESO* will abide by the following coding principles:

***Principle 1***

The *IESO* will only intervene to alter *pre-dispatch schedules* for a given dispatch hour if:

- In the IESO's opinion, as a result of changing conditions, the *real-time schedules* will not have sufficient resources available to maintain the reliable operation of the *IESO-controlled grid*, or
- Consistent with interconnection agreements and industry standards, the *IESO* is requested to do so by another control area or reliability coordinator, or
- The *market participant* has not met all requirements.

***Principle 2***

To the extent possible, *IESO* manual changes shall be consistent with the changes that would have occurred if the hour ahead pre-dispatch sequences had recognized the reliability concern.

***Principle 3***

To the extent practicable, the *IESO* shall limit manual intervention to an amount equal to the difference between the change in conditions and the real-time capability of available internal resources to address that change.

***Principle 4***

To the extent practicable, the *IESO* shall use the economic merit order of intertie transactions as the basis for determining which transactions to manually adjust.

***Principle 5***

*IESO* manual intervention shall impact the same *real-time/pre-dispatch schedule* (constrained or unconstrained) that would have had insufficient resources as a result of the changing conditions, as noted in principle 1.

***Principle 6***

The *market participant* whose transaction is affected by the *IESO* manual intervention shall be eligible for the same market compensation and be subject to the same risks as if the transaction was scheduled in the hour ahead *pre-dispatch schedule*.

**Table 6-1: Application of Interchange Schedule Codes**

| Transaction Failures | | Summary of Codes & Resulting Treatment | | | | | |
|---|---|---|---|---|---|---|---|
| **Failure Reasons** | **Further Description** | **Code Entered** | **CMSC[24] Treatment** | **DA IFC Exempt (Import)** | **RT IFC Exempt (Import)** | **RT EFC Exempt (Export)** | **DA-IOG Component #2 Treatment** |
| e-Tagging errors | e-Tagging errors | OTH | No | No | No | No | No |
| External Jurisdiction Economic Selection Failure (whole or partial) | External Jurisdiction Economic Selection Failure (whole or partial) | OTH | No | No | No | No | No |
| PJM Ramping Capacity (where ramp reservations required) | Market participant failure to acquire ramping capability. | OTH | No | No | No | No | No |
| ISO Market Participant Scheduling Errors | Scheduling errors[25] | OTH | No | No | No | No | No |
| Linked wheels (within participant control) | Curtailment of linked wheels within participant control | OTH | No | No | No | No | No |
| e-Tag held by IDC | e-Tag held by IDC following the first hour of the TLR process | OTH | No | No | No | No | No |
| Transaction on a commercially unavailable intertie | Market participant submits a bid or offer based on a commercially unavailable intertie[26] | OTH | No | No | No | No | No |
| | | | | | | | |
| External ISO Curtailments | External ISO Curtailments for TLR (including pre-emptive curtailments) | TLRe | No | Yes | Yes | Yes | No |
| External ISO Curtailments | Other Security Curtailments | TLRe | No | Yes | Yes | Yes | No |
| External ISO Curtailments | External ISO Adequacy Cuts | TLRe | No | Yes | Yes | Yes | No |
| NYISO Ramping Capacity | For NYISO Net Interchange Scheduling Limit (NISL) binding | TLRe | No | Yes | Yes | Yes | No |
| Linked wheels (outside participant control) | Curtailment of linked wheels outside participant control | TLRe | No | Yes | Yes | Yes | No |

[24] CMSC eligibility may be impacted by the scenarios defined in Market Manual 5.5: Physical Markets Settlement Statements, section 1.6.27: Limiting Constrained-off CMSC to Interties.

[25] Failures that are within the market participant's control (e.g., acquiring transmission, market scheduling).

[26] The *IESO* will issue an advisory notice in real-time when an intertie has been declared commercially unavailable. For any subsequent *bids* or *offers* received against that intertie, the transaction will be curtailed to 0 MW and the *market participant* will be subject to a failure charge.

| Transaction Failures | | Summary of Codes & Resulting Treatment | | | | | |
|---|---|---|---|---|---|---|---|
| Failure Reasons | Further Description | Code Entered | CMSC[24] Treatment | DA IFC Exempt (Import) | RT IFC Exempt (Import) | RT EFC Exempt (Export) | DA-IOG Component #2 Treatment |
| Intertie Limit Violation (when caused by an external curtailment or failure) | IESO or external curtailment to respect an intertie limit violation when the violation is caused for a reason where the failure code is tagged as OTH, TLRe or MrNh | TLRe | No | Yes | Yes | Yes | No |
| Constrain-on export transaction to Quebec | Constrain-on export transaction to Quebec to meet capacity agreement obligation | TLRe | No | N/A | N/A | Yes | N/A |
| Capacity export reduced for a transmission limitation | Capacity export reduced for a transmission limitation | TLRe | No | N/A | N/A | Yes | N/A |
| Capacity export reduced due to backing resource status | Backing generator is derated to an amount less that the scheduled quantity and the IESO is in an energy or operating reserve shortfall | TLRe | No | N/A | N/A | Yes | N/A |
| | | | | | | | |
| IESO Curtailments (Manual) | IESO Curtailments for TLR | TLRi | Yes or No based on DSO schedules | Yes | Yes | Yes | Yes |
| IESO Curtailments (Manual) | Other Security Curtailments | TLRi | Yes or No based on DSO schedules | Yes | Yes | Yes | Yes |
| Intertie Limit Reduction (total or partial) | IESO selects and decreases transaction quantity after Hour-Ahead Pre-Dispatch | TLRi | Yes or No based on DSO schedules | Yes | Yes | Yes | Yes |
| IESO Ramping Capacity (Manual management of Ramp) | For IESO managing transactions to prevent violation of Net Interchange Scheduling Limit (NISL) | TLRi | Yes or No based on DSO schedules | Yes | Yes | Yes | Yes |
| IESO Curtailments | IESO Adequacy Actions<br><br>Shortfall beyond next hour (for shifting Energy Limited Resources for future hour shortfall) | TLRi | Yes or No based on DSO schedules | Yes | Yes | Yes | Yes |
| IESO Curtailments | IESO Adequacy Actions<br><br>Internal security concerns leading to an adequacy concern. | TLRi | Yes or No based on DSO schedules | Yes | Yes | Yes | Yes |

| Transaction Failures | | Summary of Codes & Resulting Treatment | | | | | |
|---|---|---|---|---|---|---|---|
| **Failure Reasons** | **Further Description** | **Code Entered** | **CMSC[24] Treatment** | **DA IFC Exempt (Import)** | **RT IFC Exempt (Import)** | **RT EFC Exempt (Export)** | **DA-IOG Component #2 Treatment** |
| | | | | | | | |
| IESO Security Curtailment Operating Reserve Activation | Activation of OR provided by import (increase import schedule)<br>Activation of OR provided by export (reduce export schedule) | ORA | Yes or No based on DSO schedules | Yes or No based on RT Offer Price Test* | N/A | Yes | Yes |
| | | | | | | | |
| MISO - Minnesota - Inability to acquire transmission service | Real-Time transaction failures from MISO[29] | MrNh | No | No | Yes | Yes | No |
| MISO - Michigan - Inability to acquire transmission service | Real-Time transaction failures from MISO[29] | MrNh | No | No | Yes | Yes | No |
| MISO - Manitoba - Inability to acquire transmission service | Real-Time transaction failures from MISO[29] | MrNh | No | No | Yes | Yes | No |
| MISO Ramping Capacity | Market participant inability to acquire ramping capability in real time[27] | MrNh | No | No | Yes | Yes | No |
| NYISO Curtailments | Cuts by NYISO under HAM protocol due to TLR (NYISO Real-Time transactions, Not NYISO Day-Ahead transactions but could be IESO Day-Ahead Imports)[28] | MrNh | No | No | Yes | Yes | No |
| | | | | | | | |
| IESO Curtailments | IESO Adequacy (Surplus or Deficiency) Actions not caused by internal security. (Dispatching on or off of Imports or Exports after the final hour-ahead pre-dispatch) | ADQh | No | Yes or No based on RT Offer Price Test* | Yes | Yes | Yes |
| | | | | | | | |
| NYISO - IESO Scheduling Protocol | 90 Minute Checkout | NY90 | Yes or No based on DSO schedules | Yes or No based on RT Offer Price Test* | N/A | N/A | Yes |
| IESO Curtailments<br><br>(Auto - Automatic | Other Security Curtailments<br><br>Constrained Off event | AUTO or NY90 | Yes or No based on DSO schedules | Yes or No based on RT Offer Price Test* | N/A | N/A | Yes |

[27] This is communicated via the e-Tag and not a phone call to the IESO Control Room.

| Transaction Failures | | Summary of Codes & Resulting Treatment | | | | | |
|---|---|---|---|---|---|---|---|
| Failure Reasons | Further Description | Code Entered | CMSC[24] Treatment | DA IFC Exempt (Import) | RT IFC Exempt (Import) | RT EFC Exempt (Export) | DA-IOG Component #2 Treatment |
| treatment by the DSO algorithm) | (Constrained off with full or partial market schedule quantities) | | | | | | |
| IESO Economic Selection (Auto - Automatic treatment by the DSO algorithm) | Constrained Off event<br><br>(Constrained off with full or partial market schedule quantities) | AUTO or NY90 | Yes or No based on DSO schedules | Yes or No based on RT Offer Price Test* | N/A | N/A | Yes |
| Intertie Limit Reduction | Between Pre-Dispatch of Record and Hour-Ahead Pre-Dispatch<br><br>Import Schedules may be reduced by an Intertie Limit Reduction which may impact Day-Ahead Import Schedules | AUTO or NY90 | Yes or No based on DSO schedules | Yes or No based on RT Offer Price Test* | N/A | N/A | Yes |
| IESO Ramping Capacity (DSO Managing Ramp) | For DSO managing transactions to prevent violation of Net Interchange Scheduling Limit (NISL) | AUTO or NY90 | Yes or No based on DSO schedules | Yes or No based on RT Offer Price Test* | N/A | N/A | Yes |

*** RT Offer Price Test:** If DA Import Scheduled quantity is offered in RT at -MMCP then DA-IFC Exempt.

### 6.6.2 Methodology for Failure Code Application

#### TLRi or ADQh when curtailing Exports for Adequacy[28]

When exports are curtailed for adequacy there are two states:

(i) an adequacy concern that is caused by an internal security limitation resulting in resources being bottled and not being available for dispatch. When we observe an adequacy concern due to bottled resources in real-time, our Control Room staff will apply the TLRi code to an amount of curtailed export transactions equal to the quantity of bottled MWs in the current system configuration. The TLRi code does not adjust the market schedule, and

(ii) a global adequacy issue resulting from insufficient offers in the market. When we observe a global adequacy issue in real-time, our Control Room staff will apply the ADQh code. The ADQh code causes the market schedule to be adjusted to match the dispatch schedule.

When we have applied the TLRi code, we will perform an after-the-fact analysis to verify that the correct code was applied. Specifically, we will examine the market schedule for those intervals where we curtailed exports in the dispatch schedule. If the market schedule did not result in a shortage for energy or operating reserve, this indicates that there was no global adequacy issue and

[28] The TLRi code may result in CMSC payments while the ADQh will not

that TLRi was the correct code to apply. If the market schedule did result in a shortage for energy or operating reserve, we will change the code from TLRi to ADQh. The effects of any events that occur following the time that the exports are curtailed, which result in a shortage in the market schedule, will not be considered in the analysis of the original TLRi application.

When we have applied the ADQh code, we will perform an after-the-fact analysis to verify that the correct code was applied. To do this, we will rerun the unconstrained sequence with the amount of curtailed export MWs now included and assess the resulting market schedules. In order to rerun the sequence, we must retrieve a saved copy of the *pre-dispatch* run or a save case. In such an instance,

- If the curtailment was made prior to the *dispatch* hour, the *pre-dispatch* run prior to the curtailment will be retrieved to be used as the save case. This save case will be adjusted with the most up-to-date data known at the time of the curtailment. For example: all import and export transactions will be fixed as per the *pre-dispatch* results while any generation losses, import curtailments, etc. will be reflected by adjusting the save case, or
- If the curtailment was made in the dispatch hour, the real time run of the interval in which the curtailment took place will be retrieved to be used as the save case. This save case will be adjusted with the most up-to-date data known at the time of the curtailment.

If the resultant market schedule does not indicate a shortage for energy or operating reserve, the code will be changed to TLRi, as appropriate. If the resultant market schedule indicates a shortage of energy or operating reserve, the *IESO* will apply TLRi to the export transactions equal to the amount of export MWs that could be supported by the market schedule without shortages, and will apply ADQh to the remainder.

Any changes in coding that affect the market schedule will be reviewed under the administered pricing guidelines.

### External curtailment that causes an Intertie Limit Violation

In the case where an external entity curtails a transaction or a transaction fails due to participant behaviour, the IESO removes the transaction from the schedule and codes the transaction with TLRe, MrNh or OTH. If the curtailment of this transaction causes the intertie limit to be violated, the IESO will take immediate action to relieve the violation. Because this violation is on the intertie, the violation cannot be solved by internal generation. On all interties, with the exception of Quebec, we are unable to constrain on another transaction and therefore must curtail a transaction.

This further transaction will be coded using TLRe based on the coding principles established at market opening.

If the *pre-dispatch sequence* had known about the external problem before the hour-ahead pre-dispatch run, the bid or offer for the externally curtailed transaction would have been removed and the second transaction would not have been scheduled in either schedule due to the scheduling limits.

*Market participants* can visit the *NERC* website at www.nerc.com to confirm whether Transmission Loading Relief Procedures have been implemented.

## 6.7 Capacity Export Scheduling and Curtailment

This section contains information on how capacity exports[29] are maintained or *curtailed,* assuming that the export is a *called capacity export* as required by the external *control area.*

### 6.7.1 Capacity Export Delivery

In accordance with the applicable *capacity export agreements*, when Ontario has adequate supply, a capacity export is deliverable to the external *control area* as long as the *called capacity export bid* is economic.[30]

In the event of an adequacy shortfall in *energy* or *operating reserve*, the Capacity Resource must be included in the *pre-dispatch schedule* and be online injecting energy in real-time to at least the amount of the *called capacity export*.[31] If this is not the case, refer to Section 6.7.2: Curtailment Provisions.

In the event the *called capacity export* is scheduled pro-rata due to other economic exports on the intertie (*MMCP*), and the *IESO* is subsequently required to curtail exports for global *adequacy*, the *IESO* will ensure the delivery of the called amount to the external *control area,* provided that the Capacity Resource(s) is injecting sufficient *energy* to cover the called amount. In this circumstance, the intertie schedule would be based on pro-rata economic curtailment of all transactions (including capacity exports) up to the called amount.

### 6.7.2 Curtailment Provisions

In accordance with applicable *capacity export agreements*, the IESO can curtail a *called capacity export*:

- To correct or prevent a violation of voltage, stability, or thermal transmission limits/criteria,
- To prevent a threat to the safety of any person, damage to equipment, the environment, or the violation of any *applicable law*,
- If the Capacity Resource is reduced in the *pre-dispatch schedule* or real-time schedule for reasons which may include:
  - Constraints for voltage, stability, or thermal transmission limitations
  - Constraints for ensuring safety of any person
  - Constraints preventing the damage of equipment or the environment
  - Constraints for preventing the violation of any *applicable law*

[29] Capitalized terms in this section are defined in Market Manual 13: Capacity Export Requests, Appendix A: Glossary of Capacity Export Terms.

Further information on capacity exports is available in Market Manual 4.2, Section 2.6.

[30] Capacity exports are subject to normal economic scheduling. Therefore a capacity export can be scheduled to a value less than its *bid* quantity in the event that an intertie is congested and there are other economic offers (e.g., pro-rata scheduling).

[31] There can be multiple Capacity Resources responding to a capacity call.

- If the external *control area* or *IESO* markets have been suspended, or there is a market tool failure which precludes intertie scheduling and/or inter-ISO coordination, or
- If the Capacity Resource is contracted to the *IESO* to provide Black Start service and is required for Ontario grid restoration.

In the event of a shortfall in *energy* or *operating reserve*, a Capacity Resource must be included in the *pre-dispatch schedule,* and be online injecting energy in real-time to at least the amount of the Capacity Resource's called amount. If this is not the case (e.g., the resource submits an *outage* or derate), the *IESO* will curtail the transaction to the amount of the *pre-dispatch schedule* or the lower of the real-time schedule or real-time injection amount.

A *called capacity export* will not be curtailed by the *IESO* out of economic merit:

- As a result of, or to avoid, a global capacity shortfall resulting in voltage reductions and/or load shedding, or
- To compensate for generator losses other than that of the Capacity Resource.

**– End of Section –**

# 7. Issuing Dispatch Instructions

## 7.1 Registered Facilities (other than HDR resources and boundary entities)

The *IESO* issues *dispatch instructions* for each *registered facility,* except for *boundary entities, HDR* resources or *variable generators,* prior to each *dispatch interval*. The IESO issues *dispatch instructions* to each *variable generator* only for the *dispatch intervals* that have mandatory obligation indicators.[32] The *dispatch instruction* for that *dispatch interval* indicates the following:

- The target *energy* level to be achieved (in MW) by the *facility* at the end of the *dispatch interval* at a rate, in the case of a *dispatchable load*, equal to the rate provided by the *market participan*t as *dispatch data*, and, in the case of a *generation facility,* equal to the most limiting of:
  - The last *dispatch instruction* and offered ramp rate, or
  - Actual MW output and the *generation facility's* effective maximum ramp rate.[33]
- The amount of each class of *operating reserve* that is to be in a condition to respond to a *dispatch* instruction calling for additional *energy* production (as described below).

*Dispatch instructions* may also identify the amount of reactive support and *regulation* range to be provided under *ancillary service* contracts during the *dispatch interval*[34].

The *IESO* issues *release notifications* to each *variable generator* for the first *dispatch interval* when the mandatory obligation indicator for its *variable generation* no longer exists.

The *dispatch instructions* for any *registered facility* will be consistent with the current operating status of that *registered facility*, any operational constraints described in the most recent *dispatch data* submitted by the *registered market participant* for that *registered facility*, and with the *market entry* data maintained by the *IESO*.

The *IESO* will only issue *dispatch instructions* for a *registered facility*, other than a *boundary entity*, for a given *dispatch interval* when there is a change in the quantity to be scheduled from that

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[32]An obligation indicator is a piece of text information that accompanies *dispatch instructions* and *release notifications* sent to *variable generation* through the *IESO* automated dispatch systems. The value of the obligation indicator is either "mandatory," denoting a *dispatch instruction* that must be followed, or "release," denoting a *release notification*.

[33] The effective maximum ramp rate will be determined based on the lower of the r*egistered* maximum ramp rate, provided by the *market participants* and contained in the participant registration data, or the maximum *offer* ramp rate x the ramp rate multiplier. Initially the value of the ramp rate multiplier will be established at a value of 1.2 for all resources.

[34] Where the *IESO* activates *ancillary service* contracts for reactive support and *regulation* range, such contracts will be typically activated for a number of consecutive *dispatch* intervals as part of a single *dispatch* instruction.

*registered facility* for the *dispatch interval* relative to the last *dispatch* instruction issued to the *registered facility* (and confirmed by the *registered market participant*) provided,

- The new *dispatch instructions* for provision of *energy* change from the previous *dispatch instruction* issued is greater than the lesser of 2% of the maximum *offer/bid* capability and 10 MW except:

- To ensure *energy* resources are correctly dispatched to its high operating limit, or its low operating limit, when the *dispatch instructions* change falls within the filter thresholds,
- For provision of *energy* reduction change when the previous *dispatch instructions* is higher than its current maximum *offer*, when the *dispatch instructions* change falls within the filter thresholds, and
- For interval 1 and 7 of each *dispatch hour* when filtering is turned off to ensure small recurring increments or decrements of *energy* that have been legitimately offered by *market participants* are issued *dispatch instructions* on the hour and the half hour, when the change falls within the filter thresholds.

**Note**: The filter prevents *dispatch instructions* for small changes in scheduled quantities to be issued, except as noted above. The *IESO* may issue *dispatch instructions* within the *dispatch interval*, instructing any *registered facility* with a valid *energy bid* or *offer*, to increase or decrease *energy* production or consumption, consistent with its submitted *bids* or *offers*. Except for a *dispatch instruction* issued to a *market participant* with a *dispatchable load bid* at MMCP, *market participants* must acknowledge the submitted *dispatch instructions* or *release notifications* for each *dispatch interval* within 60 seconds of receipt of the instruction by confirming its intention to comply (or not comply) with the instruction.

If a *response* to the *dispatch* instruction or *release notification* is not received within 60 seconds, the *registered market participant* has an additional 30 seconds to call and have the *IESO* manually accept or reject the *dispatch* instruction or *release notification* on its behalf. Confirming that a *registered facility* will not comply with a *dispatch* instruction, or the failure to acknowledge the *dispatch instruction* or *release notification* will trigger the compliance process described in Section 7.5.

A *dispatchable load* in its "**normal**" *energy* withdrawal pattern with a varying load, which includes a brief period when it may not be following the *dispatch instruction*, as permitted by its exemption, is still required to acknowledge the submitted *dispatch instructions* for each *dispatch interval*. A *dispatchable load* is not however, required to reject the *dispatch instruction*[35] if **not** in its "**normal**" *energy* withdrawal pattern, but is required to:

- Notify[36] the *IESO* of its inability to follow the *dispatch instruction*,
- Notify[36] the *IESO* to request approval to change the *dispatch data* and/or to resume *energy* withdrawals, and
- If the dispatch instruction relates to operating reserve, notify[36] the IESO:

[35] In some circumstances automated *dispatch instruction* may not be available due to the actions of the **Resource Dispatch Filter** tool.

[36] Notification is by telephone, unless otherwise approved by the *IESO*.

- When the deviation from dispatch is expected to be greater than 10 minutes and the *dispatch instruction* is for 10 minute *operating reserve*, or
- When the deviation from dispatch is expected to be greater than 30 minutes and the *dispatch instruction* is for 30 minute *operating reserve*.

Where a *contingency event* is occurring or has occurred, the *IESO* may temporarily cease issuing *dispatch instructions* in accordance with this procedure[37]. If the *IESO* fails to issue *dispatch instructions* to any *registered market participant* with respect to a *registered facility*, that *registered market participant* should use as its default *dispatch instructions* the most recent *dispatch instruction*s issued by the *IESO* in respect of that *registered facility*.

The *IESO* records and time-stamps all *dispatch instructions* and store these records for at least seven years.

**Table 7-1: Procedural Steps for Dispatch Instructions for Registered Facilities (other than HDR resources and boundary entities)**

| Step | Completed by… | Action |
|---|---|---|
| 1 | *IESO* | The *IESO* executes a number of internal processes using different software tools and manual processes to schedule resources to supply *energy* and *operating reserve* to meet requirements. |
| 2 | *IESO* | The *IESO* issues *dispatch instructions* to the *registered market participant* for each of its *registered facilities*, where there is a change in the quantity to be scheduled from the *registered facility* relative to the last *dispatch* instruction issued to the *registered facility*. The *IESO* will also issue *dispatch instructions* for each *market participant* that is also a *variable generator* when there is a change in the obligation indicator to a mandatory *dispatch instruction* or a *release notification* relative to the last *dispatch instruction* issued to the *variable generator.*<br>The *IESO* will seek to ensure that the *dispatch instructions* issued with respect to each *registered facility* for each *dispatch interval* closely approximate the most recent *real-time schedule* for that *registered facility* and *dispatch interval*. The *IESO* may, however, issue *dispatch instructions* that depart from the *real-time schedule* where:<br>• The *security* and *adequacy* of the system would be endangered by implementing the most recent *real-time schedule*,<br>• The *dispatch* algorithm has failed, or has produced a *real-time schedule* that is clearly and materially in error,<br>• The *dispatch algorithm* has produced a *real-time schedule* that does not accurately reflect the *minimum run-time* or lockout[38] status of a *facility* due to *dispatch algorithm* limitations, |

[37] Typically, this will be as a result of a *market suspension* (refer to *Market Manual* 4.5*)*. However, short-term contingencies, such as a temporary systems failure may result in the temporary cessation of automated *dispatch* instructions without suspending the market. In such case, the *IESO* will manually *dispatch* the *market participant* resources.

[38] As defined in section 6.1.

| Step | Completed by… | Action |
|---|---|---|
| | | • Material changes subsequent to determination of the most recent *real-time schedule*, such as failure of an element of a *transmission system* or failure of a *registered facility* to follow *dispatch instructions*, have occurred, or<br>• The operation of all or part of the *IESO-administered markets* has been suspended (refer to Market Manual 4.5 for more information).<br>The *IESO* records and time-stamps all *dispatch instructions* that are submitted to *market participants*. |
| 3 | ***Market Participant*** | The *market participant* **receives the *dispatch instruction*** from the *IESO* along with a dispatch advisor report and acknowledges the *dispatch* instruction by **confirming to the *IESO* that the *registered facility* will accept or reject** the *dispatch* instruction. |
| 4 | *IESO* | The *IESO* confirms whether the *market participant* has accepted or rejected the *dispatch instruction*.<br>If a *response* to the *dispatch instruction* is not received within 60 seconds, the *registered market participant* has an additional 30 seconds to call and have the *IESO* manually accept or reject the *dispatch instruction* on its behalf[39]. The *IESO* may also contact the *market participant* by phone and, in accordance with the instructions of the *market participant*, manually accept or reject the *dispatch instruction* on behalf and on the instruction of the *market participant*.<br>Alternatively, if the *registered market participant* does not accept or reject the *dispatch instruction*, nor does it request the *IESO* to manually accept or reject the *dispatch instruction* on its behalf, the instruction will be deemed to have been rejected by the *registered market participant*. For *dispatch instructions* that are rejected or for which no *response* has been received:<br>• The *registered market participant* is required to maintain its *facility* loading at the level of the last accepted *dispatch instruction*, and<br>• These instances are deemed non-compliant and will trigger the compliance process. |

[39] Two items of note regarding *IESO* manual acceptance/rejection of *dispatch instructions* on behalf and on the instruction of *market participants*:

- Ninety seconds after the *dispatch instruction* has been issued, the *dispatch* messaging tools locks out the *IESO* from completing manual actions. Therefore, *Market Participants* must call the *IESO* before the 90-second timer times-out and provide sufficient time for the *IESO* to complete this activity. The *IESO* will manually accept or reject *dispatch instructions* on behalf and on the instruction of *Market Participants* on a reasonable effort basis. The *IESO* may be unable to complete manual acceptance/ rejection for reasons such as delays in contacting the *IESO*, the length of time it takes the *IESO* to locate a specific *dispatch instruction* in the *dispatch* messaging tools, or because of *IESO* workload. Consequently, the *IESO* does not guarantee that it can manually accept or reject any or all *dispatch instructions* on behalf and on the instruction of *Market Participants*.

- If the *IESO* is not able to manually accept a *dispatch instruction* on behalf and on the instruction of a *market participant*, the *market participant* is required to maintain its *facility* loading at the level of the last accepted *dispatch instructions*.

| Step | Completed by… | Action |
|---|---|---|
| 5 | ***Market Participant*** | A *market participant* that expects its *registered facility* to operate in a manner that, for any reason, differs materially from the *IESO*'s *dispatch instructions* shall so **notify the *IESO*** as soon as possible. |
| 6 | *IESO* | If a *market participant* for a *registered facility*:<br>• Confirms that it is rejecting a *dispatch instruction*, or<br>• Does not acknowledge the *dispatch instruction*, or<br>• Notifies the *IESO* that the *facility* will be (or is) operating in a manner that differs materially from the *dispatch* instructions,<br>The *IESO* will assess the resource shortfall. The *IESO* may address the resource shortfall by determining that:<br>• New *dispatch instructions* are required (this could include activation of *operating reserve*), or<br>• An *emergency operating state* must be declared. |
| 7 | *IESO* | When insufficient resources are available via normal market mechanisms to address a resource shortfall, the *IESO* will declare an *Emergency Operating State*[40]. |
| 8 | ***Market Participant*** | *Market participants* **access the *IESO* public website** to view the most recent advisory notice. The advisory notice contains a System *Emergency* Advisory indicating that an *Emergency Operating State* is expected. |
| 9 | *IESO* | During commissioning of a *generation unit*, the *IESO* may be required to carry additional reserve because of the increased likelihood of unit failure.<br>The *IESO* may contact any *facility* conducting commissioning tests and requests that these tests halt.<br>In some instances, stopping a commissioning test may lead to a shutdown of a generating unit. In these cases, judgment is used where the *energy* provided by the commissioning unit is more valuable than the advantage received by reducing the reserve requirement.<br>Note that commissioning units are self-schedulers and price-takers. Discontinuing commissioning tests here does not mean that the *IESO* must allow short-notice *offers* within the mandatory *bid* submission window. |
| 10 | ***Market Participant*** | *Market participant* **receives and complies with the *IESO* request to discontinue its commissioning test**. The *market participant* also **informs the *IESO* that the commissioning test has been halted**. |
| 11 | *IESO* | Implement actions to continue to satisfy 10-minute *operating reserve* requirements.<br>Refer to *Market Manual* 7.1: IESO-Controlled Grid Operating Policies, Appendix B: Emergency Operating State Control Actions. |

[40] Refer to *Market Manual* 7.1: *IESO*-Controlled Grid Operating Policies, Appendix B for the complete integrated list of *emergency operating state* control actions.

| Step | Completed by… | Action |
|---|---|---|
| 12 | *IESO* | The *IESO* issues *NERC Energy Emergency* Alert 2 (EEA-2) indicating that the *IESO control area* has or is about to initiate load management procedures. |
| 13 | *IESO* | Implement actions to continue to satisfy 10-minute **synchronized** *operating reserve* requirements.<br>Refer to *Market Manual 7.1*, Appendix B. |
| 14 | *IESO* | When insufficient resources are available via normal market mechanisms to address a resource shortfall, the *IESO* will declare an *Emergency Operating State*[41].<br>To declare an *emergency operating state*, the *IESO* issues System *Emergency* Advisories via an advisory notice. Usually, two advisories are issued: one indicating the potential for an *emergency operating state* (see step 7) and another indicating that an *emergency operating state* has been declared. |
| 15 | ***Market Participant*** | *Market participants* **access the *IESO* public website** to view the most recent advisory notice. The advisory notice contains a System *Emergency* Advisory indicating that an *Emergency Operating State* has been declared. |
| 16 | *IESO* | The *IESO* implements *emergency operating state* control actions to continue to satisfy 10-minute synchronized *operating reserve* requirements, as described in *Market Manual* 7.1, Appendix B. |
| 17 | *IESO* | Implement actions to meet *regulation* reserve requirements.<br>Refer to *Market Manual* 7.1, Appendix B. |
| 18 | ***Market Participant*** *(Transmitters* and/or *Distributors)* | *Transmitters* and/or *distributors* receive and accept instructions to reduce voltage at the distribution level either by 3%, or subsequently, by 5%. |
| 19 | *IESO* | Implement actions to avoid implementation of *non-dispatchable load curtailment*.<br>Refer to *Market Manual* 7.1, Appendix B. |
| 20 | ***Market Participant*** *(Generators)* | *Generators* apply for environmental variances in order to supply more *energy* to the at-risk *IESO-controlled grid*. |
| 21 | *IESO* | The *IESO* issues *NERC Energy Emergency* Alert 3 (EEA-3) indicating that load interruption is imminent or in process. |
| 22 | *IESO* | The *IESO* curtails *non-dispatchable load* through *emergency* or rotational load shedding. |

[41] Refer to *Market Manual* 7.1, Appendix B for the complete integrated list of *emergency operating state* control actions.

| Step | Completed by… | Action |
|---|---|---|
| | | *Market participants* are alerted that load shedding is imminent followed by specific instructions for *emergency* load shedding or controlled rotational load shedding. |
| 23 | ***Market Participant*** *(Transmitters* and/or *Distributors)* | *Transmitters* and/or *distributors* receive instructions from the *IESO* via telephone to *curtail non-dispatchable load*. |

## 7.2 Hourly Demand Response Resources

The *IESO* issues a standby notice via the standby report to the *capacity market participant* (CMP) to indicate that an *HDR* resource is on standby to provide demand response (refer to Market Manual 9.3: Operation of the Day-Ahead Commitment Process).

The *IESO* may subsequently issue a *dispatch instruction* to the *CMP,* in the form of an activation notice, by publishing an activation report to the *CMP's* private report site. An activation notice is issued when the relevant pre-dispatch schedule is less than the resource's total *bid* quantity for at least one hour during the *dispatch day* availability window based on the three hours ahead pre-dispatch run (PD-3). The resource may be activated for one up to four consecutive hours during the *dispatch day* and the number of activations per resource will be limited to a maximum of once per day. The activation notice is issued approximately 2 hours and 30 minutes in advance (but no later than 2 hours in advance) of the start of the first *dispatch hour* to which it relates. The activation notice specifies the target reductions in energy to be withdrawn (in MW) by the *HDR* resource for each *dispatch hour*. The *CMP* is expected to achieve its target by the end of the first five-minute interval of each hour and maintain it for the entire hour.

If an activation notice is not received for the first hour of the availability window, the *CMP* must continue to monitor for the receipt of an activation notice resulting from subsequent runs of *pre-dispatch* until the end of the availability window. However, if the *CMP* has submitted bids for an *HDR* resource outside the availability window and has received an activation notice, the *CMP* is expected to comply with that activation notice.

If a standby report indicates that the *HDR* resource is not required to be on standby, then the *CMP* is not required to provide demand response with that *HDR* resource for that *dispatch day.* The *CMP* must remove the *HDR* resource's *dispatch data* before 09:00 EST. Failure to do so may result in the *HDR* resource receiving an activation notice with the requirement to reduce *energy* withdrawal.

The *dispatch instructions* for any *registered facility* that is an *HDR* resource will be consistent with the current *dispatch data* for that *registered facility.*

### 7.2.1 Dispatch Instructions for CMPs with HDR Resources

The *IESO* will notify *CMPs* with *HDR* resources that may be required for demand response by issuing a standby notice in the standby report, published to the private *market participant* report site. If required to provide *demand response*, the *IESO* will issue *dispatch instructions* to *HDR* resources in the form of an activation notice approximately 2 hours and 30 minutes in advance but not later than

2 hours[42] ahead of the start of the first *dispatch hour* to which it relates. Activation notices will be published to the confidential *market participant* report site. The *CMP* is not required to formally acknowledge the *dispatch instruction*. It is expected that the *dispatch instructions* will be followed unless the *IESO* has been notified that the *HDR* resource is unable to comply.

**Table 7-2: Procedural Steps for Dispatch Instructions for HDR Resources**

| Step | Completed by… | Action |
|---|---|---|
| 1 | ***CMP*** | A *CMP* that wants to meet their *capacity obligation* for an *HDR* resource must **submit *demand response energy bids***.<br>Submission of *dispatch data* will follow the requirements identified in *MR* Ch. 7 Sec. 3 and Market Manual 4.2. |
| 2 | *IESO* | The *IESO* pre-dispatch sequences schedule *energy* and *operating reserve* (including imports) to satisfy the *non-dispatchable load* + losses prediction provided by the Load Forecast tool and to satisfy economic *bids* from *dispatchable loads* (including load *bids* from *intertie zones*). |
| 3 | *IESO* | The *IESO* publishes a standby report to the private *market participant* report site.<br>If the *HDR* resource is on standby to provide *demand response capacity* for the *dispatch day,* the standby report will include a standby notice. A standby notice is issued when one of the following requirements are satisfied:<br>1. The HDR resource's day-ahead *schedule of record* or *pre-dispatch schedule* is less than its total bid quantity for at least one hour during the *dispatch day* availability window.<br>2. The applicable pre-dispatch shadow price for an HDR resource for at least one hour of the availability window $200 or greater.<br>Effective April 30, 2020, the pre-dispatch shadow price threshold will change to $100.<br>3. The absence of a standby notice in the standby report indicates the HDR resource is not on standby to provide *demand response capacity*. |
| 4 | ***CMP*** | If the standby report indicates that the *HDR* resource is not on standby (absence of standby notice), the ***CMP* must remove *dispatch data* before 09:00 EST**. Failure to do so may result in the *HDR* resource receiving an activation notice. |
| 5 | *IESO* | The *IESO* issues *dispatch instructions* to the *CMP* for *HDR* resources:<br>• When the *HDR* resource's *pre-dispatch* schedule is less than the resource's total *bid* quantity for at least one hour during the dispatch day availability window based on the three hours ahead pre-dispatch run (PD-3). The resource may be activated for one to four consecutive hours during the dispatch day and activation per resource will be limited to a maximum of once per day. By issuing an activation notice to individual *market participant* private report site. |

[42] IESO will target to issue DR activation notification 2 hours and 30 minutes before the dispatch hour.

| Step | Completed by… | Action |
|---|---|---|
| 6 | ***CMP*** | Upon receipt of the activation notice, **the *CMP* implements the actions required to comply** with the d*ispatch instructions,* by reducing energy withdrawal for each *HDR* resource to meet the d*ispatch instructions* issued by the *IESO.* |
| 7 | ***CMP*** | A *CMP* that expects the associated *HDR* resource to operate in a manner that, for any reason, differs from the *IESO*'s *dispatch instructions* shall **notify the *IESO*** as soon as possible. |
| 8 | ***CMP*** | A *CMP* that expects the associated *HDR* resource to operate in a manner that, for any reason, differs from the *IESO*'s *dispatch instructions* shall **change their *dispatch data*** as soon as possible. |

## 7.3 Boundary Entities

The *dispatch instructions* for any *registered facility* that is a *boundary entity* will be consistent with the current *dispatch data* for that *registered facility* and with any *interconnection* limitations associated with the *registered facility*.

*Interchange schedules* may be modified within the hour as a result of instructions from an external *control area*, or due to contingencies or other *reliability* concerns in the *IESO control area*. In the instances where the schedule modification originates from sources external to Ontario (e.g., implementation of Transmission Loading Relief, by an external *control area*), the *IESO* will ensure that the schedule modification does not trigger a Congestion Management Settlement Credit (CMSC) payment.

A *registered facility* that is a *boundary entity* shall comply fully with all *dispatch instructions* for *energy* or *operating reserves* upon confirmation of the relevant *interchange schedule* with the appropriate scheduling entity.

The *IESO* expresses *interchange schedule* MW quantities to the nearest one decimal point. However, the e-Tag software, used to obtain e-Tags for import and export transactions, requires persons to express *energy* quantities in whole MW. As a result, *boundary entities* may have to round up or down their *interchange schedule* MW quantities in order to obtain an e-Tag. To ensure that the *energy* quantities expressed by *boundary entities* for the purpose of obtaining their e-Tags correspond to the *real-time schedule*, the *IESO* requires all *boundary entities* to round-up or down the *interchange schedule* MW quantities according to the following rounding rules.

| Interchange schedule value | Rounding Rule | Example |
|---|---|---|
| X.1 to X.4 | Round down | 41.3 MW must be rounded down to 41 MW |
| X.6 to X.9 | Round up | 20.7 MW must be rounded up to 21 MW |
| X.5 | Call the *IESO* to find out the actual MW quantity to be used to obtain or revise the e-Tag. | For 35.5 MW, call the *IESO* for instructions |

The *IESO* records and time-stamps all *dispatch instructions* and stores these records for at least seven years.

### 7.3.1 Dispatch Instructions for Boundary Entities

Prior to each *dispatch hour*, the *IESO* issues *dispatch instructions* to each *boundary entity*, in the form of *interchange schedules (published to the Market Participant Interface)*, indicating for that *dispatch hour*:

- The *energy* level to be injected, or withdrawn, (in MW) by the *boundary entity* resource from, or to, the specified *intertie zone*,
- The amount of each class of *operating reserve* that is scheduled, and
- The amount of reactive support and regulation that is to be provided under reliability must-run contracts.

The *registered market participant* for each *facility* must submit an e-Tag with a quantity that matches the *IESO dispatch instruction* – the *IESO* will use the e-Tag submission as confirmation of the interchange *dispatch instruction*. The *IESO* will verify that the e-Tag has been submitted correctly and will confirm *interchange schedules* with adjacent c*ontrol areas*. At any time in the process, the *IESO* may alter *interchange schedules* due to incorrect or missing e-Tags, scheduling differences with adjacent c*ontrol areas*, and *reliability* or other concerns. Following these changes, the *IESO* will inform the *market participant* of the changes and alter the m*arket schedule* to equal the interchange *dispatch instructions* where appropriate. The *market participant* will update their e-Tags and/or *dispatch data* where appropriate.

**Table 7-3: Procedural Steps for Boundary Entity Dispatch Instructions**

| Step | Completed by… | Action |
|---|---|---|
| 1 | ***Market Participant*** | **Create an e-Tag** for the *interchange schedule* and obtain an e-Tag ID.<br>**Note:** The *market participant* is required to submit the e-Tag by 32 minutes prior to the *dispatch hour* (35 minutes in advance of the *dispatch hour* to support re-allocation for *NERC* Transmission Loading Relief procedures). See step 13. |
| 2 | ***Market Participant*** | **Submit *dispatch data* from *intertie zones*.** *Dispatch data* shall be accompanied by an e-Tag ID.<br>Submission of *dispatch data* will follow the requirements identified in *MR* Ch. 7 Sec. 3 and Market Manual 4.2. |
| 3 | ***Market Participant*** | **Receive schedule for *interchange schedules* for another c*ontrol area* market.**<br>To successfully complete an *interchange schedule*, the *market participant* must also successfully navigate markets in external c*ontrol areas*.<br>If a *market participant* is scheduled in another market for a quantity that is less than the quantity offered or *bid* in the *IESO-administered markets*, the *market participant* must revise the e-Tag.<br>If it is more than 60 minutes in advance of the *dispatch hour*, the *market participant* must revise the *dispatch data* to include the updated e-Tag ID and to lower the *offer*/*bid* quantity to equal the other *control area* schedule.<br>If it is less than 60 minutes in advance of the *dispatch hour* but the *market participant* has submitted *dispatch data* for subsequent hours that use the same e-Tag, the *market participant* must: |

| Step | Completed by… | Action |
|---|---|---|
| | | • Revise *dispatch data* for these hours to include the updated e-Tag ID, and<br>• Notify the *IESO* of the potential mismatch between the *dispatch data* quantity available and the amount scheduled by another c*ontrol area*. |
| 4 | ***Market Participant*** | **The e-Tag must be revised if** the *market participant* is scheduled by the *IESO* or by an adjacent c*ontrol area* for a quantity that is different than the e-Tag quantity listed for that *interchange schedule.*<br>Where a *market participant* receives *interchange schedule*s from two or more c*ontrol areas*/markets that differ in quantity for the same *interchange schedule*s, the *market participant* will revise the e-Tag quantity to a value that equals the smallest amount scheduled by the c*ontrol areas*/markets. |
| 5 | ***Market Participant*** | If a *market participant* has revised the e-Tag and acquired a new e-Tag ID, then:<br>• If it is more than 60 minutes in advance of the *dispatch hour*, the *market participant* must **revise the *dispatch data*** to include the updated e-Tag ID and to lower the *offer*/*bid* quantity to equal the other CA schedule, and submit the revised *dispatch data* to the *IESO*, or<br>• If it is less than 60 minutes in advance of the *dispatch hour*, but the e-Tag ID has also been submitted to the *IESO* for interchange *offers*/*bids* for future hours, the *market participant* **must revise the *dispatch data*** to include the updated e-Tag ID for these hours, and submit the revised *dispatch data* to the *IESO*. |
| 6 | *IESO* | *Dispatch data* for interchange is validated as all *dispatch data* is validated. *Dispatch data* validation details are covered in a number of documents, including Market Manual 4.2.<br>In addition, for interchange *offers*/*bids* only, the *dispatch data* is checked to ensure that only the valid market scheduling points (MSP) are allowed to be submitted for a chosen constrained scheduling point (CSP). |
| 7 | *IESO* | The *IESO pre-dispatch* sequences schedule *energy* and *operating reserve* (including imports) to satisfy the *non-dispatchable load* + losses prediction provided by the Load Forecast tool and to satisfy economic *dispatchable load bids* (including load *bids* from *intertie zones*).<br>The schedules of injections/withdrawals for the next hour are provided as inputs to the real-time sequences. |
| 8 | *IESO* | The *IESO* issues *dispatch instructions*, in the form of *interchange schedule*s, to each *registered facility* that is a *boundary entity* for which a *dispatch instruction* is required. |
| 9 | ***Market Participant*** | *Market participants* are expected to **watch for *interchange schedules*** issued by the *IESO* as part of the *pre-dispatch schedule* production process.<br>*Market participants* **identify linked wheeling *interchange schedule*s** whose import and/or export component was not scheduled for the next hour and cancel the associated e-Tag. |

| Step | Completed by… | Action |
|---|---|---|
| | | Cancellation of the e-Tag is only allowed for linked wheeling *interchange schedule*s (that consist of an import that has *offered* between -$50 and –*MMCP* and a corresponding export that has *bid* +*MMCP*). If one leg of the wheel *offered*/*bid* in this manner is scheduled for a reduced quantity, the *market participant* will revise and submit an e-Tag for the wheel with the lowered quantity. |
| 10 | *IESO* | The *IESO* will review next hour's *interchange schedule* to determine if changes to interchange *dispatch instructions* are required. For example, *interchange schedule*s will be altered if system *reliability* would be endangered by implementing the schedule (*MR* Ch. 7 Sec. 7.2 identifies situations where the *IESO* will issue *dispatch instructions* that deviate from the *published* schedule). When the review of *interchange schedule*s for next hour reveals that changes are required, the *IESO* will adjust the schedules in the **Interchange Scheduler** tool.<br>The *IESO* will identify and cancel linked wheeling *interchange schedule*s whose import and/or export component was not scheduled or was partially scheduled for the next hour and for which associated e-Tags were submitted.<br>In case one component (import or export) of a linked wheeling *interchange schedule*s was partially scheduled, the *IESO* will alter pro rata the schedule for the other component.<br>**Note:** Linked wheeling *interchange schedule*s are described in Market Manual 4.2, Section 2.5.4 and consist of an *offer* between -$50 and –*MMCP* for the import and a *bid* at +*MMCP* for the export. |
| 11 | *IESO* | The *IESO* contacts *market participants* to inform them only if their *interchange schedules* have been altered relative to the quantities published to the Market Participant Interface at the conclusion of the *pre-dispatch* run to maintain system *reliability*. |
| 12 | ***Market Participant*** | **Receive notice of *interchange schedule* alterations**.<br>The *market participant* is informed that *interchange schedule(*s) have been altered relative to the quantities published to the Market Participant Interface at the conclusion of the pre-dispatch run. |
| 13 | ***Market Participant*** | *Market participant* **submits the e-Tag** that is consistent with the *dispatch data* submitted to the *IESO* (if submitted in advance) or that is consistent with the *interchange schedule* provided by the *IESO* and other c*ontrol areas*/markets for that *interchange schedule*. See step 1. |
| 14 | *IESO* | *IESO* tools automatically indicates that the e-Tag has been submitted. The *IESO* will examine the e-Tag to ensure that is has been submitted correctly (e.g. CSP and MSP of the e-Tag and schedule match, quantity and format is correct etc.) and approve the e-Tag. If not, the *IESO* may contact the *market participant* by telephone to correct and re-submit the e-Tag. If the *market participant* has not submitted the e-Tag promptly, the *IESO* may contact the *market participant* and direct them to submit the e-Tag. |

<table>
<tr><th>Step</th><th>Completed by…</th><th>Action</th></tr>
<tr><td>15</td><td>IESO</td><td>Upon reviewing the interchange schedule for the next hour, the IESO will cancel interchange schedules() if:<ul><li>The e-Tag has not been submitted,</li><li>The e-Tag has not been submitted correctly (in those cases where the IESO has not elected to contact the market participant to correct the e-Tag),</li><li>They are part of linked wheeling interchange schedules that did not get scheduled (these linked interchange schedules consist of an offer between -$50 and –MMCP for the import and a bid at +MMCP for the export),</li><li>A schedule for operating reserve will impact upon a TLR’d flowgate (but can’t be reduced via re-allocation because the associated energy interchange schedule is 0 MW), or</li><li>Required to maintain system reliability.</li></ul>Cancelled interchange schedules will be removed by the IESO from the Interchange Scheduler (IS) tool.</td></tr>
<tr><td>16</td><td>IESO</td><td>When another control area has initiated re-allocation of interchange schedules to protect an overloaded flowgate, the IESO may receive a list of interchange schedules that must be reduced or curtailed.<br><br>If the IESO receives such a list of interchange schedules, the IESO will reduce the interchange schedules quantities accordingly.<br><br>If the re-allocation reduce or curtail one component (import or export) of a linked wheeling interchange schedules, the IESO will reduce proportionally or curtail the interchange schedules for the other component.</td></tr>
<tr><td>17</td><td>IESO</td><td>IESO confirms the quantity and e-Tag ID for each interchange schedules with adjacent control areas.<br><br>For operating reserve schedules, the IESO confirms quantities on a per-interchange schedule basis.<br><br>If the quantities recorded by the IESO and the other control area are different, the interchange quantity for the interchange schedules will be changed to the lower of the two quantities.<br><br>The IESO and/or adjacent control areas may alter interchange schedules if required to maintain system reliability.</td></tr>
<tr><td>18</td><td>IESO</td><td>Following confirmation of the interchange schedules with adjacent control areas, the IESO will reduce the IS schedule quantities when they must be decreased to match the amounts scheduled by the adjacent control area.<br><br>If one component (import or export) of a linked wheeling interchange schedules was altered, the IESO will alter pro rata the interchange schedules for the other component.</td></tr>
<tr><td>19</td><td>N/A</td><td>Ramps of energy between control areas are initiated over 10 minutes. Energy ramps typically begin at five minutes to the dispatch hour.</td></tr>
</table>

| Step | Completed by… | Action |
|---|---|---|
| 20 | *IESO* | The *IESO* contacts *market participants* to inform them of *interchange schedule*s that have been reduced, curtailed or cancelled relative to the quantities published to the Market Participant Interface at the conclusion of the pre-dispatch run. |
| 21 | ***Market Participant*** | **Receive notice of *interchange schedule* alterations.**<br>The *market participant* is informed that *interchange schedule(*s) have been reduced, curtailed or cancelled relative to the quantities published at the conclusion of the pre-dispatch run. |
| 22 | *IESO* | The *IESO* will alter the *market schedule* for reduced/cancelled *interchange schedule*s.<br>When reducing/canceling one component (import or export) of a linked wheeling *interchange schedule*s, the *IESO* will also reduce/cancel the other component.<br>The *market schedule* will be altered so that the *market schedule* quantities equal the *interchange schedule* is quantities provided to the real-time constrained *dispatch* sequences. |

## 7.4 Dispatch of Operating Reserve (OR)

Each *registered facility* to which the *IESO* has sent *dispatch instructions* relating to *operating reserve* must maintain generation (or load reduction) capacity during that *dispatch interval*, consistent with the *dispatch instructions* issued to it. It should be able to increase *energy* production, decrease *energy* withdrawal or be able to schedule, in accordance with the class[43] of *operating reserve* being offered, upon being instructed to do so by the *IESO* as a result of a *contingency event*.

Where a *contingency event* has occurred or is occurring, the *IESO* may issue revised *dispatch instructions* within the *dispatch interval*. The revised *dispatch instructions* will instruct a *registered facility*, other than a *boundary entity*, providing *operating reserve* to begin increasing *energy* production (in the case of a *generator*) or reducing *energy* withdrawal (in the case of a *dispatchable load*) at a rate equal to the *operating reserve* ramp rates provided in the *dispatch data* submission.

A *dispatchable load* must reduce its' consumption, or remain at a reduced consumption level, to provide at least the amount of *operating reserve* requested.

*Dispatch instructions* issued in respect of an *operating reserve* activation must be accepted to indicate the registered facility will comply with the instruction and that the *market participant* will only alter its dispatch when it receives a new *dispatch instruction*.

*Dispatch instructions* issued in respect of a *registered facility* that is a *boundary entity* providing *operating reserve* will be such that they ensure that the *energy* associated with each *offer* of *operating reserve* is scheduled by the *IESO* in a manner that:

- Is consistent with all relevant *reliability standards* for activation of *operating reserve*, and

[43] These are 10 minute synchronized, 10 minute non-synchronized, or 30-minute *operating reserve*.

- Is as agreed upon by the entity scheduling the resulting *energy* transfer.

When issuing *dispatch instructions* to *registered facilities* providing *operating reserve*, the *IESO* will call first on the *registered facility* in each area that has offered the lowest price (in $/MWh) for *energy* produced from scheduled *operating reserve*. If such *registered facility* is instructed to produce *energy* but does not do so as rapidly as instructed, or if the *IESO* needs additional *energy* from *operating reserve* in that area, the *IESO* will call upon the *registered facility* offering the next-lowest price for *energy* from *operating reserve*.

If the *IESO* determines that calling upon *registered facilities* in strict order of increasing price of *energy* means that it will be unable to respond in a timely fashion to a *contingency event*, the *IESO* may call upon *registered facilities* out of such strict order. However, the *IESO* will, as far as is practical, call *registered facilities* in a manner that minimizes the price of *energy* called on.

When *operating reserves* are activated as a result of a *NPCC reportable event*, the otherwise applicable 10-minute *operating reserve* requirements will be reduced by a corresponding amount. The *IESO* will subsequently recover to pre-contingency levels of *operating reserve* requirements within 105 minutes of the contingency. (Refer to Market Manual 7.6: Glossary of Standard Operating Terms for the definition of *NPCC reportable event*).

For all events that cause the *IESO* to become deficient, the otherwise applicable 10-minute *operating reserve* requirements will be reduced by a corresponding amount. The *IESO* will subsequently recover to pre-contingency levels of *operating reserve* requirements within 90 minutes of the contingency.

## 7.5 Manual Procurement of Operating Reserve during forced or planned tools outages

*Outages* of *IESO-administered markets* software, hardware or communication systems may result in temporary disruptions to market activities, such as electronic scheduling and dispatching. During such disruptions, the *IESO* is required to maintain normal market operations to the greatest extent practicable and, if needed, may employ alternative procedures as described in this section (*MR* Ch. 7, Sec. 1.6.3).

Depending on the duration of the *outage* updated *real-time energy* and *operating reserve* schedules may not be available. Furthermore, if *dispatch instructions* for *energy* are issued during the *outage*, the most recent *operating reserve* schedules may not reflect the actual amount of *operating reserve* available, which may be inadequate to meet the *standard authority* requirements (*MR* Ch. 7, Sec. 1.6.1). Under these conditions, the *IESO* will manually procure additional *operating reserve* by calling upon *ancillary service providers* that have made *offers* to deliver *operating reserve* but, as a result of the *outage*, were not *dispatched* for *operating reserve*.

On a reasonable effort basis, the *IESO* will attempt to procure *operating reserve* in amounts that are proportional with each *market participant*'s share in the total available *operating reserve* capacity.

If, as a result of an *outage* of *IESO-administered markets* software, hardware or communication systems, the *IESO* has called upon a *market participant* to provide *operating reserve*, the *IESO* will:

- Notify market participants if the *dispatch instruction* issued in respect of an *operating reserve* by the Dispatch Scheduling & Optimization tool is invalid,

- Indicate the amount of *operating reserve* from each class that is to be provided by that *market participant*,
- Identify whether the request represents an activation of *operating reserve*,
- Indicate, if possible, the duration of the request. If this is not possible, the request will be valid until the *IESO* states otherwise, and
- Indicate any restrictions as to what areas the *operating reserve* needs to be provided from, leaving the *market participant* to choose what resources will be used to meet the request.

When called upon, the *market participant* will (*MR* Ch. 7, Sec. 1.6.4):

- Ensure that, at all times, the amount of *operating reserve* requested by the *IESO* is available for *dispatch*,
- Assess the status of their resources and inform the *IESO* if *operating reserve* cannot be provided as requested, and
- Immediately report to the *IESO* when their resources *dispatched* for *operating reserve* are reaching the total capacity available for *operating reserve*, within a margin specified by the *IESO*.

*Administrative pricing* may apply for the manual procurement of *operating reserve* during such market tool failures.

## 7.6 Compliance with Dispatch Instructions

Every market participant must ensure that each of its registered facilities complies with dispatch instructions issued by the IESO and is subject to all provisions of the *market rules* (*MR* Ch. 7, Sec. 7.5.1). For *variable generation,* compliance with *dispatch instructions* will only apply when the *dispatch instruction* has a mandatory obligation indicator and the *facility* has sufficient fuel (e.g., wind, irradiance) to achieve the *dispatch* target.

Furthermore a *market participant* must notify the *IESO* when it:

- Has been scheduled for 10 minute *operating reserve* and is unable to activate the *operating reserve* within 10 minutes, or
- Has been scheduled for 30 minute *operating reserve* and is unable to activate the *operating reserve* within 30 minutes.

Where a *market participant* expects that, as a result of a *forced outage*, de-rating or any other reason, its *registered facility* will operate in a manner that differs materially from the *IESO's dispatch instructions*, the *market participant* must notify the *IESO* as soon as possible. A difference is material as defined in **Interpretation Bulletin** – "Compliance with Dispatch Instructions Issued to Dispatchable Facilities" (*MR* Ch. 7, Sec. 7.5.2) except for the following:

- In the case of a *registered cogeneration facility* that is either dispatchable or *self-scheduling*, a difference is material if it exceeds:
    - The compliance band as defined in "Compliance with Dispatch Instructions Issued to Dispatchable Facilities" **Interpretation Bulletin**, or

    - The compliance band based on the impact of the production of other forms of useful energy within the facility on *energy* production as determined by the *IESO* during *market entry* (*MR* Ch. 7, Sec. 2.2.6.10), and

- In the case of an *enhanced combined cycle facility* that is either dispatchable or *self-scheduling*, a difference is material if it exceeds:
    - The compliance band as defined in "Compliance with Dispatch Instructions Issued to Dispatchable Facilities" **Interpretation Bulletin**, or
    - The compliance band based on the impact that the recovery of waste heat from an industrial process/processes within the *facility* has on *energy* production as determined by the *IESO* during *market entry* (*MR* Ch. 7, Sec. 2.2.6.10).
- In the case of an *HDR* resource, a difference is material if it exceeds 5 MW of the *demand response capacity* the *DRMP* expects to be able to deliver.

When a *registered facility* operates in a manner that differs materially from *IESO dispatch instructions market participant* actions may include the following:

- Notifying the *IESO* (by telephone) of *forced outages* or de-ratings of its equipment and/or making an *outage* submission using the *outage* submission tools (refer to Market Manual 7.1: IESO-Controlled Grid Operating Procedures and Market Manual 7.3: Outage Management, Section 2.2 for more information),
- Submitting revised *dispatch data* to reflect the current capability of the *registered facility* (refer to Market Manual 4.2, Section 2.4 for more information), and
- Rejecting subsequent *dispatch instructions* that the *registered facility* cannot meet. If the *market participant* knows that its *registered facility* will be unable to comply with a *dispatch instruction* at the time that it receives the instruction, it is preferable that the *market participant* reject the instruction within the 60-second timeframe, rather than accepting the *dispatch instructions* and then failing to respond to the instruction.

*Dispatch instructions* for *energy* or withdrawal reductions that are flagged by the *IESO* as activation of *operating reserve* are accompanied by an "ORA" flag. A departure from these *dispatch instructions* shall be material if:

- In the case of a *dispatchable generation facility*, the facility fails to be at or above the target, and
- In the case of a *dispatchable load facility*, the facility fails to be at or below the target within the timeframe specified by the operating reserve market, for which the registered facility was scheduled.

In other words, if *a dispatchable generation facility* was *scheduled and dispa*tched for 10 minute synchronized or non-synchronized *operating reserve,* the *facility* would have to be at or above the dispatch target 10 minutes after receipt of the *energy dispatch instruction* flagged for activation of *operating reserve*. In the case of a *dispatchable load facility*, scheduled and dispatched for 10 minute synchronized or non-synchronized *operating reserve,* the *facility* would have to be at or below the dispatch target 10 minutes after receipt of the *dispatch instruction* flagged for activation of *operating reserve*.

Compliance with a *dispatch instruction* by a *registered facility* is not required if such compliance would endanger the safety of any person, damage equipment, or violate any *applicable law* (*MR* Ch.

7, Sec. 7.5.3). A *market participant* that departs from *dispatch instructions* for any such reason must notify the *IESO* as soon as possible and provide the following:

- The reason the *registered facility* is unable to follow the *dispatch instruction* issued,
- The duration the *registered facility* is expected to be unable to follow the *dispatch instruction*, and
- The minimum or maximum MW level the *registered facility* can safely operate at.

Accordingly, the *IESO* will *dispatch* the *registered facility* within the "safe" operating level provided.

If the *market participant* fails to accept or reject a *dispatch instruction* (for example, the message timer times-out before the *market participant* responds to the *dispatch instruction*), the *IESO* will respond as though the *market participant* has rejected the *dispatch instruction*. Correspondingly, the *registered facility* output is to remain at its last accepted *dispatch instruction*. In all cases, the *IESO* prefers that the *market participants* respond to *dispatch instructions* by accepting or rejecting the instructions received.

If failure by a *registered facility*, other than a *boundary entity*, to comply with a *dispatch instruction* endangers *electricity system reliability*, the *IESO* will treat the action through the compliance process and may declare the *registered facility* to be non-conforming. Refer to Market Manual 2.6: Treatment of Compliance Issues for more information on the compliance process.

If a *registered facility*, other than a *boundary entity or HDR* resource*,* produces or withdraws more or less *energy* in a *dispatch interval* than set out in a valid *dispatch instruction* issued by the *IESO*, the *IESO* will, for pricing and *settlement* purposes:

- Treat the difference in *energy* production or withdrawal as a change in *non-dispatchable load* at its location[44], and
- Use any trade-off curves between *energy* and *operating reserves* in the *dispatch data* for that *registered facility* to determine an appropriate adjustment in the quantity of *operating reserve* of each class supplied by the *registered facility*.

The *IESO* will impose financial penalties on a *market participant* associated with a *boundary entity* who fails to schedule *energy* or *operating reserve* with the appropriate scheduling entity according to the applicable *interchange schedule*, other than for bona fide and legitimate reasons as determined by the *IESO.* Bona fide and legitimate reasons include failures caused by actions and circumstances beyond the control of the *market participant* or due to *IESO* or external scheduling entity error or action.

The *IESO* will impose non-performance charges on a *CMP* associated with an *HDR* resource who fails to comply with a *dispatch instruction* in the form of an activation notice other than for bona fide and legitimate reasons as determined by the *IESO,* which include failures caused by actions and circumstances beyond the control of the *CMP*. Bona fide and legitimate reasons include failure of communication infrastructure such that the *DRMP* is unable to modify *HDR bids* or contact the *IESO*.

[44] The estimated deviations between scheduled quantities and actual quantities will not be considered in determining the *market schedule* until the start of the 7th calendar month following the *market commencement date*

## 7.7 Generation Units Turnaround Time

At times, market activity may cause fossil *generation units* to be scheduled on for a period of time, then scheduled off for one or more hours and then scheduled back on again. After they have been dispatched off, due to their slower turnaround time, these units are not capable of ramping-up and providing the scheduled output for the first several hours after being dispatch on. When the *IESO* recognizes this potential pattern in the pre-dispatch, it will conduct a *reliability* impact assessment on these units, considering their turnaround time as well as the system conditions and their status at the time.

Based on this assessment, the *IESO* will determine that:

- The *IESO* cannot dispatch these units off because they are critical for maintaining the *reliability* of the *IESO-controlled grid* in the hours in which they would be unavailable and/or their operation would be restricted following their dispatch off, or
- The *IESO* can dispatch these units off because units are not critical for maintaining the *reliability* of the *IESO-controlled grid* in the hours in which they are unavailable following their dispatch off.

If the units are critical for maintaining the *reliability* of the *IESO-controlled grid*, the *IESO* will constrain these units on to their minimum output in the hours they would otherwise be scheduled off, such that they are capable of picking up to the level of their offers in the following hours when they are dispatched on.

If the units are not critical for maintaining the *reliability* of the *IESO-controlled grid*, they will be dispatched off. However, when these units are dispatched back on again, *market participants* must submit revised offers to reflect the actual capabilities of the units and the turnaround time involved. When revised dispatch data is submitted within 2 hours of the dispatch hour, the *IESO Short Notice Change Criteria*[45] apply.

**– End of Section –**

[45] Refer to Appendix C in Market Manual 4.2: Submission of Dispatch Data in the Real-Time and Operating Reserve Markets

# 8. Issuing Dispatch Advisories

## 8.1 Registered Facilities (other than HDR resources and boundary entities)

The *IESO* issues *dispatch* advisories for each *registered facility* that is a *dispatchable load* or *dispatchable generator*, other than a *boundary entity* or *HDR* resource, prior to each *dispatch interval*, indicating for that *dispatch interval*:

- The anticipated *energy* level to be achieved (in MW) by the *facility* at the end of each advisory interval, and
- The anticipated amount of each class of *operating reserve* for each advisory interval.
- The *dispatch* advisories for any *registered facility* will be consistent with the current operating status of that *registered facility*, any operational constraints described in the most recent *dispatch data* submitted by the *registered market participant* for that *registered facility*, and with the *market entry* data maintained by the *IESO*.
- *Market participants* do not have to acknowledge the receipt dispatch advisories. (*MR* Ch. 7 Sec. 7.1.6).

## 8.2 Boundary Entities and HDR Resources

The *IESO* will not issue *dispatch* advisories to *boundary entities* or *HDR* resources.

### 8.2.1 Compliance with Dispatch Advisories

There is no obligation for *market participant* to comply with *dispatch* advisories.

**– End of Section –**

# 9. Administrative Pricing

The *IESO* is required to, subject to certain prescribed limitations, establish *administrative prices* and corresponding *market schedules*, where applicable, in the following three situations:

(i) Where the real-time *energy market* and the *operating reserve market* have been suspended,

(ii) Where the *IESO* is unable to publish an *energy market price* or *operating reserve market price* due to a failure or *planned outage* of the software, hardware or the communications systems that supports the operation of the *dispatch algorithm*, or

(iii) Where the *IESO* determines in accordance with Board approved guidelines (Appendix A) relating to price error materiality and acceptable causal events that a *published energy market price* or *operating reserve market price* is incorrect due to incorrect inputs which affected the outcome of the *dispatch algorithm*.

This section only applies to the establishment of *administrative prices* and corresponding *market schedules*, where applicable, in regards to the circumstances described above in (ii) and (iii), it does not apply to (i), the establishment of *administrative prices* and corresponding *market schedules* as a result of *market suspension*. For circumstance (i) above refer to Market Manual 4.5: Market Suspension and Resumption.

In circumstances where *administrative prices* are required, the *IESO* shall establish *administrative prices* and corresponding *market schedules* that would, to the extent practical, reflect the *market prices* and corresponding *market schedules* that would have otherwise been produced by the *real-time markets*, but for the event causing *market prices* to be administered (*MR* Ch. 7, Sec. 8.4A.4).

In establishing *administrative prices* for a non-*market suspension* event and corresponding *market schedules*, where applicable, the *IESO* shall set the *administered price* and *market schedule* for a given *dispatch interval* equal to the price and schedule from either (*MR* Ch. 7, Sec. 8.4A.5):

a) The closest preceding dispatch interval that has not been administered, up to a maximum of 24 dispatch intervals, i.e. “copy forward” from “last good” interval,
b) The closest subsequent dispatch interval that has not been administered, up to a maximum of 24 dispatch intervals, i.e. “copy back” from “next good” interval,
c) A combination of the closest preceding and closest subsequent *dispatch intervals* that have not been administered, provided that neither the preceding nor subsequent *dispatch intervals* are selected for more than 24 dispatch intervals, or
d) When the need to *administer prices* extends beyond 48 *dispatch intervals*, the *IESO* will establish *administrative prices* for the remaining *dispatch intervals* of the event causing *market prices* to be administered within the *IESO control area* and the *intertie zones,* using an average *HOEP* for the *energy market* and the hourly average of the *operating reserve* prices for the applicable *dispatch intervals* for the *operating reserve markets.* The hourly average values will be determined from the corresponding hour or hours from each of the 4 most recent *business days* or non-*business days*, as the case may be, excluding those hours from any day in which *administrative pricing* has been established (*MR* Ch. 7, Sec. 8.4.A.6*)*.

The decision on which interval to use (“preceding” or “subsequent” in (a) or (b) above or the combination of (a) and (b) in (c) above) will be based on the *IESO’s* judgment as to which price would better meet the guiding principle (i.e. the price that would otherwise have been produced by the market).

Where the *IESO* establishes an *administrative price* for a *dispatch interval* beyond 48 *dispatch intervals*, a *market schedule* is not established and no congestion management *settlement* credit payments made for that *dispatch interval* (*MR* Ch. 7, Sec. 8.4A.7).

The *IESO* will cease to apply *administrative prices* from the commencement of the first *dispatch interval* after:

- The failure to the software, hardware or communications has been rectified, or
- The *planned outage* of the software, hardware or communications has been completed, or
- The incorrect inputs that affected the outcome of the *dispatch algorithm* have been corrected.

The *IESO* will not establish *administrative prices* on the basis of incorrect prices caused by incorrect inputs which affected the outcome of the *dispatch algorithm* if more than 2 *business days* have passed since the *dispatch day* in respect of which the incorrect *energy market price* or *operating reserve market price* was *published*.

To the extent that the *administrative prices* beyond 48 intervals do not adequately compensate a *market participant* for complying with the *IESO's dispatch instructions*, the *IESO* shall provide additional compensation to the *market participant,* subject to materiality limits, as described in *MR* Ch. 7, Sec. 8.4A.9. For the purpose of that section, a request will be considered material and the *market participant* eligible for compensation if the compensation requested is at least:

- $1,000 for a given trade day and registered facility, and
- $200 for a given *trade day* and *registered facility* and the equivalent of $2/MWh.

This compensation shall be calculated as the aggregate of (*MR* Ch. 7, Sec. 8.4A.10*)*:

- The fuel costs or, where applicable, the other costs referred to in *MR* Ch. 7, Sec. 8.4A.11, and the variable operating and maintenance costs incurred by the *market participant* in complying with the *dispatch instructions* issued by the *IESO,* which fuel costs or other costs and variable operating and maintenance costs shall be subject to verification and audit by the *IESO*, and
- Subject to *MR* Ch. 7, Sec. 8.4A.11, an amount equal to 10% of the actual cost as determined above.

Less the amount of the *administrative price* already paid or payable to the *market participant*.

This section does not apply to additional settlement adjustment or compensation issues associated with *administrative prices* established according to *MR* Ch. 7, Sec. 8.4A.5 (i.e., for *market schedules* and prices established by the "copy forward/back" methods). Refer to Market Manual 5.5: Physical Markets Settlement Statements for a description of the associated process where *administrative prices* were applied for 48 intervals or less.

Where the additional compensation referred to above relates to a *generation facility* that is energy limited by design or by bona fide contractual commitments, the *IESO* may accept, in lieu of the actual costs, such assessment of the expected future value or the opportunity costs of the fuel or water consumed:

- During the period while *administrative prices* were in effect, and
- In order to comply with the *dispatch instruction* issued by the *IESO*,

as the *IESO* considers reasonable.

Where such value or costs are submitted in lieu of the actual costs referred to above, the additional 10% amount above the actual costs shall not be payable if, in the *IESO's* opinion, such value or costs include or adequately cover such amount (*MR* Ch. 7, Sec. 8.4A.11). Refer to Market Manual 5.5 for applying for such compensation.

To request additional compensation, the *market participant* must complete and submit the request application IESO_FORM_1398: Additional Compensation During Administrative Pricing.

Any disputes concerning the additional compensation referred to in above shall be resolved using the dispute resolution process set forth in *MR* Ch. 3, Sec. 2.

**– End of Section –**

# 10. Compliance Aggregation

The Compliance Aggregation program allows *market participants* to aggregate *generation facilities* (that do not qualify for network model aggregation) for purposes of compliance, in order to share individual dispatch instructions among authorized *generation facilities* when system conditions permit. Only the compliance treatment of "aggregated" resources would change. The DSO and operational tools will continue to work as per the *IESO's* market rules.

To be eligible to participate in the Compliance Aggregation program, the generation facilities must complete the applicable registration process (described in Market Manual 1.2: Market Entry, Maintenance and De-registration). In addition, market participants may wish to opt for the meter disaggregation model. The registration process for the meter disaggregation model is described in Market Manual 3 Part 3.7: Totalization Table Registration.

The compliance band for the *generation facilities* accepted for Compliance Aggregation is defined in "Compliance with Dispatch Instructions Issued to Dispatchable Facilities" Interpretation Bulletin.

Under Compliance Aggregation, the generation facilities will continue to receive separate dispatch instructions and will have to comply with individual resource dispatch instructions, when the *IESO* considers it necessary to maintain reliability of the *IESO*-controlled grid. Some examples requiring individual dispatch instructions may include:

- Load rejection and/or generation rejection arming,
- Outages,
- Configuration changes, and
- Security limit violations.

If reliability concerns exist, the *IESO* will communicate instructions to the *market participant* in the following manner:

- The *IESO* Control Room will contact the market participant and specify if the dispatch is on a Unit Specific Dispatch using terminology similar to: "Compliance Aggregation Name" must return to Unit Specific Dispatch. If available, a time frame for return to operation as a compliance aggregate will be provided.
- The *IESO* Control Room will contact the *market participant* when it is possible to return to Compliance Aggregate operation using terminology similar to: "Compliance Aggregate Name" may return to Compliance Aggregate operation at <specify time>.

While operating as a compliance aggregate, *facilities* are required to:

- Follow the normal dispatch process and submit offers for individual resources to reflect the actual, intended operation,
- Respect all obligations regarding synchronized operating reserve requirements within the compliance aggregate, and
- Maintain sufficient units in the compliance aggregate to have their synchronizing breakers closed to meet the amount of synchronized operating reserve scheduled.

The non-quick start *resources* registered for Compliance Aggregation have the following additional operational requirements in order to operate as a "compliance aggregate" in *real-time*:

- Compliance aggregation may not be used to avoid starting a unit that has been dispatched or to start a unit in place of another that has been dispatched.
- Units within a compliance aggregate are to operate within 50 MW of their individual dispatch instructions unless:
    - Offered ramp up and ramp down rates are the same, or within 1 MW/min for the same MW range, and
    - All offered ramp rates above minimum loading points do not vary by more than 1 MW/min. on each unit in the compliance aggregate.

Operation as a "compliance aggregate" is only permitted where all resources are operating above the *minimum loading point.*

*Generation Facilities* eligible for compliance aggregation who also provide *regulation* may be subject to additional restrictions.

**– End of Section –**

# Appendix A: Administrative Guidelines

This appendix provides the amendments to guidelines approved by the *IESO Board* on June 10, 2004 for events other than resulting from *market suspension*. The Illustrations have been added to provide clarity.

## A.1 Acceptable Causal Events

### A.1.1 Attempt to identify dispatch intervals, during which there have been:

- Operational telemetering failures, which have resulted in the loss or corruption of inputs to the *market schedule*,
- *IESO Administered Markets'* software failures, which have resulted in the loss or corruption of inputs to the *market schedule*, or
- *IESO* business process failures, which have resulted in the loss or corruption of inputs to the *market schedule*.

### A.1.2 For intervals in which the loss or corruption of inputs has occurred, replace the prices and market schedules for those intervals with:

a. The last good interval's prices and *market schedules* for up to 24 intervals (Figure A-1),
b. The next good interval's prices and *market schedules* for up to 24 intervals (Figure A-2), or
c. A combination of the last good interval's and the next good interval's prices and *market schedules* for up to an aggregate of 48 intervals provided that neither the last good interval's nor the next good interval's prices or *market schedules* shall be used for more than 24 intervals (Figure A-3),

unless the *IESO* is able to reasonably determine that the corrupt price for those intervals is closer to what the prices likely would have been had there been correct inputs, in which case the *IESO* shall deem the prices as correct (and shall therefore not be required to *administer prices*).

When such loss or corruption of inputs continues for more than 48 intervals, the prices will be established using *HOEP* for *energy* prices and the hourly averages for the applicable *operating reserve* prices from the corresponding hour or hours from each of the 4 most recent *business days* or *non-business*, as the case may be, excluding those hours from any day in which *administrative pricing* has been established, unless the *IESO* is able to reasonably determine that the corrupt price for these ensuing intervals is closer to what the prices likely would have been had there been correct inputs, in which case the *IESO* shall deem the prices as correct (and shall therefore not be required to *administer prices*) (Figure A-3).

In determining which of the alternatives to use from section 2, the *IESO* shall be guided by the principle that *administrative prices* and *market schedules* should be established, to the extent practical, to reflect the *market prices* and corresponding *market schedules* that would otherwise have been produced by the real-time markets but for the event causing *market prices* to be administered.

At the April 5, 2002 meeting of the *IESO* Board, *IESO* Management put forward certain screens that would be used for purposes of investigation. *IESO* Management has the discretion to change these screens and to administer prices even if one of these screens has not been triggered.

### A.1.3 Copy Forward Illustration:

Assume that as a result of incorrect inputs to the dispatch scheduling & optimization (DSO) algorithm administrative prices are required for 24 intervals starting with *dispatch interval* 1 of HE 16 (see Figure A-1 below).

The *IESO* determines that the last *dispatch interval* for which *energy* and *operating reserve* prices were correctly calculated is interval 12 of HE 15, identified as interval A. The next *dispatch interval* for which *energy* and *operating reserve* prices were correctly calculated is determined to be interval 1 of HE 18.

Assessing the market conditions at the time, the *IESO* determines that the *energy* and *operating reserve* prices calculated for interval A reflect, to the extent practical, the *energy* and *operating reserve* prices that would otherwise have been produced by the market for intervals 1-24. Consequently, under the provisions of *MR* Ch. 7, Sec. 8.4A.5.1, the *IESO* will replace the *energy* and *operating reserve* prices calculated incorrectly by the DSO for intervals 1-24 with the *energy* and *operating reserve* prices calculated for interval A. In doing so, the *IESO* will replace the 4 Ontario prices (*energy*, 10S, 10NS and 30) and all 39 *intertie* prices (*energy*, 10NS, 30 for all 13 *intertie zones*) for intervals 1-24 with the corresponding *energy* and *operating reserve prices* calculated for interval A.

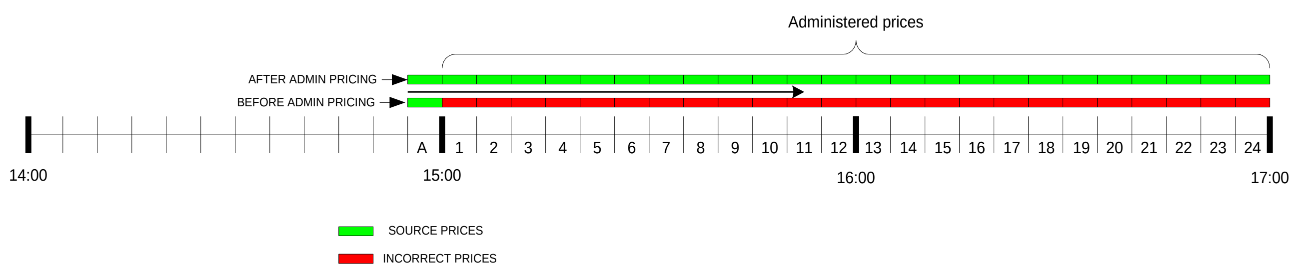



**Figure A-1: Copy Forward Scenario**

### A.1.4 Copy Backward Illustration:

In this example, *administrative prices* are needed for 4 intervals starting with interval 1 of HE 9 (see Figure A-2 below).

The *IESO* determines that the last *dispatch interval* for which *energy* and *operating reserve* prices were correctly calculated is interval 12 of HE 8. The next *dispatch interval* for which *energy* and *operating reserve* prices were correctly calculated is determined to be interval 5 of HE 9, identified as interval B.

Assessing the market conditions at the time, the *IESO* determines that the *energy* and *operating reserve* prices calculated for interval B reflect, to the extent practical, the prices that would otherwise have been produced by the market for intervals 1-4. Consequently, under the provisions of *MR* Ch. 7, Sec. 8.4A.5.2, the *IESO* will replace the *energy* and *operating reserve prices* calculated incorrectly by the DSO for intervals 1-4 with the *energy* and *operating reserve* prices calculated for interval B. In doing so, the *IESO* will replace the 4 Ontario prices (*energy*, 10S, 10NS and 30) and all 39 *intertie* prices (*energy*, 10NS, 30 for all 13 *intertie zones*) for intervals 1-4 with the corresponding *energy* and *operating reserve* prices calculated for interval B.

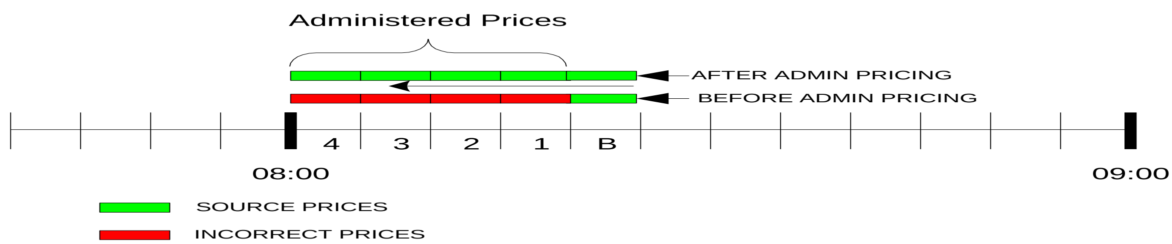



**Figure A-2: Copy Backward Scenario**

### A.1.5 Copy Forward and Backward Illustration

Assume that *administrative prices* are needed for 55 intervals starting with interval 10 of HE 17 (see Figure A-3 below).

The *IESO* determines that the last *dispatch interval* for which *energy* and *operating reserve* prices were correctly calculated is interval 9 of HE 17, identified as interval A. The next *dispatch interval* for which *energy* and *operating reserve* prices were correctly calculated is determined to be interval 5 of HE 22, identified as interval B.

Assessing the market conditions at the time, the *IESO* determines that:

- The *energy* and *operating reserve* prices calculated for interval A reflect, to the extent practical, the price that would otherwise have been produced by the market for intervals A1-A24, and
- The *energy* and *operating reserve* prices calculated for interval B reflect, to the extent practical, the price that would otherwise have been produced by the market for intervals B1-B24.

Consequently, under the provisions of *MR* Ch. 7, Sec. 8.4A.5.3, the *IESO* will replace:

- The *energy* and *operating reserve* prices calculated incorrectly by the DSO for intervals A1-A24 with the energy and *operating reserve* prices calculated for interval A, and
- The *energy* and *operating reserve* prices calculated incorrectly by the DSO for intervals B1-B24 with the *energy* and *operating reserve* prices calculated for interval B.

Since *administrative prices* are required for more than 48 intervals, the *IESO* will, under the provisions of *MR* Ch. 7, Sec. 8.4A.6, use average *HOEP* and average *operating reserve* prices to replace the *energy* and *operating reserve* prices incorrectly calculated by the DSO for intervals 10 to 12 of HE 19 and intervals to 1 to 4 of HE 20.

The average *HOEP* is determined from the corresponding hour from each of the 4 most recent business days or non-business days, as the case may be, excluding those hours from any day in which *administrative pricing* has been established under *MR* Ch. 7, Sec. 8.4A.6. The average *operating reserve* price is determined as the hourly average from the corresponding hour from each of the 4 most recent business days or non-business days, as the case may be, excluding those hours from any day in which *administrative pricing* has been established under *MR* Ch. 7, Sec. 8.4A.6.

The *IESO* will replace the 4 Ontario prices (*energy*, 10S, 10NS and 30) and all 39 *intertie* prices (energy, 10NS, 30 for all 13 *intertie zones*).

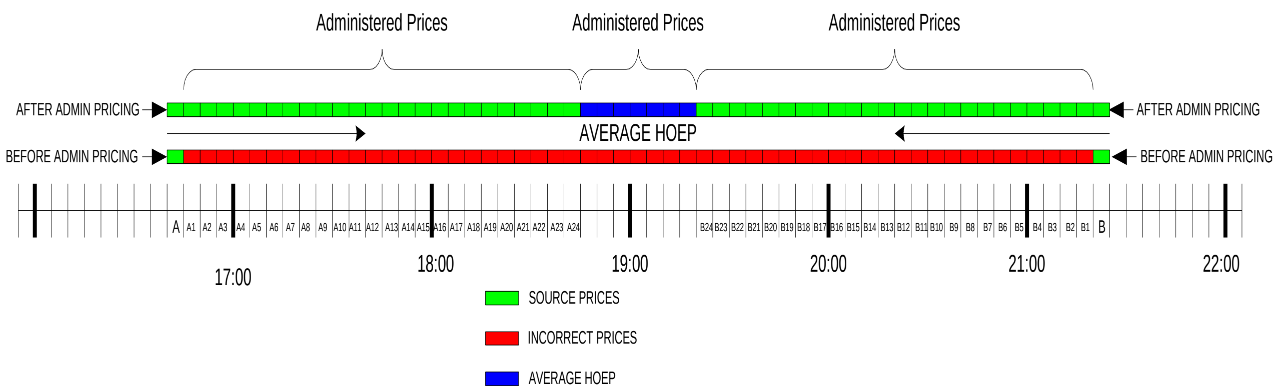



**Figure A-3: Copy Forward and Backward Scenario**

**– End of Section –**

# References

| Document ID | Document Title |
|---|---|
| MDP_RUL_0002 | Market Rules for the Ontario Electricity Market |
| MDP_PRO_0014 | Market Manual 1.1: Participant Authorization, Maintenance and Exit |
| MDP_PRO_0016 | Market Manual 1.2: Facility Registration, Maintenance, and De-registration |
| MDP_PRO_0022 | Market Manual 2.6: Treatment of Compliance Issues |
| IMP_PRO_0047 | Market Manual 3.7: Totalization Table Registration |
| MDP_PRO_0030 | Market Manual 4.5: Market Suspension and Resumption |
| MDP_PRO_0033 | Market Manual 5.5: Physical Markets Settlement Statements |
| IMO_MAN_0024 | Market Manual 6: Participant Technical Reference Manual |
| MDP_PRO_0040 | Market Manual 7.1: IESO-Controlled Grid Operating Procedures |
| IMP_PRO_0033 | Market Manual 7.2: Near Term Assessments and Reports |
| IMP_PRO_0035 | Market Manual 7.3: Outage Management |
| PRO-357 | Market Manual 13.1: Capacity Export Requests |

**– End of Document –**

# TAB D

This is Exhibit **"D"** referred to in the Revised Affidavit of Brian Rivard sworn before me this 21st day of November, 2019

*A Commissioner for Taking Affidavits*

**Lauren Theresa Daniel, a Commissioner, etc., Province of Ontario, while a Student-at-Law. Expires April 8, 2022.**

Ivey Business School
WESTERN UNIVERSITY · CANADA
Energy Policy and Management Centre

POLICY BRIEF
JULY 2019

# Don’t leave me stranded: What to do with Ontario’s Global Adjustment?

By Brian Rivard

## EXECUTIVE SUMMARY


- This Policy Brief offers an economic perspective to the ongoing policy discussions around the global adjustment. The global adjustment is a monthly fee paid by Ontario consumers to cover the fixed cost to build and maintain generation assets in the province, and to deliver Ontario’s conservation programs. It embeds costs incurred to achieve various social policy objectives, including: maintaining supply reliability, promoting environmental and health benefits, and developing green industries and green jobs. The global adjustment is the largest component of the average consumer’s electricity cost, representing between 45 to 60 percent of the total electricity bill.

- The current method used to recover the global adjustment from Ontario consumers—the Industrial Conservation Initiative—provides an extreme price incentive for some large consumers to reduce their demand during system peak demand hours. In some cases, it has induced large consumers to invest in storage or behind-the-meter generation to bypass the cost of consuming grid supplied electricity. This bypass can lead to an inefficient use of the province’s generation, transmission and distribution assets and increase the risk of the eventual stranding of the province’s large grid-related assets.

- This Policy Brief offers a practical approach for decomposing the global adjustment into three separate components: capacity costs, an energy price hedge, and system-wide fixed costs. It proposes that for efficiency and equity reasons, each component should be recovered as a separate charge, and a different cost recovery method should be applied to each component. Doing so, would reduce the risk of hastening investment in new distributed solutions, the stranding of current grid assets, and higher overall costs for Ontario’s electricity consumers.


## INTRODUCTION

Ontario is evolving its electricity pricing polices in the midst of a changing technological landscape, and the two spheres are path dependent. How the province evolves its pricing policies could materially influence the pace at which consumers adopt new distributed energy technologies as a substitute for receiving traditional grid-related services.

From a policy perspective, the Independent Electricity System Operator (IESO) is working with stakeholders to reform the design of Ontario’s competitive wholesale electricity market. The goal of the reform is to “improve the way electricity is priced, scheduled and procured in order to meet Ontario’s current and future energy needs reliably, transparently, efficiently and at lowest cost."[1] The Ontario Energy Board (OEB) is seeking to modernize the design of distribution and regulated retail rates in the face of an evolving sector, to promote the efficient and equitable recovery of system costs that are largely fixed and sunk, and to facilitate the rational adoption of new technologies.[2] More recently, the Ontario government held consultations with Ontario businesses to hear first-hand about industrial electricity pricing and programs, and their ideas on how the province's electricity system can make business more competitive.[3]

From a technological perspective, the integrated system as a whole could soon face serious competition from new distributed energy solutions, leading to the gradual decline in the use of the province's grid-related assets. Global technological development is enabling greater choice for consumers on how they use traditional electric grid services. Distributed generation solutions are becoming more cost-competitive with grid-sourced electricity, opening up the possibility that many consumers will turn to these solutions in the future as a way to lower their electricity costs.[4]

The pace of adoption of new distributed technologies will depend on the prices and regulated rates for traditional grid services. Ineffective pricing of grid services could delay consumer investment in these new innovative options when they are efficient and make sense from an environmental standpoint. Alternatively, ineffective pricing of grid services could inefficiently hasten investment in these solutions, causing the premature stranding of grid assets and higher costs for Ontario electricity consumers overall. For this reason, a renewed focus on efficient pricing and rate design of traditional grid services is timely.

One component of the overall electricity cost that deserves particular policy attention is the global adjustment. The global adjustment is a monthly fee paid by Ontario consumers to cover the fixed cost to build and maintain generation assets in the province, and to fund Ontario's conservation programs. The global adjustment is currently the largest component of the average consumer's total electricity bill. It represents roughly 80 percent of the province's generation supply costs and 45 to 60 percent of the cost to provide the fully bundled grid-related service.

Several commentators have raised concern over policy decisions that affected the size and nature of the costs incurred under the global adjustment, and the manner in which these costs are allocated across consumers.[5] Unfortunately, the costs in the global adjustment are essentially sunk and cannot be avoided; there is very little that can be done to redress the decisions that affected the size and nature of the costs. However, there are opportunities to redress decisions on how the costs are allocated to consumers. The current approach, the Industrial Conservation Initiative (ICI), provides an extreme price incentive for large consumers to reduce their demand during system peak demand hours. In some cases, it has induced large consumers to invest in distributed energy solutions such as storage or behind-the-meter generation to avoid paying the global adjustment. However, because the cost in the global adjustment are largely fixed, this results in a shifting of costs to other consumers, which creates an incentive for these consumers to also turn to distributed energy solutions to reduce their costs. Over time, this cycle risks the eventual stranding of the province's large grid-related assets. It would also imply higher costs for Ontario consumers on the whole.

This Policy Brief brings an economic perspective to the ongoing policy discussions around the global adjustment, beginning in the next section with background on the global adjustment and the ICI, followed by an evaluation of how the generation costs in the global adjustment are priced and allocated.

The Policy Brief then offers suggestions on how to improve generation cost pricing in the province to promote more efficient and equitable outcomes. In particular, it offers a practical approach for decomposing the global adjustment into three separate components: capacity costs, an energy price hedge, and system-wide fixed costs, and argues that from an efficiency and equity standpoint, a different cost recovery method should be used for each component. This proposed approach, which is compatible with the general direction of the current pricing policy initiatives, would reduce the risk of hastening investment in distributed solutions, the stranding of existing grid assets and higher overall costs for Ontario's electricity consumers.

## BACKGROUND ON THE GLOBAL ADJUSMENT AND INDUSTRIAL CONSERVATION INITIATIVE

### *Global Adjustment*

The global adjustment was established in 2005 as part of a policy transition from a fully competitive market structure to a hybrid market structure that:

- complemented the competitive wholesale market with long-term centralized planning and procurement;
- regulated the prices for certain generation assets;
- introduced a Regulated Pricing Plan (RPP) for low volume residential and small business consumers; and
- created a greater role for government through Ministerial Directive powers.[6]

Ontario Regulation 429/04, instituted the global adjustment as the variance account used to:

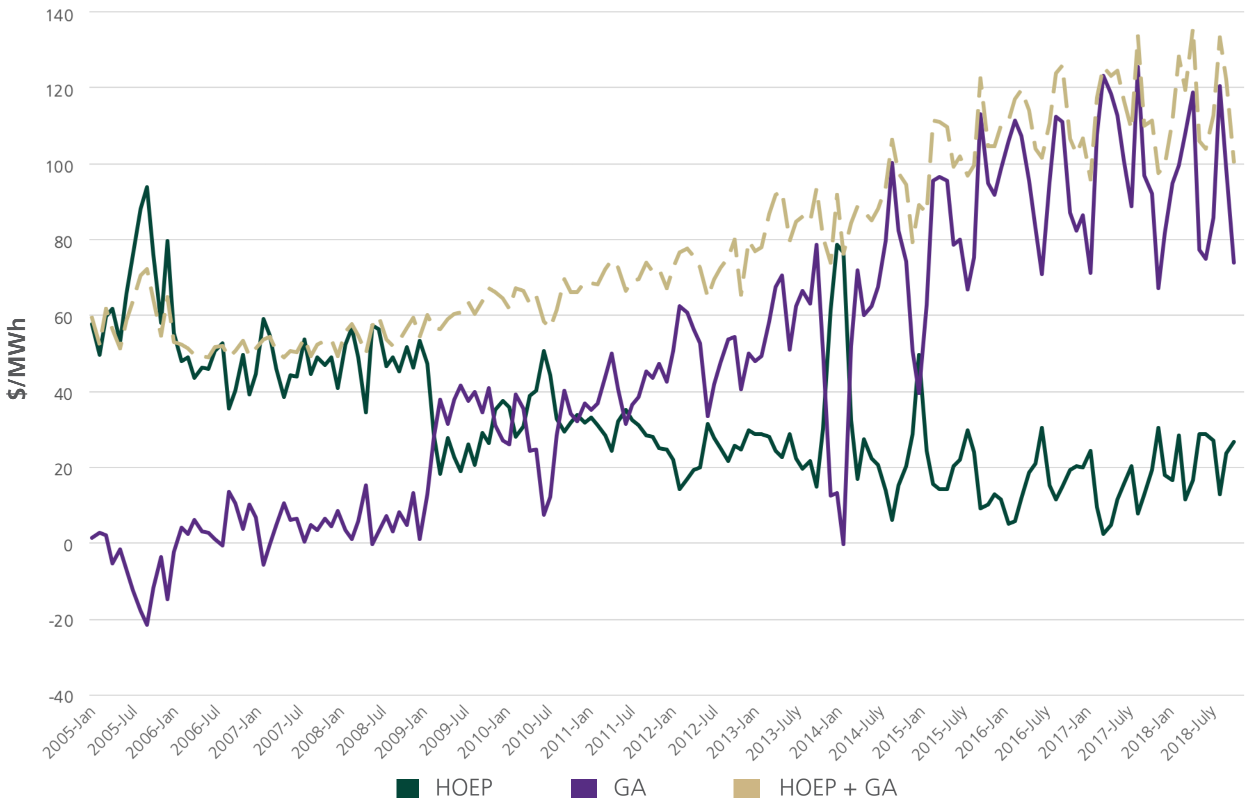
- reconcile differences between payments made to generators at the competitive wholesale market price and payments made through regulation or contract that differ from the wholesale market price; and
- fund the province's conservation and demand management programs.

The new regulation provided the global adjustment be recovered from Ontario consumers based on an individual consumer's share of the total net volume of electricity withdrawn from the grid each month (i.e., a volumetric rate).[7]

Initially, the regulated component of the global adjustment reflected electricity generated by Ontario Power Generation's (OPG) baseload hydroelectric and nuclear assets[8] (also known as "heritage assets"), and the contract component reflected electricity generated by the existing non-utility generator assets under contract to the Ontario Electricity Finance Corporation. OPG's heritage assets received an average regulated rate of 4.5 cents per kilowatt-hour, which was low relative to the prevailing competitive market price. The government expected that regulating the price of OPG's assets would "reduce price volatility and have a stabilizing effect on electricity prices, which will be of great benefit to Ontario's power consumers."[9]

In the first year, the global adjustment typically represented a monthly credit to consumers as market prices were well above the average rate paid to OPG's heritage assets. However, the government gradually directed the OPA (now the IESO)[10] to sign new contracts with generators, initially to ensure a reliable level of generation capacity, and eventually to promote broader government policy objects such as the environmental and health benefits related to the reduction of greenhouse gases, and the economic benefits related to the development of green industries and green jobs.[11] The price or revenue assurances provided under these contracts were generally higher than the competitive market price. As the contract component grew, the global adjustment grew to become a monthly charge to consumers. Figure 1 depicts the growth of the global adjustment relative to the competitive market price, the average monthly Hourly Ontario Energy Price (HOEP), from 2005 to 2018.[12]

Figure 1 | Hourly Ontario Energy Price and Global Adjustment, 2005 to 2018




Source: Author created from data available from the IESO.

## *Industrial Conservation Initiative*

In June 2011, the government introduced amendments to Ontario Regulation 429/04 through the Industrial Conservation Initiative (ICI). The amendments changed the way the global adjustment was allocated to Ontario consumers.[13] The ICI created two classes of consumers for the purpose of allocating the global adjustment. Class A consumers, which were consumers with an average monthly peak demand greater than five megawatts (MW), were charged the global adjustment based on their share of consumption during the five highest demand hours (coincident peak demands) in Ontario during a defined base period from May 1 to April 30 of the previous year. Class B consumers, which included all remaining consumers, continued to be charged the global adjustment volumetrically, but based on the total Class B share of consumption during the five coincident peak demand hours.

The ICI was introduced to address the concerns raised by large volume consumers who believed that they were paying more than their fair share of the fixed costs incurred to maintain and build sufficient generation to meet peak demands. The ICI offered large industrial consumers an incentive to reduce their consumption during critical peak demand hours, which was expected to reduce the need to procure new peaking generation capacity.[14]

The ICI has been amended since 2011 to expanded Class A eligibility. Class A consumers now include consumers with an average monthly peak demand greater than 1 MW, and consumers in certain manufacturing and industrial sectors, including greenhouses with an average monthly demand greater than 500 kilowatts (kW) during the annual base period.

## ISSUES WITH THE GLOBAL ADJUSTMENT AND GENERATION COST PRICING

Several commentators have criticised government decisions that affected the size and nature of the costs in the global adjustment. For example, the Office of the Ontario Auditor General (2015) identified several problems with past generation and conservation procurement decisions, including the procurement of more capacity than needed to meet Ontario's peak demands, overpayment for renewable energy, costly gas plant cancellations, ineffective conservation programs, and cost-ineffective conversion of the Thunder Bay coal plant to biomass. The Auditor argues that these decisions resulted in inefficient and unnecessary expenditures that inflated the size of the global adjustment.

Trebilcock (2017) argues that policies such as the Green Energy and Green Economy Act, which were implemented to reduce carbon emissions from the electricity sector and to stimulate job creation in the green energy economy failed to deliver on their objectives in a cost-effective manner. While the policies yielded modest environmental benefits, it had a likely negative effect on employment and dramatically increased the size of the global adjustment and users' electricity costs.

Unfortunately, little can be done to redress the policy decisions that affected the size and nature of the costs incurred within the global adjustment, as these costs are essentially sunk (see Insert 1 for a glossary of economic terms). The IESO is under contractual commitment to pay generators for these costs. To avoid or reduce these costs, the IESO would have to renegotiate the contracts it has with generators. While it is unlikely that generators would accept changes that would make them worse off, there may be an opportunity to push some costs further into the future. Similarly, the OEB has established regulated rate commitments with OPG. The OEB could reduce the size of payments to OPG in future rate hearings by refusing the recovery of some costs or forbearing on regulation all together. Figure 2 depicts the share of global adjustment paid to different generation technologies and their share of total installed capacity for 2017.

### Insert 1 | Glossary of Economic Terms

**Variable costs:** Costs that vary with the quantity of output produced.

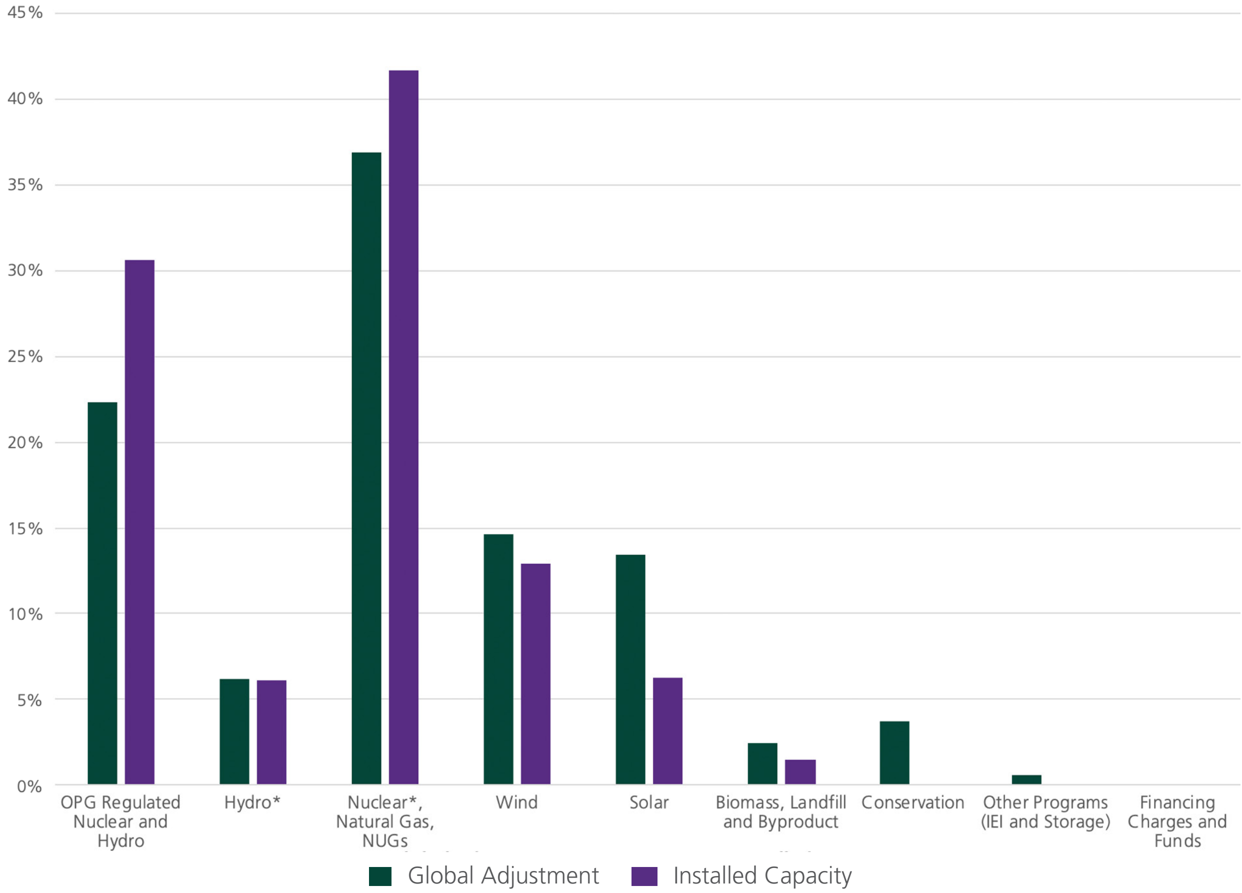
**Fixed costs:** Costs that do not vary with the quantity of output produced.

**Short-term:** A period of time in which the optimal decisions of consumers and producers are constrained by the existing stock of assets, (i.e. consumers' energy drawing assets or devices and total generation capacity are fixed).

**Sunk cost:** A cost already incurred or committed to being paid that cannot be avoided or recovered.

**Marginal cost:** The additional cost incurred by a firm to increase production by one more unit of output.

## Figure 2 | Share of Global Adjustment and Share of Total Capacity by Generation Technologies, 2017




* Non-OPG assets

Source: Author created from data available from the IESO.

A second concern around the global adjustment relates to how the province prices and allocates its generation costs. For example, the OEB's Market Surveillance Panel (MSP) has argued that the current approach leads to an inefficient and inequitable allocation of generation costs.[15] The ICI provides Class A consumers with an extreme incentive to invest in behind-the-meter generation and storage to avoid paying the global adjustment.The cost of these investments are generally higher than the actual avoided cost of using grid supplied electricity, which makes the investments socially efficient. Furthermore, as Class A consumers build on-site generation or storage and reduce overall grid level consumption, the sunk global adjustment costs are shifted to other consumers. This cost shift induces more consumers to find ways to avoid paying the global adjustment, including investing in distributed energy solutions. The MSP warns that this cycle could eventually lead to the premature stranding of large grid assets, and higher costs for Ontario consumers overall.

Unlike the concerns related to the size and nature of costs within the global adjustment, there are opportunities to redress the decision on how the province's generation costs are allocated to consumers to promote more efficient and equitable outcomes. This is the intended contribution of this Policy Brief and the focus of the next section. The remainder of this section sets out economic principles for efficient and equitable pricing and evaluates the current Ontario approach against these principles.

## *An Economic Perspective on Efficient and Equitable Pricing*

In economics, a market is efficient in the short-term if it makes best use of the presently available productive assets. This occurs when the commodity is produced by the cheapest suppliers and it is consumed by all consumers and only those consumers whose willingness to pay to consume is no less than the cost of all inputs used to make it. Long-term efficiency is about making optimal and timely decisions on the investment in new assets and the maintenance or expiry of existing assets. In the long-term, efficiency is achieved when the industry produces at the point where industry long-term average cost is minimized.

Standard microeconomic analysis clearly establishes that economic efficiency is maximized in the short-term when prices equal the marginal cost of production;[16] any departure from marginal cost pricing is likely to reduce the economic value the industry can create.[17] The exception to this rule is when there is a constraint on productive capacity. In this case, price must exceed the marginal cost of the last MW produced in order to ration demand. Efficient pricing with short-term capacity constraints requires the demand side of the market to set the price. The price equals the dollar value of the benefit consumers would get from consuming one more MW of electricity (i.e. the marginal willingness to pay). This price represents the marginal value of adding one MW of new capacity. In the energy economics literature, the portion of the peak price that is above marginal cost is called a *scarcity rent*.[18] Scarcity rents provide producers with an opportunity to cover a portion of their fixed cost. They also provide a signal to potential investors of the relative scarcity of capacity, and the value of either retiring existing capacity or investing in new capacity. Scarcity rents provide incentives for efficient long-term investment decisions. In the long-term, scarcity rents equal the marginal cost of adding new capacity.[19]

There are instances, however, when short-term marginal cost pricing fails to provide producers with sufficient revenue to recover all of their costs, particularly the fixed costs to build and maintain their productive assets. This can be true of industries that require investment in specialized assets with significant fixed costs (i.e. natural monopoly industries). Transmission and distribution services are standard examples of such an industry. Governments generally prefer regulation to competition in these industries, and the challenge for the regulator is to design consumer prices or rates that balance the goals of efficiency and consumer fairness or equity, but allow the regulated firm to recover all of the fixed costs to build and operate the assets, plus earn a fair rate of return on capital (financial viability).

In the regulatory arena, consumer fairness or equity is generally discussed in terms of cost causality (i.e., prices should be fair, in the sense of assigning costs to those who cause them and/or benefit from them being incurred).[20] This concept raises an important distinction between the recovery of fixed costs that are customer-specific versus those that are system-wide.[21] Customer-specific fixed costs vary according to whether the customer receives service from the regulated firm, but not in terms of how much electricity the customer consumes. For example, costs related to account set-up with a distribution company such as meter-related capital costs, minimum service drop costs, and final line transformer expenses are customer-specific. System-wide fixed costs cannot be attributable to a specific customer and are independent of how much electricity is consumed on the system. These can include construction and maintenance cost of a transmission or distribution system or public purpose programs such as conservation and energy efficiency programs. It is both efficient and fair from a cost causality perspective to recover customer-specific fixed costs directly from consumers as a fixed charge. It is the recovery of system-wide fixed costs that involves trade-offs between efficiency and equity. The trade-off generally requires a value judgement on the preferred distribution of wealth.[22]

There is an extensive theoretical and applied literature on approaches for the design of efficient and equitable rates to cover a utility's system-wide fixed costs.[23] Borenstein (2016) examines several approaches and notes that each has pros and cons (See Insert 2 for Bornstein's evaluation). Borenstein concludes that there is no ideal pricing policy, although balancing efficiency and equity suggests using a combination of fixed charges and increased volumetric prices above marginal cost.

### Insert 2 | Regulatory Approaches to Utility Fixed Cost Recovery

**Volumetric average cost pricing:**
A charge per kilowatt hour (kWh) consumed equal to the utility's average total cost. Often seen as fair, since all consumers are treated the same; yet it is inefficient, as it induces too much consumption when the average price is below marginal cost (typically during peak demand periods) and too little consumption when average price is above marginal cost (typically during low demand periods).

**Ramsey pricing:**
Charging different prices to different consumers based on their elasticity of demand. Efficient in a second-best sense, but generally impractical to implement, as it requires detailed information on individual consumer's demand elasticities. It is sometimes considered "unfair," as low-income consumers typically have the most inelastic demand and pay higher prices.

**Fixed charges:**
A set amount that does not vary with the volume of electricity used. A volumetric charge for the commodity equal to marginal cost, plus a fixed charge based on willingness and ability to pay, promotes first-best efficiency if there is perfect information on each consumer's willingness to pay. However, in practice, information is imperfect and finding an appropriate proxy measure for willingness and ability to pay has proven challenging, particularly for large industrial and commercial consumers.

**Demand charges:**
A charge per kWh based on a consumer's peak demand during a defined billing period. There is no efficiency or equity basis for using demand charges to recover system-wide fixed costs as there is no direct relationship between a customer's peak demand levels and these costs.

## *An Evaluation of Generation Cost Pricing in Ontario*

Generation costs include the marginal and variable costs to produce electrical energy and the fixed costs to build and maintain generation capacity. In Ontario, generators recover their variable costs (and part of their fixed costs) in the wholesale market through the competitive market clearing price, which is designed to reflect the system marginal cost at any point in time.[24] Generators are assured their fixed costs are recovered through contracts with the IESO or in the case of OPG, through regulated rates. Payment of these costs are reflected in the global adjustment.

As Figure 1 illustrates, the global adjustment has grown to be 4 to 5 times larger than the market price (i.e., marginal cost), demonstrating that generation cost recovery based on marginal cost pricing alone would result in a revenue shortfall for some if not all generators. Therefore, an alternative regulatory pricing approach, such as those examined by Borenstein (2016), must be considered.[25]

Efficient and equitable fixed cost recovery in Ontario represents a particular challenge because the global adjustment includes both customer-specific fixed costs, system-wide fixed costs and an energy price hedge. Some of the fixed costs in the global adjustment were incurred to ensure a reliable level of generation capacity. Generation capacity costs are essentially a customer-specific cost in that individuals that consume energy in the hours when the IESO projects capacity is most needed for reliability (i.e., system-peak demand periods) contribute to the need for and cost to build and maintain generation capacity. Historically, "dumb" meters did not permit measurement of individual consumer demand during these system peak hours. However, smart meters now provide an accurate hourly measure of the amount any individual consumes, allowing for more direct recovery of customer-specific capacity cost. Other fixed costs in the global adjustment were incurred to promote environmental and health objectives related to the reduction of greenhouse gases, and for economic objectives related to the development of green industries and green jobs. These costs were incurred for the benefit of all Ontarians and they cannot be attributed to any specific consumer (i.e., a system-wide fixed cost). Furthermore, a portion of the payments to OPG's regulated assets reflect the 2005 policy goal of providing consumers price stability, again for the benefit of all Ontario consumers.

## Table 1 | Generation Cost Pricing by Consumer Group

| Customer Class | Energy Cost | Global Adjustment |
|---|---|---|
| Class A | HOEP or MCP* (Marginal Cost Pricing) | Share of 5 Coincident Peaks (Demand Charge) |
| Class B - RPP | Time-of-Use Prices (Time-Varying, Volumetric Pricing) | |
| Class B - Non-RPP | HOEP (Marginal Cost Pricing) | Class B GA rate (Volumetric Pricing) |
| Exports | MCP (Marginal Cost Pricing) | Do not pay |

*A small number of large consumers that participate directly in the wholesale market (dispatchable loads) pay the 5-minute market-clearing price (MCP). The HOEP is equal to the arithmetic average of the hourly 5-minute prices.

As Table 1 illustrates, different approaches to generation cost recovery currently apply to different consumer groups. The following provides a brief evaluation of each approach against the principal criteria of efficiency and equity, using Bornstein's assessment as a guide.

In all hours, Class A consumers pay the marginal cost for the electricity that they consume. They are charged a portion of the global adjustment through a demand charge in the five coincident peak demand hours. This pricing approach encourages efficient consumption in the hours that a Class A consumer does not expect to be a coincident peak demand hour since they pay marginal cost. However, because the global adjustment includes both customer-specific fixed capacity costs and system-wide fixed costs, it can induce too little consumption in the expected coincident peak hours if the avoided global adjustment cost is greater than the marginal cost of adding new capacity or consumers' willingness to pay. The MSP recently estimated that a Class A consumer that reduced its demand by 1

MW in all 5 coincident peak demand hours in 2016, would have avoided an annual global adjustment fee of $520,000, which is considerably higher than the marginal cost of adding new generation capacity (the customer-specific cost) and well in excess of estimates of an average consumer's willingness to pay.[26]

Class B consumers are divided into Regulated Price Plan (RPP) consumers (low volume residential and small business consumers) and non-RPP consumers (larger businesses with monthly peak demand of more than 0.5 MW that are not Class A consumers). Non-RPP consumers pay marginal cost plus the Class B monthly global adjustment rate for each MW consumed in the month, which is a volumetric charge.[27] This pricing approach is inefficient in that it encourages too little consumption in all hours; it sets a price above marginal cost in all non-coincident peak hours, and a price above marginal cost plus the long-run marginal cost of new capacity in the coincident peak demand hours (as noted above for Class A consumers). RPP consumers pay time-of-use rates (on-peak, off-peak and mid-peak) set by the OEB, that embed the competitive energy price (HOEP) and the remaining Class B share of the global adjustment (i.e., a time-varying, volumetric pricing).[28] This pricing will induce inefficient consumption in virtually all hours as the time of use rates rarely if ever equal marginal cost or precisely reflect the marginal cost of adding new capacity in the coincident peak hours.

A third group of consumers, exporters, are OEB licensed companies that move electricity from Ontario to another jurisdiction for use by consumers in the other jurisdiction. Exports pay the 5-minute MCP for energy exported out of Ontario. Exporters do not pay the global adjustment. Similar to Class A consumers, this pricing approach encourages efficient consumption in the non-coincident peak hours. The efficiency of the approach in coincident peak hours is more difficult to assess and somewhat controversial for reasons discussed in the next section.

All approaches are questionable from an equity standpoint since they all essentially allocate the system-wide fixed cost in the global adjustment through a demand charge. Class A customers are allocated the system-wide costs directly through a five coincident peak demand charge, and Class B consumers are allocated these costs indirectly by being responsible for the residual of costs based on their aggregate consumption during these hours. As Borenstein notes, there is no relationship between a consumer's peak demands and system-wide fixed costs or the benefits from them being incurred. Hence allocating these costs results in an arbitrary and likely inequitable allocation.

Finally, the MSP argues that the avoided global adjustment fee of $520,000/MW creates an incentive for Class A consumers to invest in on-site generators or storage facilities that are likely more expensive to build and or operate than transmission-connected generation or demand response capacity. As a result, as Class A consumers build on-site generation or storage to reduce grid level consumption and avoid global adjustment, the sunk costs contained in the global adjustment are simply shifted to other consumers, particularly Class B consumers who currently do not have the same ability to avoid these costs. This cost shift induces more consumers to find ways to avoid paying the global adjustment, including investing in distributed energy solutions to avoid consuming from the grid. The MSP raises the concern that this cycle could eventually lead to the premature stranding of generation, transmission, and distribution costs, and higher costs for Ontario consumers overall.[29]

## RECOMMENDATIONS FOR MORE EFFICIENT AND EQUITABLE PRICING

As outlined in the previous section, a key challenge for designing efficient and equitable approaches for the pricing of generation costs in Ontario is that the global adjustment embeds customer-specific and system-wide fixed costs and the energy price hedge on OPG's regulated assets. The first step towards improving generation cost pricing in Ontario is to decompose the global adjustment into these three component amounts. The second step is to price each component separately, using an approach that balances the principal criteria of efficiency and equity as outlined above.

Table 2 sets out a practical approach to the first step, decomposing the global adjustment into its three separate components, namely customer-specific capacity costs, the OPG energy price hedge, and system-wide fixed cost. Table 3 offers suggestions for the second step.

### Table 2 | Contribution to Global Adjustment (2017)

| GA Components | Global Adjustment (Millions) | Installed Capacity (MW) | Unforced Capacity (MW) | Capacity Price ($/MW-y) | Capacity Cost (Millions) | Energy Price Hedge (Millions) | System-Wide Costs (Millions) |
|---|---|---|---|---|---|---|---|
| OPG Regulated Nuclear and Hydro | $2,649 | 12,154 | 10,234 | $125,925 | $1,289 | $1,360 | $0 |
| Hydro* | $731 | 2,433 | 1,721 | $125,925 | $217 | NA | $514 |
| Nuclear*, Natural Gas, NUGs | $4,375 | 16,554 | 15,363 | $125,925 | $1,935 | NA | $2,440 |
| Wind | $1,738 | 5,124 | 587 | $125,925 | $74 | NA | $1,664 |
| Solar | $1,594 | 2,470 | 826 | $125,925 | $104 | NA | $1,490 |
| Biomass, Landfill and Byproduct | $287 | 579 | 514 | $125,925 | $65 | NA | $222 |
| Other Programs (IEI and Storage) | $68 | 357 | 297 | $125,925 | $37 | NA | $30 |
| Conservation | $443 | 0 | 0 | $125,925 | NA | NA | $443 |
| Financing Charges and Funds | -$33 | 0 | 0 | $125,925 | NA | NA | -$33 |
| **Total** | **$11,851** | **39,670** | **29,543** | | **$3,720** | **$1,360** | **$6,770** |
| Resource Reliability Requirement | | | 27,689 | | | | |
| Surplus Capacity | | | -1,854 | | -$233 | | $233 |
| **Adjusted Total** | | | **27,689** | | **$3,487** | **$1,360** | **$7,004** |

Source: Author created using data from the Ontario Planning Outlook (2016) and The Brattle Group (2018).

### Table 3 | Generation Cost Pricing by Consumer Group, Current Approach and Proposed Approach

| | Current Approach | | Proposed Approach | | | |
|---|---|---|---|---|---|---|
| **Customer Class** | **Energy Cost** | **Global Adjustment** | **Energy Cost** | **Capacity Costs** | **OPG Energy Price Hedge** | **System-Wide Costs** |
| Class A | HOEP or MCP* (Marginal Cost Pricing) | Share of 5 Coincident Peaks (Demand Charge) | HOEP or MCP | Demand Charge | Volumetric | Fixed Charge or Taxes |
| Class B - RPP | Time-of-Use Prices (Time-Varying, Volumetric Pricing) | | Time-of-Use | Demand Charge | Volumetric | Fixed Charge or Taxes |
| Class B - Non-RPP | HOEP (Marginal Cost Pricing) | Class B GA rate (Volumetric Pricing) | HOEP | Demand Charge | Volumetric | Fixed Charge or Taxes |
| Exports | MCP (Marginal Cost Pricing) | Do not pay | MCP | Demand Charge | Not Applicable | Not Applicable |

Source: Author created using data from the Ontario Planning Outlook (2016) and The Brattle Group (2018).

Table 2 offers a retrospective and indicative estimate of the three components in 2017. First, the customer-specific capacity costs are estimated using data on projected 2017 generation capacity and reliability requirements form the IESO's Ontario Planning Outlook (2016) and estimates of the cost of building new generation presented in Brattle Group (2018) and in IESO (2019). The estimates are based on the methodology the IESO is proposing to calculate capacity payments under the Incremental Capacity Auction, one of the initiatives within the broader Market Renewal Initiative.

The IESO is required to maintain a certain level of capacity for reliability. In particular, it is required to maintain a level of capacity in the province so that the likelihood of not being able to supply firm demand due to insufficient capacity is no more than 0.1 days per year.[30] To meet this requirement, the IESO counts on all contracted and regulated generation capacity (i.e., all generation assets need to be available during system peak demand hours to ensure consumer demand is met reliably). The IESO is looking to procure capacity through the Incremental Capacity Auction on an unforced capacity basis. Installed capacity represents the maximum amount of energy that a resource can produce at any point in time, while unforced capacity represents the amount of energy that a resource can be expected to provide, on average, during system peak demand periods, accounting for the possibility of outages or in the case of renewables fuel unavailability. Table 2 presents both the installed and unforced capacity amounts for the different generation technologies and the amount of capacity the IESO estimated it would require in 2017 for reliability.

As part of the Incremental Capacity Auction, the IESO intends to use a capacity demand curve to represent the IESO's willingness to buy capacity by defining the prices that it is willing to pay for varying levels of reliability."[31] Modeling conducted by the Brattle Group (2018) and adopted by IESO (2019) suggest $125,925/MW-y is an indicative estimate for the capacity price of the future auction as this price is consistent with the price that would prevail, on average, in a market that supports entry at the long-run marginal cost of capacity.

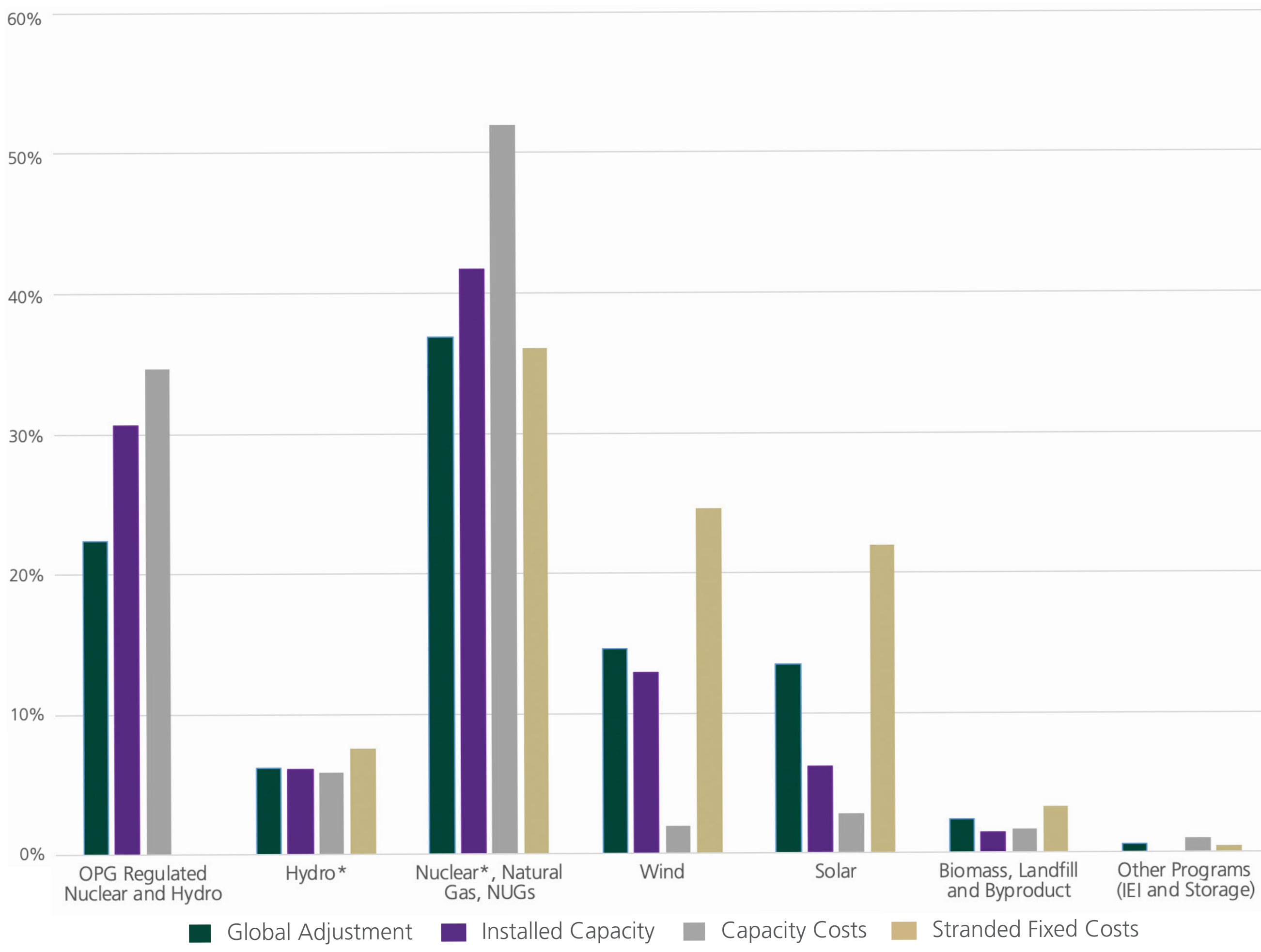
Consistent with how capacity payments would be calculated in the Incremental Capacity Auction, the capacity costs in the global adjustment can be estimated as the product of unforced capacity and the indicative capacity price. Under this approach, the total capacity-related costs embedded in the global adjustment in 2017 represented roughly $3.7 billion. However, the amount of unforced capacity under contract or regulation with the IESO in 2017 was greater than the amount the IESO projected it would need in 2017 to meet its reliability standard when planning in 2016. That is, the province had a surplus of capacity. In a competitive auction, the capacity price would likely have cleared well below the long-run marginal cost of capacity so that the implicit capacity cost for all assets would have been lower than what is estimated in Table 2. For the purpose of the present analysis, the cost of surplus capacity is valued at the long-run marginal cost of capacity, subtracted from the capacity cost component of the global adjustment and added to the system-wide cost component. After subtracting the estimated cost of surplus capacity, the net capacity cost embedded in the global adjustment in 2017 is estimated at $3.5 billion.

Second, the OPG energy price hedge provides Ontario consumers protection against volatile and high energy prices by rebating any revenues that the government-owned generator, OPG earns above what it needs to cover its total fixed and variable costs as defined by its regulated rates.[32] The amount of this price protection can be conceptualized as the difference between what OPG earns for the energy it provides, and what it would earn for its capacity in the competitive capacity auction, less the amount it needs to cover its approved costs. This value is estimated as the difference between what OPG receives from the global adjustment and its indicative capacity value as calculated in Table 2. In 2017, this is estimated as a charge to consumers of roughly $1.4 billion.

The remainder of the global adjustment consists of system-wide fixed costs incurred to achieve different policy objectives, which in 2017 amounted to roughly $7 billion. Arguably these also represent a form of stranded costs. The concept of stranded costs emerged as jurisdictions began deregulating natural monopolies and network industries. Stranded costs are the anticipated shortfall in net revenues on an incumbent's asset under competition that occur as a consequence of changes in regulatory or government policy.[33] As jurisdictions began introducing competition in previously regulated industries, incumbent utilities that had incurred costs prudently under regulation were at considerable risk of recovering the cost of these assets and of earning the regulatory approved return on invested capital. Many jurisdictions assumed the burden of these costs as part of the implicit regulatory contract with the incumbents. The costs were recovered from consumers through a separate competitive transitional charge.

In 1998, the Ontario government faced the issue of stranded costs when it decided to expose the generation services to competition. At the time, Ontario Hydro was carrying long-term debts of $26.2 billion and assets totaling $39.6 billion. The estimated market value of the assets was substantially less than the $39.6 billion. To ensure the financial solvency of the successor companies, the government assumed $19.5 billion of stranded debt and began repaying the debt through a Debt Retirement Charge levied upon Ontario ratepayers. The Debt Retirement Charge was equal to 0.7 cents per kWh of electricity consumed in Ontario. It was retired on March 31, 2018.[34]

## Figure 3 | Share of Global Adjustment, Installed Capacity, Capacity Cost and Stranded Fixed Cost, 2017




* Non-OPG assets

Source: Author created from data available from the IESO.

Fast forward to today, when the transition from central planning and procurement to a competitive capacity auction exposes a difference between the competitive energy and capacity value of the contracted assets and the payments guaranteed through contract with the IESO. This difference is a reflection of costs stranded by previous policy decisions. Figure 3 provides a share comparison of the different components by generation technology for 2017, excluding the OPG energy price hedge. System-wide stranded fixed costs accounted for roughly 60 percent of the global adjustment in 2017.

The second step for achieving a more efficient and equitable allocation of generation costs is to price each component of the global adjustment separately using an approach that balances the principal criteria of efficiency and equity as discussed above. Table 3 offers suggested approaches for each consumer group.

First, capacity costs are essentially a consumer-specific fixed cost. Individuals that consume energy in the hours when the IESO projects capacity is most needed for reliability (i.e. system-peak demand periods) contribute to the need for capacity. Furthermore, with smart-meters, we can measure each consumer's consumption in these hours and charge them directly for their share of the cost. A demand charge based on consumption in the system-peak demand hours can approximate the marginal cost of adding new capacity on the system and encourage efficient consumption. A demand charge is also equitable in that it connotes the notion of user pay and cost causality. A coincident peak demand charge such as the one used to recover the global adjustment from Class A consumers represents one option.[35] Another option includes the one considered by the in OEB (2019), which would allocate capacity costs in each hour in a manner that is directly correlated to total Ontario electricity demand (labelled the demand shaped prototype). A third approach is the one prescribed in Alberta Energy (2017), the "weighted energy method," which would allocate capacity costs across several time blocks, with greater weight assigned to time blocks that contribute more to the cost of capacity and lower weights assigned to time blocks that contribute less to the cost of capacity. Ultimately, the efficiency merits of different charge determinants (i.e. coincident peak, demand-shaped pricing, weighted energy) is an empirical question worthy of study but outside of the scope of this policy report.

There is no efficiency or equity basis for dividing consumers into different classes (i.e. Class A and Class B consumers) for the purpose of recovering consumer-specific capacity costs through a demand charge.

Currently, exports do not pay global adjustment and the IESO has indicated it will not recover the annual capacity costs of the Incremental Capacity Auction from exports. This is a standard practice of all jurisdictions. The rationale for this approach is that Ontario does not consider export demand when it establishes its resource adequacy needs (i.e. exports do not benefit from the capacity built for Ontario peak demands). Furthermore, the IESO reasons that "to the contrary, exports provide benefit to the province by exporting excess energy to neighbouring jurisdictions."[36]

However, if capacity costs are a consumer-specific cost to be recovered on a coincident peak demand basis, there is an efficiency and equity argument that exports should pay their share of the capacity costs if they choose to buy Ontario energy in these hours. With a coincident peak demand charge, exports would pay for Ontario's capacity costs, only if they chose to consume in the coincident peak demand hours. This means that in all other hours, including those when there was excess energy, they would pay the marginal energy price, as they do today so that they would still have an incentive to export excess energy. Furthermore, if the export takes on the risk of transferring energy from Ontario to another jurisdiction during an hour in which it reasonably expects to pay part of Ontario's capacity costs, it must be doing so because it thinks the price it will receive in the other jurisdiction will cover the full cost of the transaction. In this sense, the price in the other jurisdiction must be sufficiently high, signaling a severe shortage of generation capacity in the jurisdiction. Consumers in this jurisdiction are willing to pay what it costs to have energy from Ontario transferred to their jurisdiction, including paying the marginal cost of adding capacity in Ontario. The consumers in this jurisdiction benefit from Ontario's investment in capacity and hence pay their share of the use of that capacity.

Second, part of the objective of the government's initial decision to regulate OPG's heritage assets was to provide Ontario consumers protection against volatile and high energy prices. In months with relatively high competitive energy prices, OPG rebates the revenues it earns above prescribed rates to Ontario consumers. In months with relatively low competitive energy prices, OPG recovers shortfalls from their prescribed rates through a charge on Ontario consumers. Initially, the rebate and charge were applied volumetrically on the basis of total monthly Ontario demand.[37] This helped to dampen the effects of the month to month energy price volatility on consumers. The implementation of the ICI distorted this relationship. Recovering the OPG energy price hedge component volumetrically would restore the initial policy purpose of the global adjustment.[38]

Finally, the third component of the global adjustment is a system-wide fixed cost incurred to achieve various government policy objectives. These costs also represent a form of stranded costs. As discussed above, there is no ideal policy for how to recover these costs, although balancing efficiency and equity suggests using a combination of fixed charges and volumetric prices. Ideally, the fixed charges should reflect the willingness and ability of different consumers to pay for grid-related electricity services. The challenge is finding a determinant that provides a reliable measure of willingness and ability to pay. In any event, the choice of a fixed charge would inevitably involve a value assessment on the preferred distribution of wealth in Ontario, an assessment generally best made by government.

As most of these costs were incurred for broader public policy objectives, a strong argument can be made that they should be recovered through the general tax base rather than through electricity rates. In any other sector, a government subsidy paid to a company to invest in clean technologies or to build a factory in Ontario to create new jobs would be recovered from tax payers instead of from consumers through taxes on product prices.

Recovery of the system-wide stranded costs could be accomplished through a separate tax item in the collection of personal income and corporate taxes. The amount of tax paid by an individual or a corporation could depend on an individual's taxable income. For example each tax payer (individual or corporate) could pay a "stranded asset" tax that is proportional to the tax payer's share of total Ontario personal/corporate taxes. Doing it as a separate tax would mean that it would not have to come at the expense of the funding of other social programs. Further, since electricity consumers are already paying for this cost through the global adjustment, it should not have a material impact on their disposable incomes, although it would likely mean that individuals or companies with higher taxable incomes would pay a higher share of the costs than they did previously through an electricity rate.

## CONCLUSION

This report offers a practical approach for decomposing the global adjustment costs into three separate components (capacity costs, an OPG energy price hedge, and system-wide system costs), and argues that for efficiency and equity reasons, each component should be recovered as a separate charge using a different cost recovery method for each.

Decomposing the global adjustment into three separate charges at this point in the evolution of Ontario's electricity sector makes sense for at least two reasons. First, it is compatible and consistent with the objectives of current pricing policy initiatives, including the IESO's Market Renewal initiative and the OEB's RPP roadmap and utility enumeration initiatives. Second, it is timely given the changing technological landscape. Technological change is creating greater choice for consumers on how they use the integrated grid. As these solutions become more cost-competitive relative to grid-sourced electricity, there should be a gradual reduction in the use of and need for the traditional grid. This is a positive change on the whole that should take time to transpire, allowing for a gradual and rational transition. However, the current approach to recovering the global adjustment, which embeds fixed and sunk costs that are largely stranded from past policies, provides an extreme price incentive to reduce demand in peak demand hours. This is causing larger consumers to seriously consider distributed energy or behind-the-meter solutions and energy storage solutions.[39] While the extreme price incentive makes these solutions economic for the consumers that adopt them, the solutions are likely still more expensive than the actual avoided system cost of the consumer using grid-supplied electricity. This is not only inefficient, but as the Market Surveillance Panel has noted, it could hasten the transition to a more distributed energy system, causing the premature stranding of grid assets and eventually higher costs for Ontario electricity consumers on the whole. Decomposing the global adjustment and recovering only capacity-related costs during peak demand periods would reduce the potential for inefficient adoption of distributed energy solutions and future electricity costs for Ontario consumers.[40]

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## END NOTES

[1]The overall project is termed "Market Renewal," and consists of three separate but related initiatives. For a summary of the Market Renewal program, see http://www.ieso.ca/en/Sector-Participants/Market-Renewal/Overview-of-Market-Renewal .

[2]Information on these consultations can be accessed at https://www.oeb.ca/industry/policy-initiatives-and-consultations/utility-remuneration and at https://www.oeb.ca/industry/policy-initiatives-and-consultations/rpp-roadmap.

[3]The announcement of this initiative can be accessed at https://news.ontario.ca/mndmf/en/2019/03/ford-government-to-launch-consultations-on-industrial-electricity-prices.html.

[4]For a discussion of the trends in distributed energy resources, see Schwartz et al (2017). For an Ontario perspective, see Gregg (2019) and Energy Transformation Network of Ontario (2019).

[5]For example, see Office of the Ontario Auditor General (2015), Trebilcock (2017) and Ontario Energy Board (2018).

[6]The policy reforms were introduced through Bill 100, Electricity Restructuring Act, 2004. The new legislation provided the OEB the responsibility of approving the RPP and created a new agency, the Ontario Power Authority with a mandate to ensure an adequate supply of electricity through long-term planning and procurement contracting. For further background see Hansard Transcripts available at https://www.ola.org/en/legislative-business/bills/parliament-38/session-1/bill-100.

[7]See: O. Reg. 429/04, Adjustments under Section 24.33 under the Electricity Act, 1998 as it came into force on January 1, 2005.

[8]At the same time that the government decided to rate regulate OPG's heritage assets, it imposed a revenue limit of 4.7 cents/kWh on 85 per cent of the output from its remaining assets. The difference between the revenues earned at market prices and the revenue limit were carried on OPG's balance sheet and the government's General Accounts. By 2014, OPG had closed all its coal-fired facilities. Furthermore, the government asked the OEB to regulate OPG's peaking hydroelectric facilities with the differences between the market rates and the regulated rates shifted from the General Accounts to the global adjustment.

[9]See https://news.ontario.ca/archive/en/2005/02/23/Ontario-Government-Introduces-Fair-And-Stable-Prices-For-Electricity-From-Ontari.html, accessed on January 3, 2019. Ontario Regulation 429/04 provided that the global adjustment be named the "Provincial Benefit" on invoices.

[10]On January 1, 2015, the IESO merged with the OPA to create a new organization that combined their respective mandates. The merged entity retained the IESO name.

[11]These were the policy objectives of the Green Energy and Green Economy Act, 2009. For further background see Hansard Transcripts available at https://www.ola.org/en/legislative-business/bills/parliament-39/session-1/bill-150/debates.

[12]The global adjustment changes from month to month for two reasons. First, it increases or decreases as the number of aggregate contracts with the IESO increase or decrease and as the regulated rates paid to OPG increase or decrease. Second, the global adjustment varies with the market revenues earned by contracted and regulated generators. Changes in the market revenues earned is a function of the changes in the HOEP; the higher/lower the average monthly HOEP, the lower/higher the global adjustment.

[13]See http://www.ebr.gov.on.ca/ERS-WEB-External/displaynoticecontent.do?noticeId=MTEwNzI0&statusId=MTY2MTgw accessed on January 3, 2019.

[14]Ibid.

[15]See Ontario Energy Board (2018).

[16]See Borenstein (2016). As Borenstein points out, efficiency requires prices equal the marginal social cost of production which includes the cost of any externalities produced such as greenhouse gas emissions. Externalities arise whenever the actions of one economic agent make another economic agent worse or better off, yet the first agent neither bears the costs nor receives the

benefits of doing so. For example, producing electricity using natural gas creates a negative externality – it leads to the emission of greenhouse gases that negatively affect the health of people and the environment. Absent some form of explicit price placed on greenhouse gases, natural gas generators will fail to internalize the cost of the externalities when pricing their output. This means that the price of electricity will be too low, and too much electricity will be consumed from a broader social perspective. It also likely means that there will be over investment in carbon emitting generation relative to non-carbon emitting generation.

[17]The extent to which departures from marginal cost pricing can lead to economic efficiency depends on how responsive consumers are to price changes (i.e., their elasticity of demand). If demand is inelastic (not very responsive to price), all else held constant, departures from marginal cost pricing lead to smaller efficiency losses. Electricity demand is often characterised as being highly inelastic in the short-term, and at the time of consumption, demand is likely perfectly inelastic. Empirical studies have shown evidence of some degree of elasticity in Ontario consumers. For example, see Ontario Energy Board (2018) and Lessem et al (2017).

[18]Borenstein (2000), at page 52.

[19]This paragraph describes the theory of peak-load pricing. The literature on peak-load pricing is voluminous. The interested reader may consult Crew et al (1995), Church and Ware (2000), Borenstein (2000) or Harris (2015).

[20]See Ontario Energy Board (2018) at page 18.

[21]Borenstein (2016) makes this distinction at page 6.

[22]The economic literature offers only limited guidance on the issue of fairness or equity. Horizontal equity implies the like treatment of people who are alike. It corresponds to common notions of fair play and non-discrimination. For example, if two people have the same pre-tax income, they would have equal after-tax incomes. Vertical equity is concerned with how different people are treated differently. This notion of equity is a more contentious. Vertical equity is typically concerned with the “preferred” distribution of wealth in society. What represents the “preferred” distribution of wealth is a normative question that requires a value judgement. For example, it can be argued that those who earn higher pre-tax income should pay higher taxes. Given that vertical equity involves a value judgment, there is no ‘economic’ answer and most economist defer to government or regulatory agencies to determine the preferred distribution. The task of economists is to determine how to achieve the preferred distribution at least cost or with least loss of efficiency.

[23]See C Harris (2015) for a review of early rate designs.

[24]The market clearing price reflects the social marginal cost to the extent that the Federal government’s, Greenhouse Gas Pollution Pricing Act, S.C. 2018, c. 12, s. 186 properly accounts for the social cost of carbon. Under the Act, electricity generators have a direct compliance obligation when their emissions exceed a threshold amount, initially set at 50,000 tonnes, at which point a carbon price applies to the amount above emissions. The federal plan does not affect electricity imported into Ontario from US jurisdictions that continue to use fossil fuel generation, without similar comparable carbon pricing.

[25]The introduction of competition and competitive markets for generation services was expected to incentivize generation investment based only on the marginal energy price; there would be no need for a separate payment to recover the fixed costs of generation assets. However, as jurisdictions across North America gained experience with how “energy-only” markets operated in practice, many called into question the ability of these markets to provide generators with sufficient revenue to cover their fixed costs and to stimulate private invest in generation to the levels required to achieve traditional reliability standards. This has been termed the “missing money” problem – that prices do not rise high enough or often enough to attract required levels of generation capacity investment in an energy-only market. This led some jurisdictions to introduce “capacity markets” which offer generators an additional payment to make capacity available. For further explanation, see Charles River Associates (2017). Ontario choose to offer generators long-term contracts with price or revenue assurances to attract generation investment.

[26]See Ontario Energy Board (2018) at page 16. The Brattle Group (2018) estimates the cost of new entry for a single cycle generation facility at roughly $250,000 per MW per year. Breidenbough (2006) estimates the “value of loss load” for an average consumer at $2,000/MWh to $5,000/MWh US dollars or $3,325/MW to $8,320/MW in current Canadian dollars.

[27]The monthly global adjustment rate ($/MWh) is calculated by dividing the total monthly global adjustment cost not charged to Class A consumers, by the total monthly amount of energy consumed by all Class B consumers.

[28]This is true for RPP consumers that have a smart meter. The small number of RPP consumers that do not have a smart meter pay a set rate for electricity up to a certain level of consumption and a higher rate for all additional electricity consumed (i.e., a tiered price).

[29]The MSP also argues that the ICI methodology is complicated and non-transparent. Class A consumers do not know what the avoided global adjustment costs will be before they consume in a peak demand hour. They must predict in advance whether the hour will be one of the five coincident peak demand hours, their share of demand in the hour, and what the size of the GA will be in the following year. The MSP argues that not knowing the cost of consumption complicates the decision of when to consume; consumers risk reducing consumption during hours that turn out not to be one of the five coincident peak hours which results in losses to the consumers and an efficiency loss more generally.

[30]Independent Electricity System Operator (2019) at page 225. Resource adequacy refers to the ability of an electric system to provide sufficient supply to serve firm demand in aggregate. A resource adequacy standard is an expression of the acceptable frequency or duration of interruptions of power to firm demand caused by insufficiency of supply resources. The Northeast Power Coordinating Counsel's resource adequacy criteria requires that "Each Planning Coordinator or Resource Planner shall probabilistically evaluate Resource Adequacy of its Planning Coordinator Area portion of the bulk power system to demonstrate that the loss of load expectation (LOLE) of disconnecting firm load due to resource deficiencies is, on average, no more than 0.1 days per year.

[31]See Independent Electricity System Operator (2019) at page Ibid, at page 153.

[32]The OEB approved rates in 2017 were roughly $77.96/MWh for the nuclear assets and $41.67/MWh for the hydroelectric assets. See PAYMENT AMOUNTS ORDER EB-2016-0152, ONTARIO POWER GENERATION INC. Application for payment amounts for the period from January 1, 2017 to December 31, 2021.
[33]See Sidak and Spulber (1997) at page 28.

[34]See https://www.fin.gov.on.ca/en/tax/drc/index.html.

[35]All U.S. jurisdictions that operate capacity markets use a coincident peak demand charge. See Alberta Energy (2017) for a comparison of different capacity cost allocation methodologies. The IESO is proposing to recover the annual costs of the Incremental Capacity Auction using a coincident peak demand charge. See IESO (2019) at page 225.

[36]See Independent Electricity System Operator (2019) at page 226.

[37]If the OPG energy hedge amount was recovered volumetrically in 2017, it would have been a charge in all months, and roughly $10/MWh on average. That the hedge was a charge in 2017 might be expected given that the average annual HOEP in 2017 was relatively low at $15.80/MWh compared to the average annual HOEP for the prior 10 year period (2008 to 2017), which was $29.53/MWh.

[38]It has been nearly 15 years since the policy to regulate OPGs rates was introduced. Since this time, considerable change has occurred within the hybrid electricity market. There are now many private generators in the market and OPGs share of output is much smaller. The competitive energy price (HOEP) is generally lower, less volatile, and represents a much smaller component of a typical consumers electricity cost. Furthermore, the introduction of a capacity auction will offer new competitive revenue opportunities for OPG to cover its fixed operating costs that did not exist at the time of the initial policy. These changes may have affected the need to or benefit of regulating OPG's assets. Given the policy evolution, there is arguably merit to having a public consultation to review the current treatment of OPG's assets to asses the costs and benefits of the existing regulatory regime.

[39]For recent evidence of this activity see https://www.greentechmedia.com/articles/read/batteries-benefit-from-ontarios-bizarre-energy-market#gs.g79rmb.

[40]As a postscript, the changes to generation cost pricing proposed in this Policy Brief are likely to lead to a redistribution of wealth across different consumer groups and even within consumer groups. Furthermore, shifting the stranded fixed costs from electricity rates to taxes would require some time to work through the provincial budgeting process. It would be prudent to gradually phase in the changes to avoid possible large shifts in wealth and to allow all customers time to adapt their investment planning decisions and consumption habits. One approach to phasing in the changes could be to separate the capacity costs from the global adjustment in the first phase. The capacity costs could be recovered from all consumers, including exports, using a demand charge such as the current coincident peak charge, the OEB Staff's recommended demand-shaped pricing, or the Alberta weighted energy approach. The remainder of the global adjustment could then be recovered volumetrically. Realizing this phase should help reduce the risk of hastening the investment in distributed energy solutions. In the second phase, the system-wide stranded fixed costs could be gradually shifted from electricity rates to a stranded asset tax. This could be done over a period of two to three budgeting periods.

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# TAB E

This is Exhibit **"E"** referred to in the Revised Affidavit of Brian Rivard sworn before me this 21st day of November, 2019

*A Commissioner for Taking Affidavits*

**Lauren Theresa Daniel, a Commissioner, etc., Province of Ontario, while a Student-at-Law. Expires April 8, 2022.**

ONTARIO ENERGY BOARD

Market Surveillance Panel

# The Industrial Conservation Initiative:

## Evaluating its Impact and Potential Alternative Approaches

December 2018

Ontario

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## Table of Contents

## Role of the Market Surveillance Panel

The Market Surveillance Panel (Panel) is a panel of the Ontario Energy Board. Its role is to monitor, investigate and report on activities related to—and behaviour in—the wholesale electricity markets administered by the Independent Electricity System Operator (IESO).

The Panel monitors, evaluates and analyzes activities related to the IESO-administered markets and the conduct of market participants to identify:

- inappropriate or anomalous conduct in the markets, including gaming and the abuse of market power;
- activities of the IESO that may have an impact on market efficiencies or effective competition;
- actual or potential design or other flaws and inefficiencies in the Market Rules and procedures; and
- actual or potential design or other flaws in the overall structure of the IESO-administered markets and assess consistency of that structure with the efficient and fair operation of a competitive market.

Market-related activities and market conduct may also be the subject of a more formal and targeted investigation by the Panel. To that end, the Panel has authority under the Electricity Act, 1998 to compel testimony and the production of information.

The Panel reports on the results of its monitoring and investigations. The Panel does not have the legislative mandate to impose sanctions or other remedies in response to inappropriate conduct or market defects, but it does make recommendations for remedial action as it considers appropriate.

## Executive Summary

In 2011, the Government of Ontario introduced a policy known as the Industrial Conservation Initiative (ICI), which changed the way in which Global Adjustment costs are allocated to different classes of consumers.

The stated purpose of the ICI is to provide large consumers with an incentive to reduce consumption at critical peak demand times. The resulting reductions in peak demand were expected to reduce the need to invest in new peaking generation and imports of electricity from coal-reliant jurisdictions. The ICI was also intended to increase the efficiency of price signals, while also recognizing concerns that large volume consumers were paying more than their fair share of costs.

The costs recovered through the Global Adjustment include the costs of contracted and regulated generation, as well as the cost of some conservation programs. The Global Adjustment has grown from $700 million in 2006 (8% of total electricity supply costs) to $11.9 billion in 2017 (more than 80% of total electricity supply costs). As the Global Adjustment has grown, so too has the reduction in peak demand by consumers participating in the ICI. The Panel estimates that ICI participants reduced their consumption by 42% during peak demand conditions in 2016, compared to reductions of 33% and 26% in 2013 and 2011 respectively.

The ICI has the effect of shifting the electricity costs recovered through the Global Adjustment from larger volume consumers to households and small businesses. Because the Global Adjustment now accounts for the lion's share of electricity supply costs, baseload as well as peaking, how those costs are allocated between large and small consumers has a significant effect on the effective electricity prices that they pay. Since its introduction in 2011, the ICI has shifted nearly $5 billion in electricity costs from larger consumers to smaller ones. In 2017, the ICI shifted $1.2 billion in electricity costs to households and small businesses—nearly four times greater than the amount in 2011. In 2017, the ICI increased the cost of electricity for households and small businesses by 10%.

The Market Surveillance Panel (Panel), in the course of its monitoring of activities related to the IESO-administered market that may affect the efficient and fair operation of that market, regularly reports on effective electricity prices, including the Global Adjustment component of

those prices. The Panel has noted on more than one occasion that the ICI affects the effective price paid by different classes of consumers.

In the Panel's view, the ICI as presently structured is a complicated and non-transparent means of recovering costs, with limited efficiency benefits. The magnitude of the incentive to reduce peak demand during a year is inversely related to the Province's need for peak demand reduction the following year. Arguably, the ICI does not allocate costs fairly in the sense of assigning costs to those who cause them and/or benefit from them being incurred.

The Panel recognizes that striking an appropriate balance between potentially competing objectives and interests in cost allocation is a challenge and will remain so. The Panel has prepared this report to contribute in a positive way to any future discussions regarding that balancing exercise, and with a view to promoting consideration of market efficiency and fairness.

The Panel notes by way of postscript that, as it was finalizing this report, the Ontario government announced in its 2018 Ontario Economic Outlook and Fiscal Review that it was launching a public review of electricity pricing for industrial consumers as part of the government's open for business policy.

## 1. Introduction

The Global Adjustment is the mechanism by which certain electricity supply costs are recovered from electricity ratepayers. Since its introduction in 2005, the Global Adjustment has steadily increased as a percentage of total electricity supply costs, accounting for over 80% ($11.9 billion) in 2017. Given its magnitude, the allocation of Global Adjustment costs amongst consumers has a significant impact on the price consumers pay for electricity.

In January 2011, a new methodology for allocating Global Adjustment costs, called the Industrial Conservation Initiative (ICI), came into effect. Since its introduction, participation in the ICI has shifted nearly $5 billion in Global Adjustment costs from larger consumers to residential consumers and small businesses. In 2017, $1.2 billion in electricity costs were shifted, increasing the cost of electricity for residential consumers and small businesses by 10%.

The Panel recognizes that finding the right balance between competing objectives and interests when allocating costs is challenging. The Panel suggests that the following principal criteria are useful when evaluating methodologies—like the ICI—for allocating fixed costs: efficiency; fairness; simplicity/transparency; and cost recovery. In this report, the Panel assesses the performance of the ICI against those criteria.

## 2. Background: The Global Adjustment

Generating electricity requires significant investment in infrastructure. The bulk of these investments occur when building and maintaining electricity generators. In the electricity sector, the costs of building and maintaining a generator are referred to as "capacity" costs, which include a reasonable rate of return on those investments. As electricity is consumed on a day-to-day basis, capacity costs are considered "fixed" in that they do not increase or decrease with increasing or decreasing production. The fixed capacity costs associated with generating electricity ultimately need to be recovered from the consumers who benefit from this infrastructure.

In addition to fixed capacity costs, there are incremental (variable or "marginal") costs associated with generating electricity. Marginal costs are those associated with generating the electricity itself, such as the purchase of natural gas fuel, and increase or decrease with increasing or decreasing production. These costs also need to be recovered from consumers. In Ontario, there is a wholesale electricity market where generators sell electricity at the prevailing market price, which is intended to cover, at a minimum, the marginal costs of generating that electricity. In cases when the market price exceeds the marginal cost of generating the electricity, the excess revenues from the wholesale electricity market help the investor recover the fixed capacity costs associated with building and maintaining its generator.

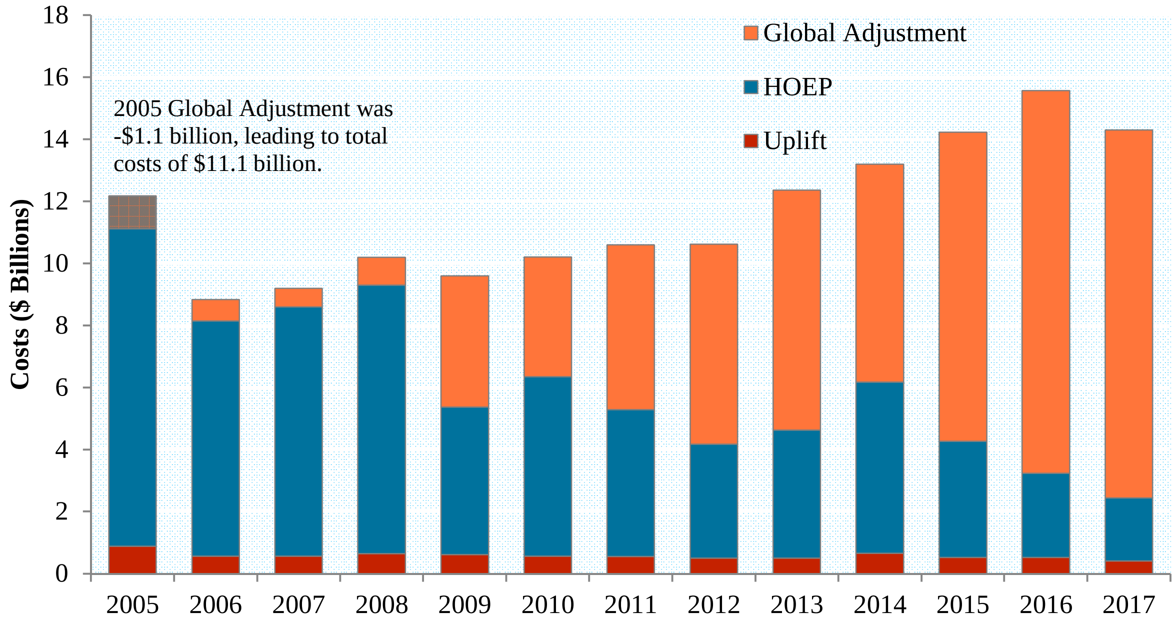
For a number of reasons, revenues from Ontario's wholesale electricity market have been insufficient to cover many generators' fixed capacity costs. In electricity sector parlance, this is referred to as the "missing money" problem. Without long-term financial viability, capacity needed to meet demand may be retired, or may not be built in the first place. Such were the circumstances in the mid-2000s when demand for electricity was growing and Ontario was facing increasingly tight supply conditions.

To address the "missing money" problem and incent investment in new generating capacity, Ontario offered long-term contracts to potential project proponents. While the terms of the contracts differed by generating technology and time of procurement, all contracts were intended to guarantee that investors would recover the fixed capacity costs associated with building and maintaining new generation capacity. This approach proved very successful and significant new generating capacity was built from 2006 onwards. In addition, some of the generation assets owned by Ontario Power Generation Inc. are subject to regulated rates that cover their fixed capacity costs. Generally speaking, when market revenues are insufficient to cover the contracted or regulated amount, supplementary payments need to be made, so a new mechanism was needed to recover these payments from electricity consumers. The Global Adjustment, a charge to Ontario electricity consumers, serves that purpose.

Since its introduction in 2005, the Global Adjustment has made up an increasing portion of the cost of electricity supply charged to consumers. There are many factors driving this trend, including an increasing number of dollars committed to an increasing number of contracted generators. Also a factor is a steady decrease in wholesale electricity market prices, which decreases revenues from the market and necessitates the recovery of a greater portion of fixed capacity costs through the Global Adjustment.

Figure 1 displays how the recovery of electricity supply costs has increasingly shifted from wholesale electricity market charges (the Hourly Ontario Energy Price or "HOEP" and uplift),[1] to the Global Adjustment, which grew from $700 million in 2006 to $11.9 billion in 2017.

***Figure 1: Annual Electricity Supply Costs***
***2005 – 2017***
***($ Billions)***




## 3. Background: The Industrial Conservation Initiative

Prior to 2011, the Global Adjustment was allocated to all Ontario consumers on a volumetric basis: the costs associated with the Global Adjustment were summed and allocated equally over all megawatt-hours consumed in the Province each month.[2] For example, if the total Global Adjustment was $500 million for a given month, and Ontario consumption was 10 million megawatt-hours, there would be a $50/MWh Global Adjustment charge for all consumers.

In 2011, the Government of Ontario introduced the ICI, a new way of allocating Global Adjustment costs. The change in the allocation of the Global Adjustment was intended to provide large consumers with an incentive to reduce consumption at critical peak demand times. The resulting reductions in peak demand were expected to reduce the need to invest in new

[1] Uplift is charged by the IESO to wholesale market participants in order to recover the costs associated with various wholesale electricity market services and programs, such as the Generation Cost Guarantee program.
[2] Exporters do not pay the Global Adjustment.

peaking generation and imports of electricity from coal-reliant jurisdictions. The ICI was also intended to increase the efficiency of price signals, while also recognizing concerns that large volume consumers were paying more than their fair share of costs.[3]

## The Industrial Conservation Initiative: How it Works

The ICI is the mechanism for allocating Global Adjustment costs amongst Ontario consumers. Under the ICI, a consumer's allocation of Global Adjustment costs depends on their consumer class and consumption profile.

### *New Consumer Classes*

The introduction of the ICI divided Ontario consumers into two classes: "Class A" and "Class B". Initially, ***Class A*** was limited to very large consumers with an average monthly peak demand of more than 5 MW (primarily large industrial consumers). Since then, the government has expanded eligibility such that Class A now includes all consumers with an average monthly peak demand of more than 1 MW, as well as consumers in certain manufacturing, industrial and agricultural sectors with an average monthly peak demand of more than 0.5 MW. As a result, the number of Class A consumers has increased from less than 200 in 2011 to over 1,600 in 2018. ***Class B*** comprises all other consumers, including residential consumers and small businesses.

### *Allocating Global Adjustment Costs*

Under the ICI, Class A and Class B consumers are allocated Global Adjustment costs differently. ***Class A*** consumers are charged the Global Adjustment based on their share of consumption during the five peak demand hours in a year.[4] For example, if a Class A consumer was responsible for 1% of Ontario demand during the five peak demand hours in a 12-month period, they would pay 1% of the Global Adjustment in the ensuing 12-month period.[5] By reducing their consumption during peak demand hours, Class A consumers are able to reduce the amount of the

[3] The proposal to amend O. Reg. 429/04 is available at: http://www.ebr.gov.on.ca/ERS-WEB-External/displaynoticecontent.do?noticeId=MTEwNzI0&statusId=MTY2MTgw&language=en

[4] Referred to as "coincident peak" demand hours, these five peak demand hours must occur on different days. For example, in 2016 three of the five highest demand hours occurred on August 8th, but only the peak hour during that day (hour ending 18 at 23,100 MW of demand) was treated as one of the five peak demand hours for the purposes of allocating the Global Adjustment under the ICI.

[5] The year-long period during which a consumer's demand during peak demand hours is recorded is the "base period", taking place from May 1 to the following April 30. A consumer's peak demand factor (i.e. percentage of total peak demand) during this base period determines their share of the Global Adjustment for a 12-month "adjustment period" beginning July 1 following the end of the base period.

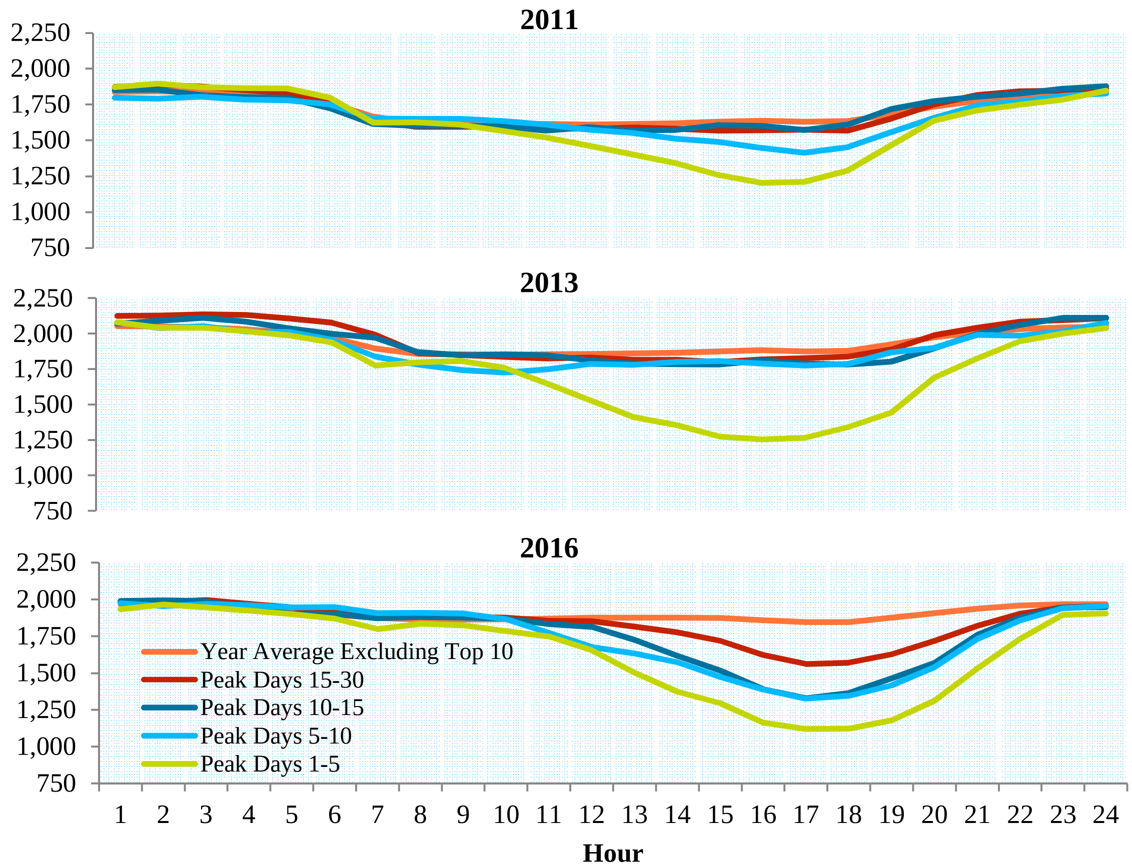
Global Adjustment they pay. Those avoided costs are shifted to ***Class B*** consumers, who pay the remaining Global Adjustment costs on a volumetric basis.

### *3.1 Impact on Class A Consumption during Peak Demand Hours*

The ICI provides Class A consumers with a strong incentive to reduce consumption during peak demand hours. The Panel estimates that by reducing consumption by one megawatt during each of the five peak demand hours in 2016, a Class A consumer would have saved approximately $520,000 in Global Adjustment charges. This incentive has proved effective in reducing Class A consumption during peak demand hours. Figure 2 compares the aggregated consumption profile of all directly-connected Class A consumers[6] on days when peak demand hours occurred in 2011, 2013, and 2016. Reductions in consumption can be measured by comparing consumption during days with a peak demand hour ("Peak Days 1-5" line) to consumption during days without a peak demand hour ("Year Average Excluding Top 10" line).

[6] Directly-connected Class A consumers are those that are connected to the transmission grid. This does not include Class A consumers that are connected at the distribution level. Except where otherwise noted, references to Class A consumers in this report refer to all Class A consumers.

***Figure 2: Directly-Connected Class A Response During Peak Demand Days 2011, 2013 and 2016 (MW)***




Over the years, consumption reductions have grown as the magnitude of the Global Adjustment, and thus the ICI incentive, have grown. In 2016, on the five days when a peak demand hour occurred, the ICI produced a maximum hourly reduction in directly-connected Class A consumption of 42%, and more moderate reductions during other hours of those days. This compares to a 33% reduction in 2013, and a 26% reduction in 2011.

The Panel cannot precisely determine the total magnitude of peak demand reductions resulting from the ICI as it does not have access to hourly consumption data for Class A consumers that are connected at the distribution level, and not directly connected to the transmission grid.[7] In 2016, 40% of Class A consumers were connected at the distribution level, increasing to 49% in 2017. Based on the assumption that these distribution-connected Class A consumers had the

[7] For more information on data limitations, see the Panel's April 2015 Monitoring Report, pages 105-109, available at: http://www.ontarioenergyboard.ca/oeb/_Documents/MSP/MSP_Report_Nov2013-Apr2014_20150420.pdf

same consumption profile as directly-connected Class A consumers, the Panel estimates that the ICI produced an average peak reduction of 1,200 MW on the five days with peak demand hours in 2016.

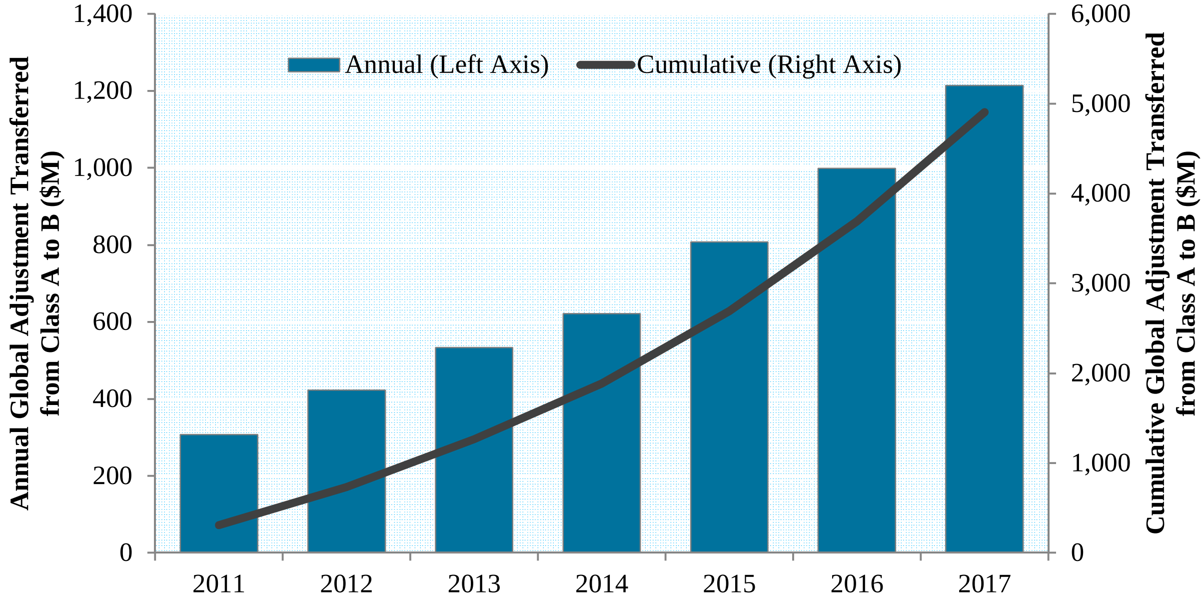
Due to the uncertainty around the days when the year's top five peak demand hours will occur, and given the costly implications of consuming during those hours, Class A consumers reduce consumption in more than just the top five days. This behaviour was prevalent in 2016 (see Figure 2), when there was less certainty around which hours would ultimately make up the five peak demand hours. As a result, directly-connected Class A consumers reduced consumption during a greater number of days (days 6 through 30) compared to years past.[8]

### *3.2 Impact of the Allocation of the Global Adjustment*

As Class A consumers reduce their consumption during peak demand hours and, by extension, the Global Adjustment they pay, the Global Adjustment payable by Class B consumers increases. The resultant shifting of Global Adjustment costs from Class A to Class B consumers has had a significant impact on the effective electricity price paid by both consumer classes. Figure 3 displays the annual Global Adjustment costs shifted from Class A to Class B as a result of participation in the ICI.

[8] In some years, the days containing peak demand hours have been consecutive and easier to predict, resulting in less peak-reducing behaviour outside of those days. In recent years, Ontario has been a summer-peaking jurisdiction, with the peaks typically set during the hottest weekdays in the summer, when air conditioning usage is at its highest. For example, in both 2011 and 2013 the five peak demand hours occurred on consecutive days in the midst of an intense heat wave. Both of these episodes were in mid-July, thus there was little reduction in consumption during the lesser demand days that followed. In the summer of 2016, the 10 highest demand hours occurred over four different weeks from July to September, and this uncertainty induced consumption reductions during hours outside of the days containing the five highest peak demand hours (seen in Figure 2). The expansion of Class A adds further uncertainty around predicting peak demand hours. As more consumers are added to the class, ICI-related demand reductions increase, potentially shifting when the peak demand hours occur. In other words, Class A consumers need to predict the response of other Class A consumers to correctly identify the five peak demand hours.

***Figure 3: Global Adjustment Costs Shifted from Class A to Class B Consumers 2011 – 2017 ($ Millions)***

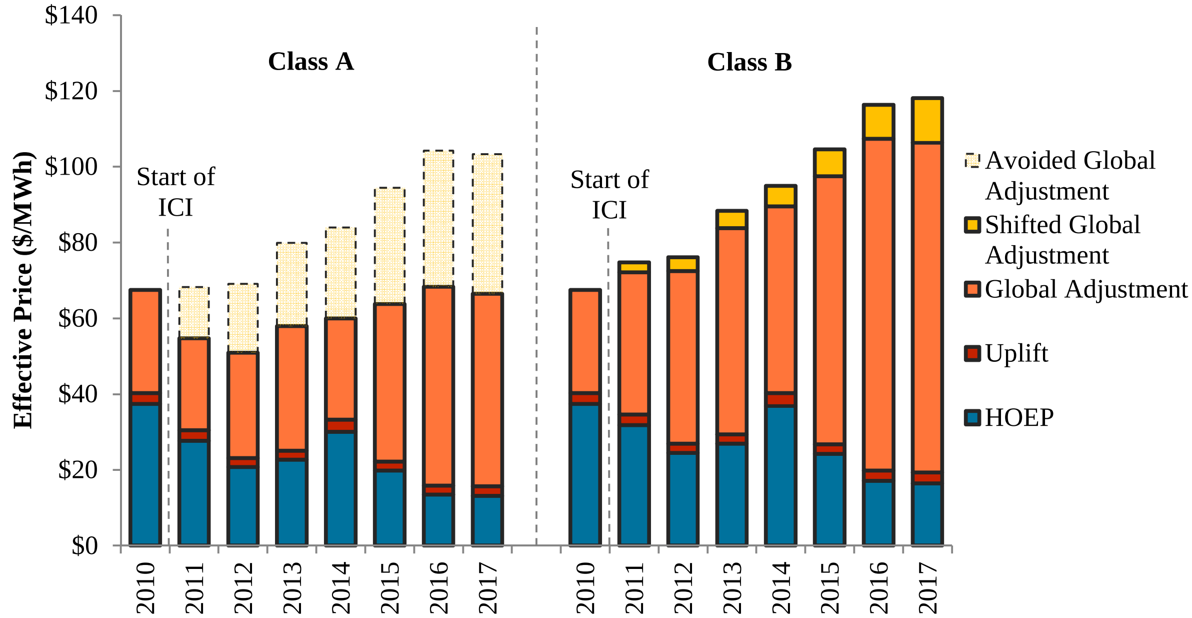



The amount of Global Adjustment costs shifted from Class A to Class B consumers has increased every year since the introduction of the ICI. In 2011, approximately $300 million in Global Adjustment costs were shifted from Class A to Class B consumers as a result of participation in the ICI, representing approximately 3.5% of the total electricity supply costs for Class B consumers that year. In 2017, the costs shifted had increased to $1.2 billion, representing approximately 10% of the total electricity supply costs for Class B consumers. Since 2011, participation in the ICI has shifted a total of $4.91 billion in Global Adjustment costs from Class A to Class B consumers.[9]

Figure 4 displays the average effective electricity price paid by Class A and Class B consumers since 2010, the year prior to the introduction of the ICI. The effective price is broken down by cost component and shows the Global Adjustment costs avoided by Class A consumers and shifted to Class B consumers as a result of Class A participation in the ICI.

[9] As measured from January 2011 to December 2017. Not adjusted for inflation.

***Figure 4: Average Effective Electricity Price by Consumer Class***
***2010 - 2017***
***($/MWh)***




In 2010, the average effective electricity price for both Class A and Class B consumers was $67/MWh. Since then, the average effective price for Class A consumers has decreased to $66/MWh (1.5% decrease), while the average effective price for Class B consumers has increased to $118/MWh (76% increase). In 2017, through participation in the ICI, Class A consumers were able to reduce the average price they pay by $37/MWh. The resultant shift in Global Adjustment costs added approximately $12/MWh to the average price paid by Class B consumers in that same year, representing 24% of the total increase since 2010.[10]

In light of the expansion of the ICI and the increased number of consumers that are eligible for Class A, it is reasonable to expect that the Global Adjustment costs shifted from Class A to Class B consumers will continue to increase.

## 4. Criteria for Effective Cost Allocation

The Panel recognizes that finding an appropriate balance between competing objectives and interests when allocating costs is challenging. When evaluating the ICI and other methodologies

[10] The per megawatt-hour effective price increase for Class B consumers is smaller than the corresponding decrease for Class A because Class B consumes far more electricity, spreading the cost over more megawatt-hours.

for allocating fixed costs, the Panel suggests that the following should be the principal criteria: efficiency; fairness; simplicity/transparency; and cost recovery.[11] Prices should incent efficient production and consumption decisions in the short-term and efficient investment decisions in the long-term. Prices should be "fair", in the sense of allocating costs to those who cause them and/or benefit from them being incurred. Prices should be simple and transparent, so that consumers can make informed decisions. Finally, prices should be set to wholly recover costs, and should be sustainable in the long-term.

In the following section, the Panel assesses the ICI against these criteria.

## 5. Assessment of the Industrial Conservation Initiative

### *5.1 Efficiency*

*Prices should incent efficient production and consumption decisions in the short-run and efficient investment decisions in the long-run.*

Efficiency is concerned with the optimal use of scarce resources in both the short-term and the long-term. In the short-term, this means the least-costly producers of electricity are supplying it to the consumers who value it the most. In the long-term, this means making investments that minimize the average cost of electricity over that period.

#### *Short-Term Efficiency*

In a competitive wholesale electricity market, suppliers will offer to sell electricity based on their marginal cost of production, while consumers will bid to buy electricity based on the marginal value they derive from consuming electricity. These offers and bids are aggregated into supply and demand curves respectively, and the market price is set at the intersection of these curves. The result will be a market price equal to the system-wide marginal cost of production. This market price will serve to coordinate the production and consumption of electricity: suppliers of electricity with production costs below the market price will be induced to produce electricity, while consumers who value electricity above the market price will be induced to consume that electricity. This is an efficient outcome.

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[11] These principles were articulated in the paper *The Price Isn't Right: Need for Reform in Consumer Electricity Pricing* (2010), available at: https://www.cdhowe.org/sites/default/files/attachments/research_papers/mixed//backgrounder_124.pdf . For a recent summary of economic principles and an overview of fixed cost recovery pricing designs see Severin Borenstein's *The Economics of Fixed Cost Recovery by Utilities* (2016), available at: https://ei.haas.berkeley.edu/research/papers/WP272.pdf .

Charging consumers more than the market price of electricity may cause them to forgo consumption, notwithstanding that the value they derive from that electricity exceeds the actual cost of production. This is not an efficient outcome. The volumetric allocation of the Global Adjustment that predated the ICI exhibited deficiencies in this regard. Under that allocation, consumers participating in the wholesale electricity market were charged the market price plus a Global Adjustment charge for every megawatt they consumed. For example, in 2010 the average market price (HOEP) was $37/MWh, while the average volumetric Global Adjustment charge was $27/MWh. Consequently, assuming that market prices reflected the marginal cost of production, consumers were charged $64/MWh (plus uplift) for electricity that cost $37/MWh to produce. Any consumer that valued electricity at more than $37/MWh, but less than $64/MWh, would have been dissuaded from consuming electricity, despite that consumption being efficient.

For a subset of consumers and hours, the ICI represents an efficiency improvement over the volumetric allocation of the Global Adjustment. Class A consumers no longer pay the Global Adjustment based on their consumption in all hours. Instead, their share of the Global Adjustment is now wholly determined by their consumption during the five peak demand hours of the year; their consumption during all other hours has no impact on the Global Adjustment they pay. Consequently, the incremental cost of consumption during all non-peak demand hours is equal to the market price (plus uplift), which serves to maximize short-term efficiency during those hours.

While the ICI resulted in short-term efficiency gains for Class A consumers during non-peak demand hours, it resulted in short-term efficiency losses for Class A consumers during peak demand hours and potential peak demand hours. Whereas a Class A consumer’s allocation of the Global Adjustment was formerly determined by their consumption in all hours, it is now determined based on their consumption in just five hours per year, greatly increasing the cost of consumption during those hours. In 2016, the cost of consuming during a single peak demand hour was approximately $104,000/MWh, more than 6,000 times the average market price of $16/MWh in the same period. In the face of this much higher cost, Class A consumers have foregone from what would otherwise be efficient short-term consumption (see Figure 2).

While shifting costs amongst consumers may not always be viewed as fair, it can be efficient. Consumers value electricity differently; those that place the highest value are willing to bear higher costs before reducing their consumption. To the degree that costs can be shifted from more price-sensitive consumers to less price-sensitive ones, efficiency can be improved. Under the ICI, Class B consumers continue to pay the Global Adjustment on a volumetric basis. As Global Adjustment costs are shifted to Class B consumers, their cost of consumption increases well above the market price. In the face of this higher cost, Class B consumers may also forgo efficient short-term consumption.

When assessing the ICI's overall impact on short-term efficiency, the Panel estimates that the efficiency loss associated with foregone economic consumption by Class A consumers during peak and potential peak demand hours offsets the efficiency gains associated with improving efficiency during non-peak demand hours.[12] An ambiguous or even negative impact on short-term efficiency may ultimately be an acceptable trade-off if it results in increased efficiency in the long term; this is discussed below.

In order to maximize short-term efficiency, the cost of consumption should reflect the short-term marginal cost of production. This should apply to as many consumers and during as many hours as possible.

### *Long-Term Efficiency*

Achieving long-term efficiency means making investments that minimize the average cost of electricity. Doing so means procuring sufficient capacity to meet future demand and reliability needs, but no more, and doing so at the least cost.

Future demand will be affected by expected decreases in peak consumption associated with the ICI. In this respect, the ICI—and the expected peak demand reduction—serve as an alternative to constructing new generating capacity. This can improve long-term efficiency: unlike building a new generator, in theory the ICI does not increase total electricity supply costs, it merely shifts existing costs amongst consumers.

The Panel has not assessed past central-planning activities to determine whether expected demand reductions associated with the ICI alleviated the need to procure additional grid-

[12] See pages 84-91 of the Panel's June 2013 semi-annual Monitoring Report, available at: https://www.oeb.ca/oeb/_Documents/MSP/MSP_Report_May2012-Oct2012_20130621.pdf

connected generating capacity. Assuming that the ICI alleviated the need to procure additional grid-connected generating capacity, it has not necessarily increased long-term efficiency.

The ICI creates an incentive for Class A consumers to invest in new generating or storage capacity located at their facilities. On-site generation offsets consumption from the transmission or distribution grids, allowing Class A consumers to continue their operations during peak demand hours while simultaneously benefiting from the reduction in Global Adjustment charges. Investing in on-site generation has become increasingly economic as the Global Adjustment has increased: building an on-site generator has an annualized cost of approximately $105,000/MW to $135,000/MW, while operating that generator during all five peak demand hours in 2016 would have saved a Class A consumer approximately $520,000/MW in Global Adjustment costs.[13]

Information on exactly how much on-site generation or storage has been built in response to the ICI is not readily available. Nevertheless, there is some evidence that suggests such investments are being made. In 2017 and 2018, three Class A consumers made a combined 33 applications to the Ministry of Environment and Climate Change (as it then was) to build a total of 44 MW of natural gas-fired capacity.[14] One of the express purposes for which this new on-site capacity is being built is "peak shaving", which in turn suggests the purpose is, at least in part, to reduce Global Adjustment costs through participation in the ICI.[15]

The ICI has the potential to change – and appears to be changing – the nature of a portion of generation investments in the province: from large-scale, centrally-procured, grid-connected investments to small-scale, privately-funded, on-site investments. This has the benefit of shifting risk from ratepayers (who pay the costs associated with the IESO's supply contracts) to private investors and increasing the reliability of service for those investing in on-site generation. However, there are potential inefficiencies associated with the decentralization of supply planning.

[13] Estimates of the cost of building on-site generation are based on the construction of a 5 MW gas-fired generator, amortized over 20 years. These estimates are informed by a 2016 study from the U.S. Energy Information Administration and a 2015 study from the U.S. Environmental Protection Agency.
[14] Pending and approved Environmental Compliance Approvals in the province of Ontario are publicly available at: https://www.ebr.gov.on.ca/ERS-WEB-External/
[15] An August 2018 article notes that, "Ontario's Global Adjustment is creating a behind-the-meter energy storage boom," citing the construction of a 10 MW storage system as a recent example. Peter Mahoney, Utility Dive, *Behind-The-Meter Storage is Booming in Ontario,* available at: https://www.utilitydive.com/news/btm-storage-is-booming-in-ontario/530518/

The decision to centrally procure additional grid-connected capacity should be based on whether that capacity is needed to meet system-wide demand. Conversely, a private enterprise's decision on whether to build an on-site generator is based on their private incentives, not on the supply needs of the system as a whole.

Ontario currently finds itself in surplus supply conditions, yet the incentive to reduce consumption under the ICI has never been stronger. Perversely, the incentive for Class A consumers to reduce peak demand—by investing in on-site generation capacity or otherwise—is strongest when there is ample supply and wholesale market electricity prices are low. As shown in Figure 1, lower market prices result in a higher portion of costs being recovered through the Global Adjustment, providing a stronger incentive for Class A consumers to reduce their consumption during peak demand hours. These conditions may encourage private investment in generating capacity that is not needed to meet system-wide demand. The converse is also true; when supply is tight and market prices are high, the Global Adjustment is smaller and the incentive to reduce peak consumption is lower.

Additionally, investment in small on-site generation capacity may be less efficient than investment in large grid-connected capacity. To the degree capacity was or will be needed, Ontario has a multitude of options available to it, including investments in different generating technologies, demand response, conservation, etc. The IESO also has (or is developing) competitive mechanisms to procure these resources, which uniquely situates it to be able to select the least costly sources of capacity. IESO procurement also benefits from economies of scale, as its investments in large grid-connected capacity may be less costly than many private investments in small on-site capacity on a per megawatt of capacity basis.

Improving long-term efficiency requires a better understanding of how the current allocation of the Global Adjustment is affecting investment in new capacity. To that end, information related to the construction of on-site generation and storage should be gathered. That information can inform decisions about the extent to which the ICI is inducing private investment in unnecessary capacity. If investment is needed, the ICI should not provide a private incentive to build on-site capacity that significantly exceeds the cost of centrally procuring grid-connected capacity, as is the case with the ICI incentive today.

## *5.2 Fairness*

*Prices should be fair, in the sense of assigning costs to those who cause them and/or benefit from them being incurred.*

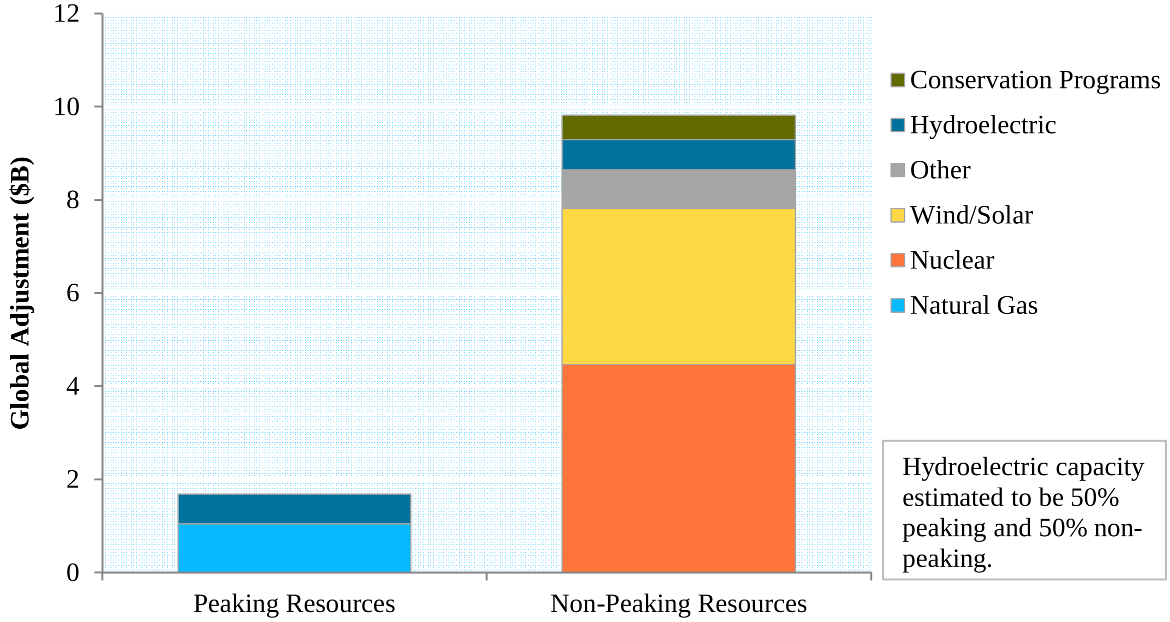
The costs recovered through the Global Adjustment are not limited to the cost of needed generation, nor was all capacity procured on a least-cost basis. Global Adjustment costs include costs related in part to the achievement of environmental and other social policy goals. For instance, the *Green Energy and Green Economy Act, 2009* (Act) offered prospective proponents the opportunity to build new wind and solar generators based on long-term contracts. However, the Act had objectives beyond simply securing needed generating capacity at least cost, including environmental and health objectives related to greenhouse gas reductions and economic objectives related to developing new green industries in the province. In the service of these broader policy goals, the Act procured clean, but more costly, generating capacity in the form of wind and solar resources, in lieu of less clean, but less costly, capacity. Paying a premium to procure clean capacity and recovering those costs through the Global Adjustment means the associated charge covers more than the cost of procuring needed generation at least cost. Incremental costs incurred in support of such broader policy goals are to the benefit of all Ontarians—not just electricity consumers subject to paying the Global Adjustment.

Assuming that costs unrelated to the fixed capacity costs of needed generation are removed from the Global Adjustment, allocating the remaining costs in a fair manner becomes a question of who induces the fixed capacity costs and who benefits from having that capacity available.

One of the considerations in transitioning to the ICI was a concern that large electricity consumers were paying more than their fair share of fixed capacity costs under the volumetric allocation of the Global Adjustment. As the argument goes, large industrial consumers, who typically consume a similar quantity of electricity irrespective of the time of day or weather, do not typically contribute to peaks in demand. Therefore, they should not have to pay the fixed capacity costs of generators that primarily operate during periods of peak demand.

While that fairness argument has some merit, the ICI goes further than necessary. The fixed capacity costs recovered through the Global Adjustment are not limited to those associated with peaking capacity; in fact, the Global Adjustment is mainly composed of the fixed capacity costs of non-peaking generators, as seen in Figure 5.

***Figure 5: Components of the Global Adjustment May 2016 – April 2017 ($ Billions)***




The Panel estimates that payments to peaking resources make up less than 20% of the costs recovered through the Global Adjustment.[16] The remaining 80% of fixed capacity costs are for non-peaking resources, which Class A consumers use and benefit from during most hours of the year. Despite benefitting from non-peaking resources, the ICI provides Class A consumers with the opportunity to avoid all Global Adjustment costs, which some manage to do. During the five peak demand hours in 2017, five directly-connected Class A consumers consumed no electricity, meaning they pay no Global Adjustment during the following 12-month period. Of the other directly-connected Class A consumers, more than half paid less than 50% of the Global Adjustment they would have paid under a volumetric allocation. This suggests that they too avoided paying for some of the fixed capacity costs of non-peaking generation from which they benefit.  Fairness would therefore be enhanced if the cost of peaking generation were to be

[16] Another way to delineate between the fixed capacity costs associated with peaking generation versus non-peaking generation is to consider the utilisation of these resources during peak demand hours. For instance, if a wind resource could reliably generate 25% of its maximum capacity during peak demand hours, 25% of its fixed capacity costs would be considered peaking, while 75% would be considered non-peaking.

allocated based on consumption during peak demand hours, with the cost of non-peaking generation being allocated such that all consumers that benefit from that capacity pay for that capacity.

### *5.3 Simplicity and Transparency*

*Prices should be simple and transparent, so that consumers can make informed consumption decisions.*

For Class A consumers, determining the cost of consuming electricity during peak and potential peak demand hours is neither simple nor transparent. In order to know the cost of consuming, a Class A consumer must correctly predict whether the hour in question will be a peak demand hour, what percentage of Ontario demand their consumption will represent and the size of the Global Adjustment in the following year, among other things. Figure 1 shows that the Global Adjustment has grown ten-fold in the last decade and has varied by billions of dollars from one year to the next.

Consider the uncertainty around whether or not a given hour will be a peak demand hour, and how the cost of consumption changes under either scenario. The cost of consuming during a non-peak demand hour is equal to the market price for electricity plus uplift, which together averaged approximately $16/MWh in 2016. During a peak demand hour—when a Class A consumer's share of Global Adjustment costs is determined—the cost of consumption is vastly greater. In 2016, the cost of consuming during a single peak demand hour was approximately $104,000/MWh, over 6,000 times the cost of consumption in an average non-peak demand hour.

Not knowing whether the cost of consumption is $16/MWh or $104,000/MWh complicates consumption decisions. The risk of the much higher cost can drive Class A consumers to reduce their consumption during what turn out to be non-peak demand hours (see Figure 2), foregoing efficient consumption. Knowing the cost of consumption in advance of having to make their consumption decision—or being able to predict the cost more easily—can prevent this undesirable outcome.

### *5.4 Cost Recovery*

*Prices should be set to wholly recover costs, and should do so sustainably.*

The ICI results in the full recovery of Global Adjustment costs. However, as the cost of electricity increases—for Class B consumers, in part as a result of the ICI—consumers are incented to reduce their consumption or withdraw from the grid entirely.[17] As they do so, the average Global Adjustment to be recovered from all remaining consumers increases further, incenting additional consumers to reduce consumption or withdraw, perpetuating the cycle.

Class B consumption has decreased every year since the ICI was introduced, with 2017 consumption down 15.3 TWh (12.9%) relative to 2011. Part of this decline can be attributed to a number of larger Class B consumers converting to Class A consumers as the threshold for participating in the ICI was lowered. Illustrating this, Class A consumption has increased every year, with 2017 consumption up 10.2 TWh (44.7%) relative to 2011. The remaining decline in Class B consumption is in part due to the rising cost of electricity over the years. The decline in Class B consumption increases the price of electricity for remaining Class B consumers. While this dynamic is currently only a minor contributor to increasing Class B electricity costs, its effects could grow as Class B consumption declines.

## 6. Conclusion and Enhancing Alignment with Cost Allocation Principles

In the Panel's view, the ICI as presently structured is a complicated and non-transparent means of recovering costs, with limited efficiency benefits. Arguably, the ICI does not allocate costs fairly in the sense of assigning costs to those who cause them and/or benefit from them being incurred. In addition, the ICI perversely creates the greatest incentive for peak conservation in years when the supply is ample and marginal cost is lowest and the least incentive in years when supply is tight and marginal cost is high.

The Panel recognizes that trade-offs may be necessary or desirable in relation to the cost allocation criteria discussed in this report; sacrificing fairness in service of long-term efficiency, for example. Nevertheless, the Panel believes that both market efficiency and fairness of the ICI

[17] Withdrawing from the grid entails consuming no electricity from the transmission or distribution grid. For some, particularly large industrial or manufacturing loads, this means relocating business; for others, this means installing on-site generation, such as solar panels. Withdrawing from the grid is becoming increasingly economic as the cost of small-scale generating technology decreases and the price of consuming electricity from the grid increases.

(or an alternative methodology intended to serve much the same purpose) can be enhanced by ensuring that:

- Costs that are not related to the fixed capacity costs of needed generation are removed from the Global Adjustment and recovered by other means.
- Only the cost of peaking generation is recovered based on consumption during peak demand hours; the cost of non-peaking generation should be allocated such that all consumers that benefit from that capacity pay for that capacity.
- Information is gathered in relation to the construction of on-site generation and storage; this can inform decisions about the extent to which the ICI is incenting private investment in unnecessary capacity.
- The ICI does not provide a private incentive to build on-site capacity that significantly exceeds the cost of centrally procuring grid-connected capacity, as is the case with the ICI incentive today.
- The cost of consumption reflects the short-term marginal cost of production; this should apply to as many consumers and during as many hours as possible.

# TAB F

This is Exhibit **"F"** referred to in the Revised Affidavit of Brian Rivard sworn before me this 21st day of November, 2019

*A Commissioner for Taking Affidavits*

Lauren Theresa Daniel, a Commissioner, etc., Province of Ontario, while a Student-at-Law. Expires April 8, 2022.

130 FERC ¶ 61,213
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

18 CFR Part 35

Demand Response Compensation in Organized Wholesale Energy Markets — Docket No. RM10-17-000

PJM Interconnection, L.L.C. — Docket No. EL09-68-000

(March 18, 2010)

AGENCY: Federal Energy Regulatory Commission

ACTION: Notice of Proposed Rulemaking.

SUMMARY: The Federal Energy Regulatory Commission is issuing a Notice of Proposed Rulemaking (NOPR) proposing an approach for compensating demand response resources in order to improve the competitiveness of organized wholesale energy markets and thus ensure just and reasonable wholesale rates. The Commission invites all interested persons to submit comments in response to the regulatory text proposed herein.

DATES: Comments are due 45 days after publication in the Federal Register.

ADDRESSES: You may submit comments, identified by docket number by any of the following methods:

- Agency Web Site: http://ferc.gov. Documents created electronically using word processing software should be filed in native applications or print-to-PDF format and not in a scanned format.

- Mail/Hand Delivery: Commenters unable to file comments electronically must mail or hand deliver an original and 14 copies of their comments to: Federal Energy Regulatory Commission, Secretary of the Commission, 888 First Street, N.E., Washington, DC 20426.

Instructions: For detailed instructions on submitting comments and additional information on the rulemaking process, see the Comment Procedures Section of this document.

FOR FURTHER INFORMATION CONTACT:

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SUPPLEMENTARY INFORMATION:

130 FERC ¶ 61,213
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

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| Demand Response Compensation in Organized Wholesale Energy Markets | Docket No. RM10-17-000 |
| PJM Interconnection, L.L.C. | Docket No. EL09-68-000 |

# NOTICE OF PROPOSED RULEMAKING

(March 18, 2010)

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130 FERC ¶ 61,213
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Demand Response Compensation in Organized Wholesale Energy Markets — Docket No. RM10-17-000

PJM Interconnection, L.L.C. — Docket No. EL09-68-000

NOTICE OF PROPOSED RULEMAKING

(March 18, 2010)

1. The Federal Energy Regulatory Commission (Commission) is proposing to revise its regulations to establish the approach described below as compensation for demand response[1] resources[2] participating in organized energy markets. We propose that Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs)[3] with tariff provisions permitting demand response providers to participate as resources in energy markets by reducing consumption of electricity from their expected

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[1] Demand response means a reduction in the consumption of electric energy by customers from their expected consumption in response to an increase in the price of electric energy or to incentive payments designed to induce lower consumption of electric energy. 18 CFR § 35.28 (b)(4).

[2] Demand response resource means a resource capable of providing demand response. 18 CFR § 35.28 (b)(5).

[3] The following RTOs and ISOs have organized wholesale electricity markets: PJM Interconnection, L.L.C. (PJM); New York Independent System Operator, Inc. (NYISO); Midwest Independent Transmission System Operator, Inc. (Midwest ISO); ISO New England, Inc. (ISO-NE); California Independent System Operator Corp. (CAISO); and Southwest Power Pool, Inc. (SPP).

levels in response to price signals be required to pay to demand response providers, in all hours, the market price for energy for such reductions.[4]

## I. Background

### A. Role of Demand Response in Organized Wholesale Energy Markets

2. The Commission has acted over the last several decades to implement Congressional policy to expand the wholesale energy markets to facilitate entry of new resources and support competitive markets. Most recently, the Commission in Order No. 719 implemented a series of reforms aimed at improving the competitiveness of the organized energy markets, finding that effective wholesale competition protects consumers by, among other things, providing more supply options, encouraging new entry and innovation, and spurring deployment of new technologies.[5] Improving the

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[4] This provision applies only to demand response acting as a resource in organized wholesale energy markets. The provision will not apply to demand response under programs that ISOs and RTOs administer for reliability or emergency conditions, such as, for instance, Midwest ISO's Emergency Demand Response; NYISO's Emergency Demand Response Program; PJM's Emergency Load Response; and ISO-NE's Real-Time 30-Minute Demand Response Program, Real-Time and 2-Hour Demand Response Program, and Real-Time Profiled Response Program. This provision also will not apply to compensation in ancillary services markets, which the Commission has addressed elsewhere. See e.g., Wholesale Competition in Regions with Organized Electric Markets, Order No. 719, 73 Fed. Reg. 64,100 (Oct. 28, 2008), FERC Stats. & Regs. P 31,281 (2008) (Order No. 719 or Final Rule).

[5] See Order No. 719 at P 1; see also Regional Transmission Organizations, Order No. 2000, FERC Stats. & Regs. ¶ 31,089, at P 1 (1999), order on reh'g, Order No. 2000-A, FERC Stats. & Regs. ¶ 31,092 (2000), aff'd sub nom. Pub. Util. Dist. No. 1 of Snohomish County, Washington v. FERC, 272 F.3d 607, 348 U.S. App. D.C. 205

(continued…)

competitiveness of organized wholesale markets, the Commission concluded, is therefore "integral to the Commission fulfilling its statutory mandate to ensure supplies of electric energy at just, reasonable, and not unduly discriminatory or preferential rates."[6]

3. As the Commission recognized in Order No. 719, active participation by customers in organized wholesale energy markets through demand reductions helps to increase competition in those markets.[7] Demand reductions whereby customers reduce electricity consumption from normal usage levels in response to price signals can generally occur in two ways: (1) customers reduce demand by responding to dynamic rates that are based on wholesale prices (sometimes called "price-responsive demand"); and (2) customers can provide demand response that acts as a resource in wholesale markets to balance supply and demand. While a number of states and utilities are pursuing retail-level price-responsive demand initiatives based on dynamic and time-differentiated retail prices and utility investments, these are state initiatives, and, thus, are not the subject of this proceeding.[8] Our focus here is on customers providing - through bids - demand response that acts as a resource in organized wholesale energy markets.

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(D.C. Cir. 2001).

[6] Order No. 719 at P 1.

[7] See Order No. 719 at P 48.

[8] Some ISOs and RTOs are engaged in stakeholder discussions concerning the coordination necessary between wholesale markets and retail rate design, and we expect

(continued…)

4. Demand response acting as a resource in organized wholesale energy markets helps to improve the functioning and competitiveness of such markets in several ways. First, demand response can lower prices. When bid directly into the wholesale market, demand response – which results in lower demand – can result in lower clearing prices.[9] For example, a study conducted by PJM, which simulated the effect of demand response on prices, demonstrated that a modest three percent load reduction in the 100 highest peak hours corresponds to a price decline of six to 12 percent.[10] Demand response can also lower prices in the organized wholesale energy markets by reducing the need to dispatch higher-priced generation, or construct new generation, in an effort to satisfy load.[11] Second, demand response can mitigate generator market power.[12] This is

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to address any filings emerging from those discussions in future proceedings.

[9] Wholesale Competition in Regions with Organized Electric Markets, Order No. 719-A, FERC Stats. & Regs. ¶ 31,292 (2009).

[10] ISO-RTO Council Report, Harnessing the Power of Demand How ISOs and RTOs Are Integrating Demand Response into Wholesale Electricity Markets, found at http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC_DR_Report_101607.pdf.

[11] Id. ("Demand response tends to flatten an area's load profile, which in turn may reduce the need to construct and use more costly resources during periods of high demand; the overall effect is to lower the average cost of producing energy."). Similarly, NYISO "has experienced a significant increase in the registration of the [demand response] programs that have effectively reduced the need for additional [generation] capacity resources to the system based on customer pledges to cut energy usage on demand." See NYISO's 2009 Comprehensive Reliability Plan at 3, found at http://www.nyiso.com/public/webdocs/newsroom/planning_reports/CRP__FINAL_5-19-

(continued…)

because the more demand response is able to reduce demand, the more downward pressure it places on generator bidding strategies by increasing the risk to a supplier that it will not be dispatched if it bids a price that is too high.[13] Third, demand response has the potential to support system reliability and address resource adequacy[14] and resource management challenges surrounding the unexpected loss of generation.[15]

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09.pdf.

[12] See Comments of NYISO's Market Monitor filed in Docket No. ER09-1142-000, May 15, 2009 (Demand response "contributes to reliability in the short-term, resource adequacy in the long-term, reduces price volatility and other market costs, and mitigates supplier market power.").

[13] Id.

[14] See ISO-RTO Council Report, Harnessing the Power of Demand How ISOs and RTOs Are Integrating Demand Response into Wholesale Electricity Markets at 4, found at http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC_DR_Report_101607.pdf ("Demand response contributes to maintaining system reliability. Lower electric load when supply is especially tight reduces the likelihood of load shedding. Improvements in reliability mean that many circumstances that otherwise result in forced outages and rolling blackouts are averted, resulting in substantial financial savings . . . ."); Smart Grid Policy, 126 FERC ¶ 61,253, at P 19 and n.23 (2009) ("The Smart Grid concept envisions a power system architecture that permits two-way communication between the grid and essentially all devices that connect to it, ultimately all the way down to large consumer appliances. . . . Once that is achieved, a significant proportion of electric load could become an important resource to the electric system, able to respond automatically to customer-selected price or dispatch signals delivered over the Smart Grid infrastructure without significant degradation of service quality.").

[15] For instance, in ERCOT, on February 26, 2008, through a combination of a sudden drop in power supplied by wind generators, a quicker-than-expected ramping up of demand, and the loss of thermal generation, ERCOT found itself short of reserves.

(continued…)

5. Given its ability to lower electricity prices and ensure reliability, demand response can play a critical role in helping the Commission fulfill its mandate under the Federal Power Act (FPA) to ensure that rates charged for energy are just and reasonable.[16] Accordingly, and consistent with national policy requiring facilitation of demand response,[17] the Commission has acted to remove barriers to participation of demand response resources in organized wholesale electricity markets. For example, in Order No. 890, the Commission modified the pro forma Open Access Transmission Tariff to allow non-generation resources, including demand response resources, to be used in the provision of certain ancillary services where appropriate on a comparable basis to service provided by generation resources.[18] Order No. 890-A further requires transmission

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The system operator called on all demand response resources, and 1200 MW of Load acting as Resource (LaaRs) responded within ten minutes, bringing ERCOT back into balance, from 59.85 Hz back to 60 Hz.

[16] 16 U.S.C. § 824d (2006).

[17] See EPAct 2005, Pub. L. No. 109-58, § 1252(f), 119 Stat. 594, 965 (2005) ("It is the policy of the United States that . . . unnecessary barriers to demand response participation in energy, capacity, and ancillary service markets shall be eliminated.").

[18] Preventing Undue Discrimination and Preference in Transmission Service, Order No. 890, FERC Stats. & Regs. ¶ 31,241 at P 887-88 (2007), order on reh'g, Order No. 890-A, FERC Stats. & Regs. ¶ 31,261 (2007), order on reh'g and clarification, Order No. 890-B, 73 Fed. Reg. 39092 (Jul. 8, 2008), 123 FERC ¶ 61,299 (2008), order on reh'g, Order No. 890-C, 126 FERC ¶ 61,228 (2009), order on clarification, Order No. 890-D, 129 FERC ¶ 61,126 (2009).

providers to develop transmission planning processes that treat all resources, including demand response, on a comparable basis.[19]

6. The Commission built on these reforms in Order No. 719, requiring ISOs and RTOs to, among other things, accept bids from demand response resources in their markets for certain ancillary services on a basis comparable to other resources.[20] The Commission also required each ISO and RTO "to reform or demonstrate the adequacy of its existing market rules to ensure that the market price for energy reflects the value of energy during an operating reserve shortage,"[21] for purposes of encouraging existing generation and demand resources to continue to be relied upon during an operating reserve shortage, and encouraging entry of new generation and demand resources.[22]

## B. Current ISO and RTO Demand Response Programs

7. In addition to the foregoing efforts, the Commission has issued orders in recent years approving various types of ISO and RTO demand response programs. As noted above, some of these programs are administered for reliability and emergency conditions. Apart from these programs, wholesale customers and qualifying large retail customers

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[19] Order No. 890-A at P 216.

[20] Order No. 719 at P 47-49.

[21] Id. P 194.

[22] Id. P 247.

may bid demand response directly into the day-ahead and real-time energy markets, certain ancillary service markets and capacity markets.[23] Demand response providers participating as resources in the day-ahead and real-time energy markets are the subject of this proceeding.

8. With particular regard to demand response compensation for this latter category of resources, the Commission previously has allowed a system-by-system approach, whereby each RTO and ISO has developed its own compensation methodologies for demand response resources in its energy market. As a result, the levels of compensation for demand response vary significantly among RTOs and ISOs. PJM pays the Locational Marginal Price (LMP)[24] minus the generation and transmission portions of the retail

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[23] Other demand response programs allow demand response to be used as a capacity resource and as a resource during system emergencies or permit the use of demand response for synchronized reserves and regulation service. See, e.g., PJM Interconnection, L.L.C., 117 FERC ¶ 61,331 (2006); Devon Power LLC, 115 FERC ¶ 61,340, order on reh'g, 117 FERC ¶ 61,133 (2006), appeal pending sub nom., Maine Pub. Utils. Comm'n v. FERC, No. 06-1403 (D.C. Cir. 2007); New York Indep. Sys. Operator., Inc., 95 FERC ¶ 61,136 (2001); NSTAR Services Co. v. New England Power Pool, 95 FERC ¶ 61,250 (2001); New England Power Pool and ISO New England, Inc., 100 FERC ¶ 61,287, order on reh'g, 101 FERC ¶ 61,344 (2002), order on reh'g, 103 FERC ¶ 61,304, order on reh'g, 105 FERC ¶ 61,211 (2003); PJM Interconnection, L.L.C., 99 FERC ¶ 61,227 (2002).

[24] LMP refers to the price calculated by the ISO or RTO at particular locations or electrical nodes within the ISO or RTO footprint and is used as the market price to compensate generators. There are variations in the way ISOs and RTOs calculate LMP; however, each method establishes the marginal value of resources in that market. Nothing in this NOPR is intended to change ISO and RTO methods for calculating LMP.

rate.[25] ISO-NE and NYISO currently pay LMP when prices are above a threshold level, with the levels differing between the RTOs.[26] The Midwest ISO currently has a program that pays LMP for demand response in the real-time energy market when the demand response provider has purchased the amount reduced in the day-ahead market for energy and ancillary services.[27] CAISO pays LMP in its participating load program that allows qualifying resources to provide day-ahead and real-time energy and non-spinning reserves.[28] SPP currently has no demand response program at all.[29] ISOs and RTOs

[25] PJM FERC Electric Tariff, Sixth Revised Sheet No. 388D.01.

[26] For example, under ISO-NE's Real Time Price Response Program, the minimum bid is $100/MWh and a demand response resource is paid the higher of LMP or $100/MWh. See Section III.1.3 of the ISO New England Transmission, Markets and Services Tariff, Section 1 of the Second Restated New England Power Pool Agreement. NYISO implements a day-ahead demand response program by which resources bid into the market at a minimum of $75/MWh and can get paid the LMP. See NYISO Incentivized Day-Ahead Economic Load Curtailment Program, Fifth Revised Tariff Sheet No. 34-34A, 89.

[27] See Charges and Credits for Real-Time Energy and Operating Reserve Market Energy Purchases and Sales Associated with Demand Response Resources. Midwest ISO FERC Electric Tariff, Fourth Revised Volume No. 1, Second Revised Sheet No. 1114.

[28] See section 11.2.1.1 IFM Payments for Supply of Energy, CAISO FERC Electric Tariff.

[29] However, the Commission has directed SPP to report on ways it can incorporate demand response into its imbalance market. Southwest Power Pool, Inc., 114 FERC ¶ 61,289, at P 229 (2006). In its orders addressing SPP's compliance with Order No. 719, the Commission also directed SPP to make a subsequent compliance filing addressing demand response participation in its organized markets.

(continued…)

have continued to examine the effectiveness of demand response compensation in their respective regions, and, as a result, the issue of proper compensation continues to be the subject of several proceedings.[30]

## C. The Need for Reform

9. Despite the benefits of demand response and various efforts by the Commission, ISOs and RTOs to address barriers to and compensation for demand response participation, demand response providers collectively play a small role in wholesale markets. After several years of observing demand response participation in ISO and RTO markets with different, and often evolving, demand response compensation structures, the Commission is concerned that some existing, inadequate compensation structures have hindered the development and use of demand response. The impediment has been addressed at Commission-sponsored technical conferences concerning demand response, where participants have confirmed that customers "must have confidence that appropriate price signals will be sustained by stable competitive pricing structures, before

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Southwest Power Pool, Inc., 129 FERC ¶ 61,163, at P 51 (2009).

[30] See PJM Interconnection, L.L.C., Docket No. EL09-68-000; ISO New England, Inc., Docket No. ER09-1051-000; ISO New England, Inc., Docket No. ER08-830-000; Midwest Indep. Transmission Sys. Operator, Inc., Docket No. ER09-1049-000.

they will make an investment in demand response."[31] Some participants have advised that demand response quite simply will not occur without adequate compensation.[32]

10. Indeed, there are indications that demand response resources react correspondingly to increases or decreases in payment. PJM provides a case study on this point. It first implemented its Economic Load Response Program (Economic Program) providing for demand response compensation in June 2002.[33] Several years later, starting in January 2008, when PJM reduced its compensation for demand response, settled demand reductions began decreasing from previous years.[34] Specifically, PJM's Market Monitor noted that, from 2007 to 2008, following the decrease in compensation, settled demand

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[31] Transcript of Order No. 719 technical conference at 24, statement by James Eber, Director of Demand Response at Commonwealth Edison, found at http://www.ferc.gov/EventCalendar/EventDetails.aspx?ID=3994&CalType=%20&CalendarID=116&Date=05/21/2008&View=Listview.

[32] See Statements of Larry Stalica, Vice President, Linde Energy Services, Inc. FERC Technical Conference- Demand Response in Organized Electric Markets, May 21, 2008, found at http://www.ferc.gov/EventCalendar/Files/20080521081612-Stalica,%20Linde%20Energy%20Services.pdf. ("The mere avoidance of electricity prices often provides insufficient value to offset these real costs. Demand response will not occur if customers do not have an economic incentive to reduce consumption.").

[33] See PJM Interconnection, L.L.C., 99 FERC ¶ 61,227 (2002). PJM's Economic Program provided for payment of LMP for all demand response reductions when LMP equaled or exceeded $75/MWh and paid LMP minus the generation and transmission components of the retail rate when LMP was less than $75/MWh.

[34] The tariff provision providing for payment of LMP when LMP equaled or exceeded $75/MWh terminated by its terms on December 31, 2007, and, since then, PJM has paid only LMP minus the generation and transmission components of the retail rate.

reductions decreased by 36.8 percent, from 714,200 MWh to 458,300 MWh, and the decline has continued at least through March 2009.[35] Although the Commission had rejected a request to prevent the compensation decrease from occurring as per the terms of PJM's then-existing tariff, the Commission encouraged PJM and its stakeholders to continue analyzing the effectiveness of PJM's demand response program with the decreased payments for demand response.[36] Based upon our own review, the Commission is now concerned that evidence of demand reductions in PJM, and inadequate demand response participation , now and in the future, may be the result of compensation that is no longer just and reasonable, because, as detailed below, the existing and varying levels of compensation generally fail to reflect the marginal value of demand response resources to ISO and RTO energy markets.

## II. Discussion

11. Given the importance of demand response resources to the competitiveness of organized wholesale electricity markets, and based upon our experience to date with demand response in the ISO- and RTO-administered markets, the Commission proposes to address compensation for demand response resources participating in organized wholesale energy markets generically in this proceeding. The Commission proposes to

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[35] Monitoring Analytics, Barriers to Demand Side Response in PJM at 22 (July 1, 2009).

[36] PJM Interconnection, L.L.C., 121 FERC ¶ 61,315, at P 29 (2007).

add section 35.18(g)(1)(v) to our regulations to establish a specific compensation approach for demand response resources participating in organized wholesale energy markets (such as the day-ahead and real-time markets administered by the ISOs and RTOs). Under the proposed section, each Commission-approved ISO and RTO that has a tariff provision providing for participation of demand response resources in its energy market must pay demand response resources, in all hours, the market price for energy, i.e., full LMP, for demand reductions made in response to price signals.[37]

12. The Commission proposes to take this action generically to address issues that are common to the RTO and ISO markets in a coordinated manner in a single proceeding. As discussed further below, we believe paying demand response resources the LMP in all hours will compensate those resources in a manner that reflects the marginal value of the resource to each RTO and ISO, comparable to treatment of generation resources. This will improve the competitiveness of the organized wholesale energy markets and, in turn, help to ensure that energy prices in those markets are just and reasonable.

13. As explained above, we have previously accepted a variety of ISO and RTO proposals for compensation for demand response providers, with different levels of

[37] This provision will not apply to programs that ISOs and RTOs administer for reliability or emergency conditions. In those situations, the ISO and RTO tariffs may provide compensation that is not necessarily related solely to energy prices but is designed to prevent involuntary load curtailment.

payment. As we have gained experience with these programs, we are concerned that the current compensation levels appear to have become unjust and unreasonable. Providers may submit price and quantity bids into the organized wholesale energy markets and the market clears at the marginal resource yet they fail to compensate demand response at levels that reflect the marginal value of the resource being used by the RTO or ISO to balance supply and demand. The current wholesale compensation levels may therefore be leading to under-investment in demand response resources, resulting in higher, and unjust and unreasonable, prices in the organized electricity markets. To help ensure that wholesale prices in ISOs and RTOs remain just and reasonable, we are proposing to require each ISO and RTO to pay the LMP to demand response providers participating in the organized wholesale energy markets.

14. It is a well-established practice in the organized wholesale energy markets to rely on LMPs to encourage efficient behavior by market participants. The LMP represents the value of additional supply or reductions in consumption at each node within the RTO or ISO and, thus, reflects the marginal cost of the last unit necessary to efficiently balance supply and demand.[38] The LMP is therefore the primary mechanism for compensating

[38] See ISO New England, Inc., 100 FERC ¶ 61,287, at P 71 (2002) (LMP "provide[s] appropriate price signals indicating the value of additional resources or conservation at each node in the transmission system"); Cleco Power LLC, et al., 103 FERC ¶ 61,272, at P 67 (2003) ("It is widely observed that markets work efficiently when prices reflect marginal costs, i.e., when the market price will be equal to the cost of

(continued…)

generation resources clearing in the organized electricity markets, which the Commission has found encourages "more efficient supply and demand decisions in both the short run and long run."[39]

15. Given that the LMP represents the marginal value of the resource being used by the RTO or ISO to balance supply and demand, it follows that the LMP should be paid to any resource clearing in the RTO's or ISO's energy market. In balancing supply and demand, a one megawatt reduction in demand is equivalent to a one megawatt increase in energy for purposes of meeting load requirements and maintaining a reliable electric system. The ISO or RTO is able to avoid dispatching suppliers with higher bids, be they generation or demand response, by accepting a lower bid to either reduce consumption or increase generation. As Dr. Alfred E. Kahn noted in a recent *PJM* proceeding in Docket No. EL09-68-000, consumers offering to reduce consumption should be induced "to behave as they would if the market mechanisms alone were capable of rewarding them directly for efficient economizing."[40] This is because "the (incremental) costs saved by curtailments in demand clearly will be LMP - including the marginal costs of generation.

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bringing to market the last unit necessary to balance supply and demand.").

[39] See New England Power Pool, 101 FERC ¶ 61,344, at P 35 (2002).

[40] Kahn Affidavit at 4.

So, in the end the LMP inducement is the economically correct one."[41] This appears to be true across all ISOs and RTOs and, therefore, it appears appropriate to compensate both generation and demand response resources participating in the organized wholesale electricity markets at the LMP.

16. Ultimately, the markets themselves will determine the level of generation and demand response resources needed to balance energy and demand. The level of compensation provided to each resource, however, affects its willingness and ability to participate in the market.[42] For example, demand response resources need to make investments in technologies to enable participation in the organized wholesale energy markets, as well as incur costs in changing their operations in order to provide demand response. In those markets paying less than the LMP to demand response resources, such resources have less revenues to support investment in demand response-enabling technology (such as metering equipment, energy usage monitors and process controls) necessary to enable more wholesale market participation by demand response resources. Where compensation for demand response is inadequate, demand response resources will be hesitant to invest in demand response devices. Compared to existing compensation

[41] Id. at 3.

[42] Generation and demand response resources have the potential to earn other revenues through bilateral arrangements, capacity markets where they exist, and ancillary services.

levels, paying the LMP in all hours should allow more demand response resources to cover their investment costs and increase their ability to participate in the organized wholesale electric markets.

17. Increased levels of demand response participation, in turn, should lead to lower clearing prices in the organized wholesale energy markets. As the Commission explained in accepting PJM's Economic Load Response Program:

> Without a demand response mechanism, [an independent system operator] is forced to work under the assumption that all customers have an inelastic demand for energy and will pay any price for power. There is ample evidence that this is not true. Many customers, given the right tools, can and will manage their demand. . . . A working demand response program puts downward pressure on price, because suppliers have additional incentives to keep bids close to their marginal production costs and high supply bids are more likely to reduce the bidder's energy sales. Appropriate price signals to customers thus helps to mitigate market power as high supply bids are more likely to reduce the bidders' energy sales. Suppliers thus have additional incentive to keep bids close to their marginal production costs.[43]

18. Additionally, increasing the aggregate amount of demand response resources in the organized wholesale energy markets will help to move prices closer to the levels that would result if all demand could respond to the marginal cost of energy. Paying the LMP to those potential demand response resources who are capable of responding – but who

[43] PJM Interconnection, L.L.C., 99 FERC ¶ 61,227, at 61,939 (2002) (quoting PJM Interconnection, L.L.C., 99 FERC ¶ 61,139, at 61,573 (2002)).

have not been participating as a resource due to inadequate compensation – should bring those additional demand response resources into the organized wholesale energy markets. But again, the markets themselves will determine the appropriate level of demand response, and generation, resources needed by the ISO and RTO to balance energy and demand based on their relative bids into the markets.

19. We recognize that the appropriate level of compensation for demand response resources participating in organized wholesale energy markets has been the subject of debate. In various proceedings, some parties have advocated payment of LMP minus components of the retail rate, on the theory that such an approach permits all consumers to react as if they were paying LMP.[44] Some parties have argued that payment of LMP is appropriate only during the most expensive hours,[45] on the theory that demand response will have the greatest impact during those hours in which the aggregate supply curve is steep (i.e., when supply is less elastic). Given the current barriers to demand response[46]

[44] Professor William W. Hogan has argued, for instance, that payment of LMP (without an offset for some portion of the retail rate) over-compensates individual demand response providers and might result in more demand response than is efficient. See Attachment to Answer of Electric Power Supply Association, Providing Incentives for Efficient Demand Response, William W. Hogan, October 29, 2009, submitted in Docket No. EL09-68-000.

[45] See PJM's Transmittal Letter at 29 submitted in Docket No. EL09-68-000.

[46] A recent Commission Staff report details several barriers to demand response, including regulatory barriers, such as lack of a direct connection between wholesale and

(continued…)

and the evolving nature of the technology enabling demand response, a perfect solution or payment scheme may not exist. We nonetheless believe that paying LMP in all hours to the demand response resources that can participate in the organized wholesale energy markets is the correct approach at this time, because that payment reflects the marginal effect of each demand response resource in the hour, just as the LMP reflects the marginal effect of generation resources in each hour. LMP is the marginal value of both demand response and generation in any hour, regardless of whether it is morning or evening, daytime or nighttime, weekday or weekend.[47]

20. We, nevertheless, seek comment on the need to compensate demand response acting as a resource in organized wholesale energy markets. Commenters may address

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retail prices, lack of dynamic prices, measurement and verification challenges, lack of real-time information sharing, and ineffective demand response program design; technological barriers, such as lack of advanced metering infrastructure and the high cost of some enabling technologies; and other barriers, such as lack of customer awareness and education. Federal Energy Regulatory Commission Staff, A National Assessment of Demand Response Potential (June 2009), found at http://www.ferc.gov/legal/staff-refports/06-09-demand-response.pdf. In compliance filings submitted by RTOs and ISOs and their market monitors pursuant to Order No. 719, as well as in responsive pleadings, parties have mentioned additional barriers, such as the inability of demand response resources to set LMP, minimum size requirements, and others.

[47] We note that in PJM, 17 percent of load reductions by demand response resources for that year occurred between the non-peak hours of 11 p.m. and 8 a.m. See 2008 State of the Market Report for PJM, Volume 2, Table 2-93 at 103, found at http://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2008/2008-som-pjm-volume2.pdf.

whether current compensation for demand response providers acting as a resource in the organized wholesale energy markets is adequately procuring demand response. We further solicit comment on alternative approaches to compensating demand response resources participating in organized wholesale energy markets, and the merit of those approaches in comparison to the one proposed here. In particular, we ask for comment on whether a reduction in consumption is comparable to an increase in electricity production for purposes of balancing supply and demand, and whether, therefore, demand response providers and generators should receive comparable compensation. We further seek comment on whether paying LMP to demand response resources is comparable compensation or is more or less than comparable to compensation paid to generation in the ISO and RTO energy markets. We also request comment on whether payment of LMP should apply to all hours, and, if not, the criteria that should be used for establishing the hours when LMP should apply. Additionally, we seek comment on whether requiring payment of LMP is appropriate across all ISOs and RTOs, or whether variations among ISOs and RTOs justify varying levels of demand response resource compensation. To that end, we further seek comment on whether the Commission should allow regional variations for an ISO or RTO that does not seek to compensate demand response resources participating in the organized wholesale energy market.

21. Organized wholesale energy markets are evolving and, as such, the rules and regulations related to those markets will continue to evolve. This is no less so for

demand response, as the markets, and the types of demand response participating in them, continue to evolve. Therefore, it may be necessary in the future for industry and the Commission to reassess the appropriate method for compensating demand response resources in organized wholesale energy markets.[48] Accordingly, we also seek comment on whether, and under what circumstances, the Commission should conduct periodic reviews of demand response compensation and the criteria that should be used in making such assessments.

22. With specific regard to the proposed regulatory text set forth below, we seek comments on whether terms such as "expected levels," "price signals," and "market prices" are sufficiently defined.

23. Because we are addressing generically in this rulemaking proceeding the same issues raised in the PJM proceeding in Docket No. EL09-68-000, that docket is hereby terminated.[49] The Commission will take administrative notice of the record in the PJM

[48] Indeed, the Commission's proposed action in this proceeding is evidence of our continuing assessment of compensation for demand response resources. In PJM Interconnection, L.L.C., 121 FERC ¶ 61,315 (2007), the Commission rejected a complaint that PJM's existing compensation for demand response (LMP minus the generation and transmission components of the retail rate) was unjust and unreasonable, finding that there was insufficient evidence at the time to make such a finding. As we have acquired more experience with the participation of demand response resources in the organized wholesale energy markets, we are concerned that compensation for demand response in PJM and other RTO and ISO markets may no longer be just and reasonable.

[49] See Michigan Pub. Power Agency v. Midwest Indep. Transmission Sys.

(continued…)

proceeding so that parties in that proceeding need not refile affidavits or other evidence introduced there.

## III. Information Collection Statement

24. The Office of Management and Budget (OMB) requires that OMB approve certain information collection and data retention requirements imposed by agency rules.[50] Therefore, the Commission is submitting the proposed modifications to its information collections to OMB for review and approval in accordance with section 3507(d) of the Paperwork Reduction Act of 1995.[51]

25. The Office of Management and Budget's (OMB) regulations require approval of certain information collection requirements imposed by agency rules. Upon approval of a collection(s) of information, OMB will assign an OMB control number and an expiration date. Respondents subject to the filing requirements of a rule will not be penalized for failing to respond to these collections of information unless the collections of information display a valid OMB control number.

26. The Commission is submitting these reporting requirements to OMB for its review and approval under section 3507(d) of the Paperwork Reduction Act. Comments are

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Operator, Inc., 128 FERC ¶ 61,268, at P 29 n.47 (2009) (Commission has discretion to decide when and where it will resolve an issue).

[50] 5 CFR § 1320.11(b) (2009).

[51] 44 U.S.C. § 3507(d) (2006).

solicited on the Commission's need for this information, whether the information will have practical utility, the accuracy of provided burden estimates, ways to enhance the quality, utility, and clarity of the information to be collected, and any suggested methods for minimizing the respondent's burden, including the use of automated information techniques.

Burden Estimate: The Public Reporting burden for the requirements contained in the NOPR is as follows:

| Data Collection | Number of Respondents | No. of Responses | Hours Per Response | Total Annual Hours |
|---|---|---|---|---|
| FERC-516 | | | | |
| Transmission Organizations with Organized Electricity Markets | 6 | 1 | 6 | 36 |

Information Collection Costs: The Commission seeks comments on the costs to comply with these requirements. The Commission has projected the average annualized cost of all respondents to be the following: 36 hours @ $220 per hour = $7,920 for respondents. No capital costs are estimated to be incurred by respondents.

Title: FERC-516 "Electric Rate Schedule Tariff Filings"

Action: Proposed Collections.

OMB Control No: 1902-0096.

Respondents: Business or other for profit, and/or not for profit institutions.

Frequency of Responses: One time to initially comply with the rule, and then on occasion as needed to revise or modify.

27. Necessity of the Information: The information from FERC-516 enables the Commission to exercise its statutory obligation under Sections 205 and 206 of the FPA. FPA section 205 specifies that all rates and charges, and related contracts and service conditions for wholesale sales and transmission of energy in interstate commerce be filed with the Commission and must be "just and reasonable." In addition, FPA section 206 requires the Commission upon complaint or its own motion, to modify existing rates or services that are found to unjust, unreasonable, unduly discriminatory or preferential. The Commission needs sufficient detail to make an informed and reasonable decision concerning the appropriate level of rates, and the appropriateness of non-rate terms and conditions, and to aid customers and other parties who may wish to challenge the rates, terms, and conditions proposed by the utility.

28. This proposed rule, if adopted, would amend the Commission's regulations to obligate ISOs and RTOs to pay the market price for energy to demand response resources for demand reductions within each respective ISO and RTO region. Requiring ISOs and RTOs to pay the market price for energy to demand response resources for demand reductions in response to price signals will potentially reduce the market clearing price of electricity. The Commission has emphasized the importance of demand response as a vehicle for improving the competitiveness of organized wholesale electricity markets and

ensuring supplies of energy at just, reasonable and not unduly discriminatory or preferential rates.[52]

29. Internal review: The Commission has reviewed the requirements pertaining to organized wholesale electric markets and determined the proposed requirements are necessary to its responsibilities under sections 205 and 206 of the FPA.

30. These requirements conform to the Commission's plan for efficient information collection, communication and management within the energy industry. The Commission has assured itself, by means of internal review, that there is specific, objective support for the burden estimates associated with the information requirements.

31. Interested persons may obtain information on the reporting requirements by contacting: Federal Energy Regulatory Commission, 888 First Street, NE, Washington, DC 20426 [Attention: Michael Miller, Office of the Executive Director, Phone: (202) 502-8415, fax: (202) 273-0873, e-mail: michael.miller@ferc.gov]. Comments on the requirements of the proposed rule may also be sent to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, D.C. 20503 [Attention: Desk Officer for the Federal Energy Regulatory Commission], e-mail: oira_submission@omb.eop.gov.

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[52] Order No. 719 at P 16.

## IV. Environmental Analysis

32. The Commission is required to prepare an Environmental Assessment or an Environmental Impact Statement for any action that may have a significant adverse effect on the human environment.[53] The Commission concludes that neither an Environmental Assessment nor an Environmental Impact Statement is required for this NOPR under section 380.4(a)(15) of the Commission's regulations, which provides a categorical exemption for approval of actions under sections 205 and 206 of the FPA relating to the filing of schedules containing all rates and charges for the transmission or sale of electric energy subject to the Commission's jurisdiction, plus the classification, practices, contracts and regulations that affect rates, charges, classifications, and services.[54]

## V. Regulatory Flexibility Act Certification

33. The Regulatory Flexibility Act of 1980 (RFA)[55] generally requires a description and analysis of final rules that will have significant economic impact on a substantial

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[53] Order No. 486, Regulations Implementing the National Environmental Policy Act, 52 Fed. Reg. 47,897, FERC Stats. & Regs. Regulations Preambles 1986-1990 ¶ 30,783 (1987).

[54] 18 CFR § 380.4(a)(15) (2009).

[55] 5 U.S.C. § 601-12 (2000).

number of small entities.[56] ISOs and RTOs, not small entities, are impacted directly by this rule.

34. California Independent System Operator Corp. (CAISO) is a non-profit organization comprised of more than 90 electric transmission-owning companies and generators operating in its markets and serving more than 30 million customers.

35. New York Independent System Operator, Inc. (NYISO) is a non-profit organization that oversees wholesale electricity markets serving 19.2 million customers. NYISO manages a 10,775-mile network of high-voltage lines.

36. PJM Interconnection, L.L.C. (PJM) is comprised of more than 450 members including power generators, transmission owners, electricity distributors, power marketers, and large industrial customers, serving 13 states and the District of Columbia.

37. Southwest Power Pool, Inc. (SPP) is comprised of 50 members serving 4.5 million customers in eight states and has 52,301 miles of transmission lines.

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[56] The RFA definition of "small entity" refers to the definition provided in the Small Business Act, which defines a "small business concern" as a business that is independently owned and operated and that is not dominant in its field of operation. See 15 U.S.C. § 601(3) (2000) (citing to section 3 of the Small Business Act, 15 U.S.C. § 632 (2000)). The Small Business Size Standards component of the North American Industry Classification system defines a small utility as one that, including its affiliates, is primarily engaged in the generation, transmission, or distribution of electric energy for sale, and whose total electric output for the preceding fiscal years did not exceed 4 MWh. 13 CFR § 121.202 (Sector 22, Utilities, North American Industry Classification System, NAICS) (2004).

38. Midwest Independent Transmission System Operator, Inc. (Midwest ISO) is a non-profit organization with over 131,000 megawatts of installed generation. Midwest ISO has 93,600 miles of transmission lines and serves 15 states and one Canadian province.

39. ISO New England, Inc. (ISO-NE) is a regional transmission organization serving six states in New England. The system is comprised of more than 8,000 miles of high-voltage transmission lines and several hundred generation facilities, of which more than 350 are under ISO-NE's direct control.

40. The Commission believes this rule will not have a significant economic impact on a substantial number of small entities, and therefore no regulatory flexibility analysis is required.

## VI. Comment Procedures

41. The Commission invites interested persons to submit comments on the proposed regulatory text that commenters may wish to discuss. Comments are due 45 days after publication in the Federal Register. Comments must refer to Docket No. RM10-17-000,[57] and must include the commenter's name, the organization they represent, if applicable, and their address in their comments.

[57] Because this NOPR terminates Docket No. EL09-68-000, comments should not refer to that proceeding.

42. The Commission encourages comments to be filed electronically via the eFiling link on the Commission's web site at http://www.ferc.gov. The Commission accepts most standard word processing formats. Documents created electronically using word processing software should be filed in native applications or print-to-PDF format and not in a scanned format. Commenters filing electronically do not need to make a paper filing.

43. Commenters that are not able to file comments electronically must send an original and 14 copies of their comments to: Federal Energy Regulatory Commission, Secretary of the Commission, 888 First Street, NE, Washington, DC 20426.

44. All comments will be placed in the Commission's public files and may be viewed, printed, or downloaded remotely as described in the Document Availability section below. Commenters on this proposal are not required to serve copies of their comments on other commenters.

## VII. Document Availability

45. In addition to publishing the full text of this document in the Federal Register, the Commission provides all interested persons an opportunity to view and/or print the contents of this document via the Internet through FERC's Home Page (http://www.ferc.gov) and in FERC's Public Reference Room during normal business hours (8:30 a.m. to 5:00 p.m. Eastern time) at 888 First Street, NE, Room 2A, Washington, DC 20426.

46. From FERC's Home Page on the Internet, this information is available on eLibrary. The full text of this document is available on eLibrary in PDF and Microsoft Word format for viewing, printing, and/or downloading. To access this document in eLibrary, type the docket number excluding the last three digits of this document in the docket number field.

47. User assistance is available for eLibrary and the FERC's web site during normal business hours from FERC Online Support at (202) 502-6652 (toll free at 1-866-208-3676) or email at ferconlinesupport@ferc.gov, or the Public Reference Room at (202) 502-8371, TTY (202)502-8659. E-mail the Public Reference Room at public.referenceroom@ferc.gov.

List of subjects in 18 CFR Part 35

Electric power rates, Electric utilities, Reporting and recordkeeping requirements.

By direction of the Commission. Commissioner Moeller is concurring in part and dissenting in part with separate statement attached.

( S E A L )

Nathaniel J. Davis, Sr.,
Deputy Secretary.

In consideration of the foregoing, the Commission proposes to amend Chapter I, Title 18 of the Code of Federal Regulations as follows:

**PART 35—FILING OF RATE SCHEDULES AND TARIFFS**

1. The authority citation for Part 35 continues to read as follows:

**Authority:** 16 U.S.C. § 791a-825r, 2601-2645; 31 U.S.C. § 9701; 42 U.S.C. § 7101-7352.

2. Amend § 35.28 as follows:

Add a new paragraph (g)(1)(v).

**§ 35.28 Non-discriminatory open access transmission tariff.**

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(v) Demand response compensation in energy markets. Each Commission-approved independent system operator or regional transmission organization that has a tariff provision permitting demand response resources to participate as a resource in the energy market by reducing consumption of electric energy from their expected levels in response to price signals must pay to those demand response providers, in all hours, the market price for energy for these reductions.

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Demand Response Compensation in Organized Wholesale Energy Markets — Docket No. RM10-17-000

PJM Interconnection, L.L.C. — Docket No. EL09-68-000

(Issued March 18, 2010)

MOELLER, Commissioner, *concurring, in part* and *dissenting, in part*:

As our country's demand for energy increases, the reduction of energy usage through demand response programs will play a critical role in meeting our needs and it is my hope that this nascent industry will thrive and succeed. In the Energy Policy Act of 2005, Congress established a policy to encourage the use of demand response by: (1) facilitating the deployment of technology to enable customers to participate in demand response programs; and (2) eliminating unnecessary barriers to demand response participation.[1] Even before this law was passed, this Commission supported similar policies in the organized electric markets by encouraging the use of price responsive demand during high priced energy periods.[2]

Demand response is playing an increasingly critical role in our nation's energy supply mix. Additional demand response has the potential to produce more efficient market outcomes, contribute to a cleaner environment,[3] result in lower costs to customers, and help to check market power since it provides a countervailing willingness

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[1] Energy Policy Act of 2005, Pub. L. No. 109-58 § 1252(f), 119 Stat. 594 (2005).

[2] *PJM Interconnection, L.L.C.*, 99 FERC ¶ 61,227, at 61,943 (2002), *see also* Order No. 719 at P 16 ("Thus, enabling demand-side resources…improves the economic operation of electric power markets by aligning prices more closely with the value customers place on electric power.")

[3] A recent report by the National Research Council, *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*, provides estimates of the cost associated with air pollution as the result of energy production.

to reduce demand in the face of high prices.[4] With respect to prices, studies have shown that sometimes a small decrease in demand from demand response resources during peak periods can significantly reduce market prices. In sum, the benefits that demand response resources can bring to the energy markets are proven and significant.

The initial success of demand response has resulted in a steady maturation of the demand response industry. However, as the industry continues to mature, we must ensure that our policies are properly tailored to guide the development of demand response in a manner that will result in economically-efficient outcomes. Moving too quickly to reach a desired result can result in unintended consequences – and I believe that today's decision to propose a standard payment could have unintentional effects on both demand response participation and the efficient operation of the organized markets over the longer term.

In today's notice of proposed rulemaking (NOPR), the majority concludes that the Commission should require a standard payment to compensate demand response resources. Specifically, the majority's proposed outcome would be that these resources are paid the market price (*i.e.*, the locational marginal price or "LMP") for energy reductions in all 8,760 hours of the year. This determination is followed by questions such as whether other compensation designs could also work; questions that I believe would have been more appropriately asked *prior* to establishing this NOPR.[5] For that reason, I believe that a preliminary issuance (such as a Notice of Inquiry) should have been established to collect and analyze the evidence in advance of initiating a formal rulemaking proceeding.

While the majority claims that it is "concerned that compensation for demand response in PJM and other RTO and ISO markets may no longer be just and reasonable", the NOPR lacks a thorough discussion of the evidence that they relied upon to substantiate their concerns.[6] The NOPR also lacks a sufficient explanation of the

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[4] *California Indep. Sys. Operator Corp.*, 116 FERC ¶ 61,274, at P 689.

[5] To the extent that this NOPR asks questions to determine whether the proposed rule is just and reasonable, I concur.

[6] NOPR at n. 48. In support of the conclusion that compensation may no longer be just and reasonable, the preamble provides an example involving PJM's Economic Load Response Program and the drop of settled demand reductions experienced after the subsidy payments expired per the terms of PJM's tariff. NOPR at P 10. While the cited level of reduction is a fact, the PJM market monitor stated that "[w]hile the removal of

(continued…)

"experience" that FERC has recently gained that would otherwise support the conclusion that the organized electric markets "fail to compensate demand response at levels that reflect the marginal value of the resource being used by the RTO or ISO to balance supply and demand."[7]

To the contrary, the record in Docket No. EL09-68-000 shows wide disagreement in the industry regarding the issue of demand response compensation. In that proceeding, state utility commissions[8], the grid operator, industry economists, and the market participants all reached various conclusions regarding the question of how to compensate demand response resources in PJM.[9] In light of such rigorous debate, I am not sure if the

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the incentive program, effective November 2007, may have reduced participation, the exact role of the elimination of the incentive program is not known because there were changes to other key factors which directly impact participation." *Citing* Monitoring Analytics, *Barriers to Demand Side Response* in PJM, at 22 (July 1, 2009). More recently, the PJM market monitor recognized that between 2008 and 2009, "[t]here were many factors contributing to the lower levels of participation and lower revenues in the Economic Program, including lower price levels in 2009, lower load levels, and improved measurement and verification." Notably, while payments from the Economic Program have fallen substantially since 2007, capacity revenue for demand response has increased significantly (rising 114% to $303 million from 2008 to 2009.) *Citing* Monitoring Analytics, *State of the Market Report for PJM*, at 111 (March 11, 2010).

[7] NOPR at P 13.

[8] Compare the position of the Indiana Utility Regulatory Commission (*i.e.*, LMP less the generation portion of retail rates (LMP-G) is an accepted indication of cost-effectiveness) with the position taken by the New Jersey Board of Public Utilities and the District of Columbia Public Service Commission (*i.e.*, compensation for demand response should be based solely on LMP). Comments filed in Docket No. EL09-68-000.

[9] While there appears to be no disagreement that the correct price signal for all customers is the LMP, the debate centers on whether demand response resources should be *paid* the LMP *or* should realize the *value* of LMP if they choose to reduce demand. Additionally, at certain times, the LMP can become negative, meaning that generators must pay into the market to the extent they generate power. Should demand response resources likewise be required to pay into the market during negative LMP events, or should they be exempt?

Commission has a sustainable rationale to support a finding that the proposed rule is just and reasonable and that the existing compensation methods (that have been approved by this Commission) are no longer just and reasonable.

In fact, only recently did the Commission issue an order that not only sustained the manner by which PJM compensates demand response resources but also encouraged PJM and its stakeholders to identify and analyze issues to improve their demand response program.[10] Subsequently, PJM filed a detailed report explaining that while the stakeholder process did not yield a consensus position, the PJM Board moved forward and developed a compromise solution that was designed to strengthen its demand response markets.[11] In lieu of evaluating the merits of the proposal approved by PJM's Board, the NOPR terminates the PJM docket and directs PJM and its stakeholders to focus on whether demand response resources should be paid the market price – a question that has undoubtedly been analyzed, addressed and debated at numerous stakeholder meetings.

Since today's NOPR does not sufficiently explain the need for a uniform compensation approach, I am troubled by the decision to terminate PJM's individual proceeding. If approved, PJM's efforts toward developing a compromise solution for its market would have likely resulted in additional demand response participation and its associated benefits. However, with this NOPR's issuance, PJM and the other RTOs must now refrain from making changes to its demand response compensation rules pending the outcome of the rulemaking proceeding. The NOPR may also discourage some emerging organized markets from continuing to evolve toward the LMP model, as well as discourage some non-organized regions from seriously considering moving toward a market structure.

Ultimately, I want demand response to thrive and succeed in *all* the energy markets.[12] However, there are only so many policy decisions and rulemakings that this

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[10] *PJM Industrial Customer Coalition v. PJM Interconnection, L.L.C.*, 121 FERC ¶ 61,315, at P 29 (2007) (Wellinghoff and Kelly, Comm'rs, dissenting).

[11] PJM did note that the concept of paying LMP-G received considerable support and "conservatively could be said to have garnered at least a three-quarters majority approval." *See* PJM Supplemental Report in Docket No. EL09-68-000 at 24-25.

[12] My concern here goes to highlight the differences between regions with competitive wholesale markets and those that consist of largely bilateral market structures. By imposing a uniform compensation requirement, this proposed rulemaking

(continued…)

Commission can make to encourage its development. As mentioned in the preamble, the primary barrier to increased demand response is the disconnect between retail and wholesale prices and the remedy resides at the retail level where there is a lack of dynamic pricing. The approach embraced in the NOPR may also lead to a situation where residential ratepayers could be subsidizing other classes of service while unable to participate themselves in demand response programs. Absent attention to these issues, it will be difficult for any proposal to place generation and demand response on a precisely level playing field.

Until then, this Commission must review what options it has available without resorting to policies that would adversely enable the short-term development of demand response at the expense of its longer-term success. In closing, I believe that demand response programs have great potential to enhance the organized energy markets and I look forward to their continued development. I am concerned, however, that a one-size-fits-all approach could result in uneconomic outcomes that ultimately set back the future development of demand response.

Philip D. Moeller
Commissioner

could further exacerbate bifurcated approach toward national policy: entities in a competitive wholesale market must comply with increasingly burdensome requirements while entities operating in bilateral markets are often free from requirements that otherwise advance national policy goals.

# TAB G

This is Exhibit **"G"** referred to in the Revised Affidavit of Brian Rivard sworn before me this 21st day of November, 2019

*A Commissioner for Taking Affidavits*

Lauren Theresa Daniel, a Commissioner, etc.,
Province of Ontario, while a Student-at-Law.
Expires April 8, 2022.

# Demand Response
# Net Benefits Test

**Lin Xu, Ph.D.**

**Market Analysis and Development,**

**California Independent System Operator**

**June 29, 2011**

# Demand Response Net Benefits Test

## 1. INTRODUCTION

This paper covers the ISO's proposal to fulfill FERC order 745 regarding demand response compensation in the organized wholesale energy market. FERC order 745 requires:

- Demand response (DR) resources will be compensated at full LMP if the LMP is above a threshold price as will be determined by the Net Benefits Test.
- The Net Benefits Test will be performed monthly (by the 15th day) to establish the static monthly threshold price to be used in the next trade month.
- The threshold price is determined by the point where the net benefits of dispatching DR exceeds the marginal cost of DR.
- The net benefit of dispatching DR is estimated based on a representative aggregated supply curve for the trade month.

Per FERC order 745, the representative aggregated supply curve is created in the following way:

- Pick a representative curve of the trade month using previous year's curve.
- Adjust for resource availability.
- Adjust for fuel prices.
- Smooth the curve using numerical methods.

The theory behind the Net Benefits Test is illustrated in Figure 1. In Figure 1, an aggregated supply curve is drawn on the p-q plane, with p representing price and q representing supply quantity. As a convention, consider the aggregated supply curve as price function of supply quantity. A load curve is also drawn on the same p-q plane, which intersects the supply curve at the market clearing equilibrium. Demand response adds elasticity to load. Dispatching demand response will reduce the market clearing price.

- Dispatching an incremental amount (dq) of demand response will reduce the system marginal price (dp) according to the supply curve.
- The benefit to non-DR load for dispatching demand response is q*dp.
- The cost of dispatching demand response is p*dq.
- The net benefit is non-negative if q*dp >= p*dq, or dp/dq >= p/q.
- If there exists a point on the supply curve (p0, q0) with q0 > 0, p0 > 0 and q*dp = p*dq, or equivalently [dp/dq(@q0)] /[ p0/q0] = 1 (where @q0 means being evaluated at q0), such that the net benefit is non-negative for all p > p0, then p0 is called the threshold price.
- Demand response should be dispatched only when the clearing price is above the threshold price.

The threshold point condition, q*dp = p*dq, or equivalently (dp/dq) / (p/q) = 1, is a first order necessary condition. It cannot distinguish positive net benefits and negative net benefits for p greater than the threshold price. In the appendix, two theorems are proved to provide second order necessary condition and second order locally sufficient condition for the threshold point. The meaning of theorem 1 (second order necessary condition) is that in order for a point (q0, p0) that satisfies the first order necessary condition to have net non-negative benefits for p>p0, the supply curve must be convex at q0. The meaning of Theorem 2 (second order locally sufficient condition) is that if the supply curve has elasticity equal to one and is strictly convex at a point, then incremental price from this point will result in positive net benefits.

The two theorems further characterize the true threshold point locally beyond the first order necessary condition of elasticity equal to one. When there exists multiple candidate points satisfying the first order necessary condition (elasticity equal to one), the theorems will help find the correct threshold point.

The main body of the ISO's proposal will cover three major aspects:

- How to construct the representative supply curve?
- How to smooth the representative curve?
- How to find the threshold point on the representative curve?

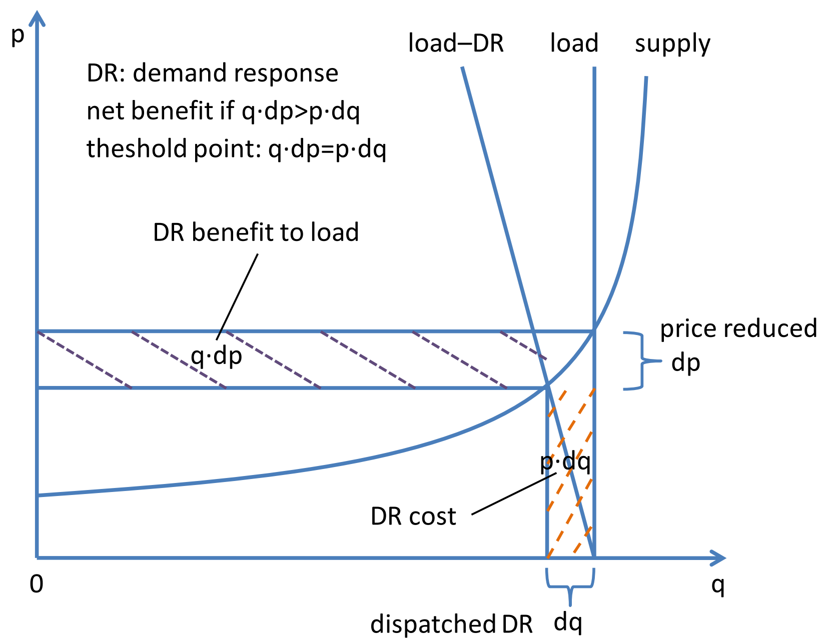


FIGURE 1: DEMAND RESPONSE COST AND BENEFIT

# 2. CAISO NET BENEFITS TEST DETAILS

## 2.1 CONSTRUCTING THE REPRESENTITIVE SUPPLY CURVE

The first and most important step of the Net Benefits Test is to construct a representative aggregated supply curve for the trade month, say July 2011. The ISO would publish the Net Benefits Test results by Jun 15th 2011 for July 2011. The construction of the representative supply curves will be based on historical market offers from July 2010, which will be referred to as the reference month. The reference month aggregated supply curve will be called the reference supply curves.

The ISO will construct two reference curves, one for on-peak hours and the other for off-peak hours according to North American Electric Reliability Corporation's (NERC) definition of on-peak and off-peak.[1] The reference supply curves will be constructed based on real-time predispatch (RTPD) mitigated bids from all generation resources including tie-generators, both committed and uncommitted. Import and export bids are excluded.

The reference supply curve must also be adjusted for resource availability. The resource availability can be captured by averaging the hourly reference supply curves over the entire reference month (for every price level, the supply quantities will be averaged). For example, there are 416 on-peak hours and 328 off-peak hours (for a total of 744 hours) in July 2010. The 416 on-peak hourly supply curves are averaged and used to construct the average on-peak reference supply curve, and the 328 off-peak hourly supply curves are averaged and used to construct the average off-peak reference supply curve. The on-peak and off-peak reference supply curves are illustrated in Figure 2.

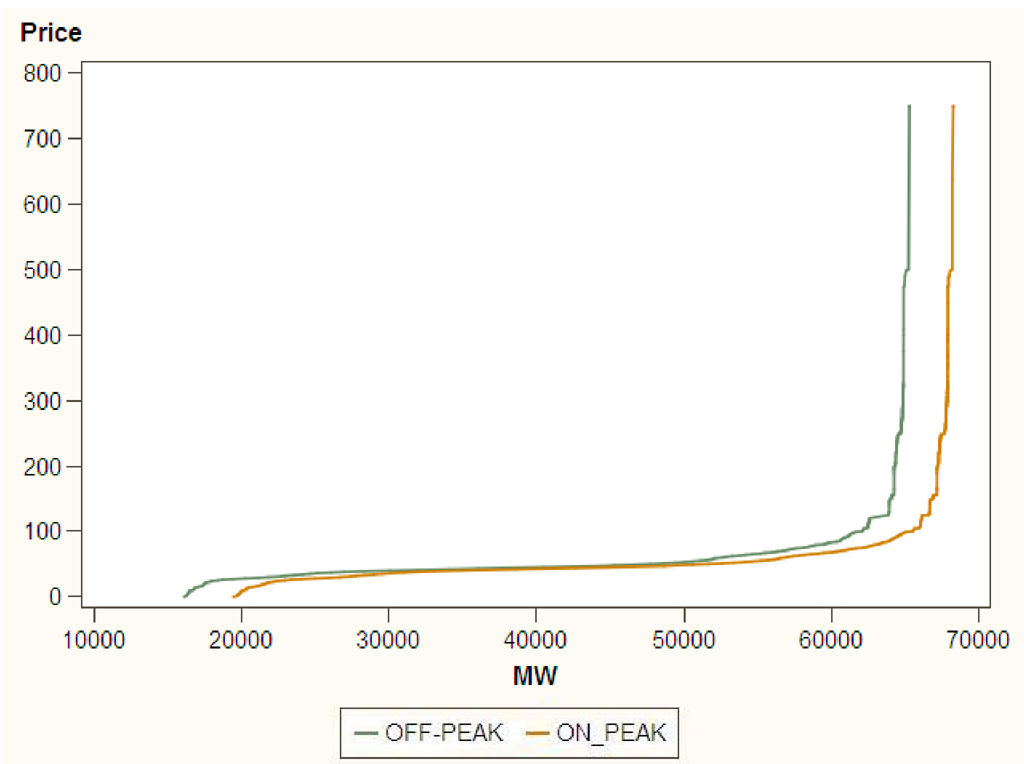


FIGURE 2: A SAMPLE SUPPLY CURVE FROM JULY 2010

[1] NERC, http://www.nerc.com/docs/oc/rs/Additional_Off-peak_Days.doc

FERC order 745 requires the reference supply curve be adjusted for fuel price differences between the reference month and the trade month. Gas fired units account for approximately 60% of the installed capacity in the ISO, while oil units and coal units each account for 1%. Because the oil and coal percentages are so small relative to gas, the ISO will only adjust for gas price differences in the Net Benefits Test. The ISO intends to use the simple average of the following two indices to calculate the California gas price:[2]

- PG&E Citygate, and
- Southern California Border

The supply curve will be scaled by a scaling factor, which is defined as the forward gas price for the trade month divided by the historical average gas price for the reference month. More specifically, for every supply quantity, the corresponding bid price will be scaled by the scaling factor. For example, if the forward monthly average gas price is $4.73 for July 2011,[3] and the historical monthly average gas price was $4.25 for July 2010, then the gas scalar = 4.73/4.25 = 1.11.

Scaling the supply curve factors in both the fuel cost difference for gas fired units and the opportunity cost differences for generators of other fuel types. Even though the whole supply curve is scaled, only the portion that is close to the threshold price is relevant for calculation of the threshold. With typical threshold prices around $45 to $60, the supply bids in this range are mainly from gas fired units or generators of other fuel types whose bids incorporate opportunity costs. Therefore, it is appropriate to scale the system wide supply curve without needing to drill down to the unit specific level.

In summary, for each trade month, the ISO will have an on-peak representative supply curve and an off-peak representative supply curve, which accounts for resource availability and fuel price differences between the reference month and the trade month.

## 2.2 CURVE SMOOTHING

FERC order 745 requires the supply curve be smoothed using numerical methods. The curve will be smoothed to twice differentiable so that theorem 1 and theorem 2 can be used to characterize the threshold point.

The smoothing method proposed by the ISO is an exponential function curve fitting expressed as

p = exp($a$*q^3+$b$*q^2+$c$*q+$d$),[4]

[2] The ISO is working on acquiring reliable data source for these two gas price indices. However, if the data source is unavailable, the ISO will use the Henry Hub price index instead.

[3] The $4.73 forward gas price is only intended to demonstrate how to calculate the gas scalar, and may not be the actual monthly average forward gas price.

[4] Midwest ISO adopts similar function form, https://www.midwestiso.org/Library/Repository/Meeting%20Material/Stakeholder/DRWG/2011/20110509/20110509%20DRWG%20Item%2003b%20Net%20Benefit%20Test%20for%20Demand%20Response%20Compensation.pdf

where *a*, *b*, *c*, and *d* are coefficients to be determined by a regression on observations of supply quantities and prices.

The regression can be carried out by taking the natural logarithm of the price:

ln(p) = $a$*q^3+$b$*q^2+$c$*q+$d$.

This converts the regression from non-linear to linear.

One technique to achieve a better fit is to apply a price window to the representative supply curves such that the threshold price is inside the price window. In this way, observations that are far away from the threshold, which are irrelevant for the Net Benefits Test, will not affect the regression. In other words, a properly chosen price window allows the regression to focus on observations that are close to the threshold in order to more accurately estimate the threshold price point. On the other hand, the price window should not be too small. If the threshold is too small, it is possible that the threshold price resides outside this price window. If this happens, the price window must be adjusted, and the regression process repeated until the threshold price is well situated inside the price window. Choosing a window from $25 to $100 produces good results from the historical data. Sample smoothed supply curves for July 2011 are illustrated in Figure 3 and Figure 4. In this example, the parameters of the smoothed curves are listed in

Table 1.

| Coefficients | Off-peak | On-peak |
|---|---|---|
| *a* (*10^(−9)) | 0.00004274 | 0.0000465 |
| *b* (*10^(−6)) | -0.0049986 | -0.0059874 |
| *c* (*10^(−3)) | 0.20570776 | 0.2678375 |
| *d* | 0.96260595 | -0.2399994 |

TABLE 1: SAMPLE JULY 2011 REGRESSION RESULTS

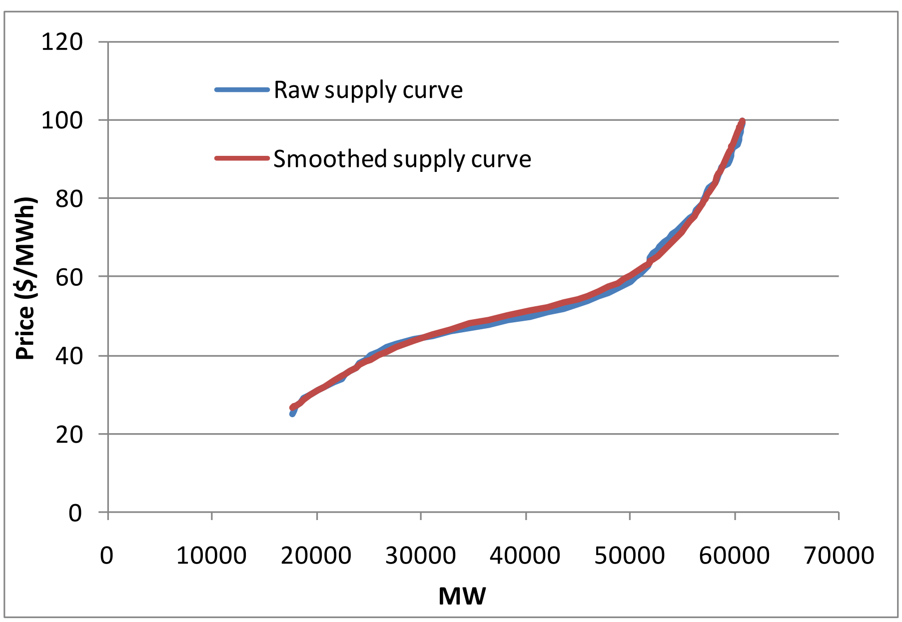

FIGURE 3: SMOOTHED OFF-PEAK SUPPLY CURVE FOR JULY 2011 WITH PRICE WINDOW [25, 100]

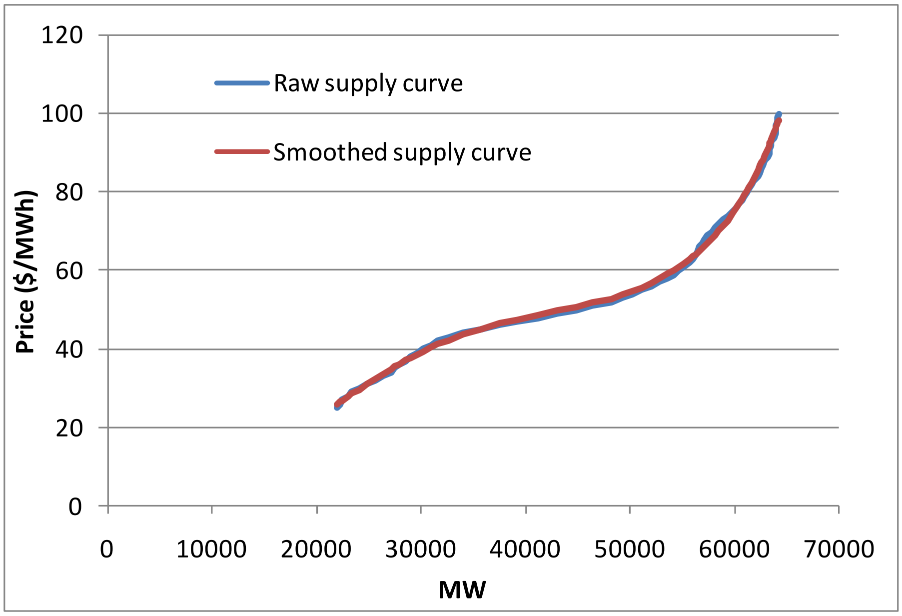


FIGURE 4: SMOOTHED ON-PEAK SUPPLY CURVE FOR JULY 2011 WITH PRICE WINDOW [25, 100]

## 2.3 FINDING THE THRESHOLD PRICE

Given the supply curve in the form of $p = \exp(a*q^3+b*q^2+c*q+d)$, the threshold price is first calculated using the first order necessary condition (the elasticity equal to one) as follows:

$(dp/dq) / (p/q) = 1$, or

$(3*a*q^2+2*b*q+c)*\exp(a*q^3+b*q^2+c*q+d) / [\exp(a*q^3+b*q^2+c*q+d) / q] = 1$, or

$3*a*q^3+2*b*q^2+c*q = 1$.

Solve this cubic equation, and denote the root by q0.

This is a cubic equation, so there are three roots. If there is one real root, and two complex roots, then the real root should be used to calculate the threshold price. If there are three real roots, then:

- The one produces a price outside the price window should be discarded.
- The one, at which the supply curve is concave, should be discarded by theorem 1.

In the July 2011 on-peak example, the three roots are 4646.7, 30329.4, and 50864.8, and the corresponding prices are $2.41, $39.37, and $55.26. The price $2.41 is outside the price window, so it should be discarded. At the price $39.37, the supply curve is concave, so it should also be discarded. The price of $55.26 is the only point that satisfies theorem 1. In addition, because the supply curve is strictly convex at the price of $55.26, it is a true threshold price locally per theorem 2. Similarly, the true threshold price for July 2011 off-peak hours is $57.00.

## 3. RESULTS

Preliminary results based on actual historical market bids without gas price adjustment typically produce threshold prices of $45 to $60.

# APPENDIX

Theorem 1 [second order necessary condition]: Assuming the supply curve is monotonically increasing and twice differentiable, if there exists a point (q0, p0) on the supply curve with q0 > 0 and p0 > 0 that satisfies the first order necessary condition (the supply curve has elasticity equal to one at q0), and for all p > p0, dp/dq >= p/q, then the supply curve is convex at q0, i.e.

$d^2p/dq^2(@q0) >= 0$.

Proof:

Suppose (q0, p0) is a point satisfies the first order necessary condition, [dp/dq(@q0)] / (p0/q0) = 1, and for all p > p0, dp/dq >= p/q.

By first order Taylor expansion, $dp/dq = dp/dq(@q0) + [d^2p/dq^2(@q0)] * (q-q0)$.

By first order Taylor expansion, p/q = p0/q0 + [(dp/dq*q – p) / q^2](@q0) * (q-q0) = p0/q0.

Then, dp/dq >= p/q implies $dp/dq(@q0) + [d^2p/dq^2(@q0)] * (q-q0) >= p0/q0$, or

$[d^2p/dq^2(@q0)] * (q-q0) >= 0$.

Because the supply function is monotonically increasing, p > p0 implies q > p0. Therefore,

$d^2p/dq^2(@q0)>=0$.

Theorem 2 [second order locally sufficient condition]: Assuming the supply curve is monotonically increasing and twice differentiable, if the following conditions hold at a point (q0, p0) with q0 > 0 and p0 > 0 on the supply curve:

2A) the supply curve has elasticity equal to one at q0, i.e. [dp/dq(@q0)] / (p0/q0) = 1, and

2B) the supply curve is convex at q0, i.e. $d^2p/dq^2(@q0) > 0$,

then for all p > p0 in the vicinity of p0, dp/dq > p/q.

Proof:

Similar as the proof of Theorem 1,

$d^2p/dq^2(@q0) > 0$ implies $[d^2p/dq^2(@q0)] * (q-q0) > 0$ for all p > p0 in the vicinity of p0.

Because [dp/dq(@q0)] / (p0/q0) = 1, dp/dq(@q0) = p0/q0.

Therefore, $dp/dq(@q0) + [d^2p/dq^2(@q0)] * (q-q0) > p0/q0$.

By first order Taylor expansion of dp/dq and p/q, dp/dq > p/q for all q > q0 in the vicinity of q0.

Because the supply curve is monotonically increasing, dp/dq > p/q for all p > p0 in the vicinity of p0.

# TAB H

This is Exhibit **"H"** referred to in the Revised Affidavit of Brian Rivard sworn before me this 21st day of November, 2019

*A Commissioner for Taking Affidavits*

Lauren Theresa Daniel, a Commissioner, etc.,
Province of Ontario, while a Student-at-Law.
Expires April 8, 2022.

| Date | Hour | HOEP ($/MWh) | NDL (MWh) | DL (MWh) | Contracted or Regulated | Non Contract (MWh) | Imports (MWh) | Exports (MWh) |
|---|---|---|---|---|---|---|---|---|
| January 1, 2018 | 1 | 51.29 | 16188 | 186 | 18528 | 19 | 376 | -2394 |
| January 1, 2018 | 2 | 43.59 | 15774 | 162 | 18216 | 20 | 242 | -2402 |
| January 1, 2018 | 3 | 93.6 | 15594 | 154 | 18347 | 19 | 92 | -2599 |
| January 1, 2018 | 4 | 54.78 | 15304 | 138 | 18109 | 19 | 587 | -3008 |
| January 1, 2018 | 5 | 14.35 | 15197 | 171 | 17929 | 19 | 265 | -2630 |
| January 1, 2018 | 6 | 18.6 | 15290 | 131 | 18175 | 20 | 341 | -2961 |
| January 1, 2018 | 7 | 21.72 | 15460 | 201 | 19134 | 19 | 114 | -3434 |
| January 1, 2018 | 8 | 40.89 | 15657 | 205 | 19420 | 19 | 114 | -3645 |
| January 1, 2018 | 9 | 20.75 | 15849 | 193 | 19246 | 19 | 264 | -3452 |
| January 1, 2018 | 10 | 74.57 | 16205 | 203 | 19701 | 17 | 189 | -3498 |
| January 1, 2018 | 11 | 4.65 | 16430 | 215 | 19452 | 19 | 344 | -3040 |
| January 1, 2018 | 12 | 9.45 | 16580 | 218 | 19336 | 18 | 463 | -3010 |
| January 1, 2018 | 13 | 13.65 | 16662 | 227 | 19556 | 18 | 214 | -2820 |
| January 1, 2018 | 14 | 14.37 | 16608 | 197 | 19387 | 18 | 331 | -2875 |
| January 1, 2018 | 15 | 26.73 | 16780 | 182 | 19436 | 18 | 346 | -2761 |
| January 1, 2018 | 16 | 42.12 | 17101 | 202 | 20283 | 18 | 355 | -3288 |
| January 1, 2018 | 17 | 42.28 | 17753 | 208 | 21613 | 18 | 189 | -3686 |
| January 1, 2018 | 18 | 44.84 | 18913 | 216 | 22849 | 18 | 330 | -3870 |
| January 1, 2018 | 19 | 42.22 | 18763 | 229 | 22454 | 19 | 642 | -3742 |
| January 1, 2018 | 20 | 41.06 | 18487 | 235 | 22311 | 19 | 583 | -3951 |
| January 1, 2018 | 21 | 43.76 | 18157 | 257 | 22112 | 19 | 396 | -3869 |
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| January 1, 2018 | 24 | 38.14 | 16120 | 237 | 19302 | 19 | 312 | -3099 |
| January 2, 2018 | 1 | 31.12 | 15629 | 189 | 19218 | 19 | 147 | -3416 |
| January 2, 2018 | 2 | 10.76 | 15263 | 175 | 18141 | 19 | 212 | -2748 |
| January 2, 2018 | 3 | 14.34 | 14996 | 236 | 18160 | 19 | 224 | -3084 |
| January 2, 2018 | 4 | 0.29 | 14979 | 223 | 17804 | 19 | 335 | -2873 |
| January 2, 2018 | 5 | 1.43 | 14996 | 202 | 18305 | 19 | 282 | -3255 |
| January 2, 2018 | 6 | 14.36 | 15490 | 230 | 18983 | 19 | 372 | -3547 |
| January 2, 2018 | 7 | 19.1 | 16577 | 206 | 20199 | 19 | 229 | -3579 |
| January 2, 2018 | 8 | 34.9 | 17751 | 124 | 21583 | 19 | 379 | -4021 |
| January 2, 2018 | 9 | 43.72 | 18324 | 105 | 22015 | 19 | 376 | -4115 |
| January 2, 2018 | 10 | 46.03 | 18744 | 94 | 22262 | 21 | 433 | -3901 |
| January 2, 2018 | 11 | 49.4 | 18917 | 179 | 22433 | 19 | 909 | -4283 |
| January 2, 2018 | 12 | 66.6 | 19012 | 111 | 22298 | 19 | 599 | -3801 |
| January 2, 2018 | 13 | 42.14 | 18817 | 120 | 21938 | 20 | 545 | -3520 |
| January 2, 2018 | 14 | 40.35 | 18678 | 135 | 21553 | 18 | 382 | -3094 |
| January 2, 2018 | 15 | 34.36 | 18490 | 204 | 21436 | 18 | 515 | -3173 |
| January 2, 2018 | 16 | 29.98 | 18564 | 232 | 21637 | 18 | 444 | -3161 |
| January 2, 2018 | 17 | 42.86 | 19138 | 198 | 22559 | 20 | 415 | -3633 |
| January 2, 2018 | 18 | 42.33 | 19962 | 88 | 23452 | 17 | 635 | -3863 |
| January 2, 2018 | 19 | 40.37 | 19796 | 121 | 23304 | 19 | 705 | -4119 |
| January 2, 2018 | 20 | 42.44 | 19589 | 142 | 22867 | 21 | 942 | -3978 |
| January 2, 2018 | 21 | 42.29 | 19255 | 190 | 23082 | 19 | 278 | -3817 |
| January 2, 2018 | 22 | 41.64 | 18585 | 214 | 21492 | 19 | 427 | -3088 |
| January 2, 2018 | 23 | 8.01 | 17582 | 256 | 19972 | 20 | 276 | -2399 |
| January 2, 2018 | 24 | 29.72 | 16609 | 260 | 19511 | 20 | 131 | -2767 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| January 3, 2018 | 1 | 2.31 | 15807 | 274 | 18460 | 19 | 635 | -2805 |
| January 3, 2018 | 2 | 19.43 | 15435 | 262 | 18366 | 18 | 501 | -3076 |
| January 3, 2018 | 3 | 0 | 15251 | 264 | 18185 | 18 | 428 | -2970 |
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| January 3, 2018 | 5 | 0 | 15252 | 251 | 18395 | 18 | 349 | -3155 |
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| January 3, 2018 | 7 | 32.26 | 16749 | 263 | 19427 | 18 | 1148 | -3535 |
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| January 3, 2018 | 9 | 79.95 | 18344 | 219 | 21337 | 18 | 714 | -3585 |
| January 3, 2018 | 10 | 88.93 | 18589 | 209 | 21725 | 18 | 639 | -3555 |
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| January 4, 2018 | 8 | 64.7 | 17963 | 181 | 20620 | 22 | 1342 | -3796 |
| January 4, 2018 | 9 | 67.25 | 18510 | 161 | 21115 | 22 | 1290 | -3841 |
| January 4, 2018 | 10 | 66.97 | 18606 | 135 | 20943 | 19 | 1407 | -3657 |
| January 4, 2018 | 11 | 61.74 | 18527 | 114 | 20760 | 26 | 1638 | -3735 |
| January 4, 2018 | 12 | 58.55 | 18432 | 191 | 20320 | 26 | 2067 | -3754 |
| January 4, 2018 | 13 | 51.98 | 18309 | 207 | 20077 | 22 | 2267 | -3778 |
| January 4, 2018 | 14 | 13.35 | 18274 | 172 | 20233 | 20 | 1989 | -3675 |
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| January 4, 2018 | 24 | 106.23 | 17563 | 303 | 20262 | 17 | 317 | -2735 |
| January 5, 2018 | 1 | 18.5 | 16802 | 278 | 18817 | 21 | 816 | -2328 |
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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
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| January 6, 2018 | 15 | 61 | 18471 | 244 | 21756 | 41 | 542 | -3651 |
| January 6, 2018 | 16 | 67.48 | 18621 | 269 | 22103 | 40 | 544 | -3760 |
| January 6, 2018 | 17 | 78.69 | 19346 | 196 | 22515 | 40 | 499 | -3556 |
| January 6, 2018 | 18 | 246.37 | 20321 | 107 | 23384 | 41 | 627 | -3431 |
| January 6, 2018 | 19 | 75.54 | 20213 | 67 | 22470 | 40 | 500 | -2655 |
| January 6, 2018 | 20 | 60.75 | 19910 | 116 | 22396 | 21 | 582 | -3071 |
| January 6, 2018 | 21 | 75.64 | 19701 | 145 | 22696 | 20 | 265 | -3263 |
| January 6, 2018 | 22 | 104 | 19208 | 199 | 22771 | 19 | 124 | -3540 |
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| March 5, 2018 | 5 | 6.04 | 13434 | 282 | 16009 | 13 | 564 | -2844 |
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| March 13, 2018 | 15 | 5.91 | 15708 | 292 | 16605 | 15 | 1323 | -1835 |
| March 13, 2018 | 16 | 14.35 | 15972 | 324 | 17234 | 15 | 873 | -1797 |
| March 13, 2018 | 17 | 14.35 | 16417 | 306 | 17223 | 17 | 1348 | -1779 |
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| March 13, 2018 | 20 | 26.25 | 17454 | 334 | 17862 | 13 | 1733 | -1690 |
| March 13, 2018 | 21 | 23.91 | 16907 | 324 | 17678 | 13 | 1478 | -1837 |
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| March 13, 2018 | 24 | 2.55 | 14076 | 363 | 15531 | 14 | 1219 | -2219 |
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| March 15, 2018 | 15 | 13.35 | 15350 | 285 | 17304 | 19 | 362 | -2040 |
| March 15, 2018 | 16 | 17.1 | 15570 | 325 | 17583 | 19 | 301 | -1965 |
| March 15, 2018 | 17 | 26.12 | 16060 | 319 | 17733 | 19 | 246 | -1624 |
| March 15, 2018 | 18 | 21.65 | 16424 | 309 | 18112 | 19 | 490 | -1858 |
| March 15, 2018 | 19 | 19.46 | 17132 | 243 | 18012 | 19 | 1220 | -1844 |
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| March 18, 2018 | 1 | 33.75 | 13339 | 297 | 14318 | 14 | 1956 | -2539 |
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| March 19, 2018 | 1 | 0.98 | 13132 | 296 | 14069 | 14 | 2030 | -2617 |
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| March 20, 2018 | 1 | 30.95 | 13748 | 338 | 15381 | 12 | 1081 | -2220 |
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| March 21, 2018 | 1 | 13.37 | 13621 | 264 | 15615 | 12 | 650 | -2340 |
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| March 21, 2018 | 3 | 6.19 | 13417 | 286 | 15109 | 12 | 1139 | -2564 |
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| April 16, 2018 | 1 | 23.31 | 13427 | 287 | 14198 | 23 | 1789 | -2091 |
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| April 18, 2018 | 2 | 27.53 | 13130 | 294 | 14386 | 18 | 1387 | -2350 |
| April 18, 2018 | 3 | 9.66 | 13076 | 294 | 14160 | 18 | 1275 | -2004 |
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| April 19, 2018 | 7 | 90.13 | 15910 | 283 | 16406 | 17 | 1180 | -1281 |
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| April 20, 2018 | 4 | 43.98 | 13067 | 259 | 14775 | 13 | 310 | -1733 |
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| April 20, 2018 | 11 | 43.26 | 14361 | 263 | 15729 | 19 | 567 | -1538 |
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| April 21, 2018 | 9 | 36.21 | 13506 | 198 | 15166 | 17 | 567 | -1968 |
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| April 23, 2018 | 2 | 0 | 11382 | 262 | 13763 | 16 | 464 | -2616 |
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| April 23, 2018 | 4 | 0 | 11654 | 189 | 13860 | 16 | 458 | -2535 |
| April 23, 2018 | 5 | 3.17 | 12429 | 159 | 14400 | 16 | 465 | -2428 |
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| April 23, 2018 | 11 | 13.19 | 13598 | 147 | 15287 | 16 | 613 | -2211 |
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| April 24, 2018 | 22 | 18.23 | 13998 | 255 | 14544 | 16 | 1229 | -1511 |
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| April 25, 2018 | 13 | 11.57 | 15147 | 177 | 15791 | 17 | 1508 | -1936 |
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| May 19, 2018 | 17 | 17.08 | 13692 | 261 | 16364 | 18 | 314 | -2757 |
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| May 26, 2018 | 15 | 30.51 | 15991 | 257 | 17061 | 18 | 1432 | -2251 |
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| June 7, 2018 | 1 | 5.88 | 11667 | 308 | 14414 | 15 | 287 | -2844 |
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| July 11, 2018 | 5 | 21.47 | 12935 | 304 | 15784 | 18 | 313 | -2832 |
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| August 4, 2018 | 7 | 15.42 | 13948 | 247 | 14900 | 18 | 416 | -1119 |
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| August 5, 2018 | 15 | 38.83 | 19650 | 202 | 20446 | 36 | 1925 | -2608 |
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| February 28, 2019 | 16 | 31.58 | 17109 | 106 | 17574 | 22 | 1707 | -2106 |
| February 28, 2019 | 17 | 31.97 | 17804 | 158 | 18343 | 23 | 1720 | -2139 |
| February 28, 2019 | 18 | 42.27 | 18624 | 234 | 19469 | 52 | 1125 | -1876 |
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| March 3, 2019 | 16 | 40.27 | 16019 | 274 | 15716 | 15 | 1785 | -1241 |
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| March 6, 2019 | 3 | 30.72 | 15453 | 289 | 17020 | 15 | 1702 | -2957 |
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| March 10, 2019 | 8 | 38.23 | 14522 | 229 | 17059 | 14 | 222 | -2511 |
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| March 11, 2019 | 4 | 13.56 | 13372 | 269 | 16116 | 15 | 358 | -2833 |
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| March 13, 2019 | 3 | 12.08 | 13426 | 205 | 14895 | 15 | 109 | -1288 |
| March 13, 2019 | 4 | 13.96 | 13514 | 224 | 14982 | 14 | 109 | -1340 |
| March 13, 2019 | 5 | 16.65 | 14068 | 237 | 15461 | 14 | 194 | -1378 |
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| March 14, 2019 | 11 | 19.83 | 15919 | 221 | 18233 | 13 | 209 | -2334 |
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| March 16, 2019 | 13 | 15.36 | 14526 | 146 | 16631 | 13 | 919 | -2891 |
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| March 20, 2019 | 12 | 14.38 | 14702 | 248 | 16380 | 16 | 1077 | -2587 |
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| March 21, 2019 | 16 | 29.32 | 16281 | 118 | 16633 | 16 | 1829 | -2061 |
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| March 25, 2019 | 14 | 27.24 | 14524 | 244 | 16841 | 15 | 268 | -2346 |
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| March 26, 2019 | 23 | 25 | 14703 | 250 | 15043 | 13 | 1548 | -1636 |
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| March 31, 2019 | 3 | 5.86 | 12442 | 197 | 15131 | 12 | 255 | -2735 |
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| July 22, 2019 | 8 | 22.57 | 16350 | 229 | 16573 | 15 | 1647 | -1631 |
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| July 22, 2019 | 11 | 24.07 | 17636 | 217 | 17908 | 20 | 1639 | -1733 |
| July 22, 2019 | 12 | 24.88 | 17998 | 219 | 18484 | 21 | 1607 | -1958 |
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| July 25, 2019 | 24 | 19.4 | 15254 | 201 | 16435 | 13 | 1454 | -2470 |
| July 26, 2019 | 1 | 15.38 | 14266 | 217 | 15533 | 13 | 1463 | -2448 |
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| July 27, 2019 | 21 | 19.91 | 18034 | 180 | 19384 | 15 | 1672 | -2812 |
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| July 28, 2019 | 2 | 12.81 | 13601 | 188 | 16082 | 15 | 342 | -2541 |
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| August 5, 2019 | 5 | 2 | 11826 | 174 | 14068 | 12 | 389 | -2418 |
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| October 27, 2019 | 19 | 3.36 | 14987 | 105 | 17072 | 13 | 24 | -1736 |
| October 27, 2019 | 20 | 5.77 | 14602 | 114 | 16577 | 13 | 120 | -1841 |
| October 27, 2019 | 21 | 2.26 | 13959 | 107 | 15971 | 13 | 89 | -1835 |
| October 27, 2019 | 22 | 3.82 | 13285 | 206 | 15333 | 13 | 126 | -1896 |
| October 27, 2019 | 23 | -0.63 | 12377 | 217 | 14751 | 13 | 111 | -2019 |
| October 27, 2019 | 24 | -3.28 | 11845 | 214 | 14504 | 13 | 23 | -2380 |
| October 28, 2019 | 1 | -1.78 | 11645 | 126 | 14329 | 13 | 59 | -2606 |
| October 28, 2019 | 2 | 0 | 11418 | 186 | 14179 | 13 | 158 | -2705 |
| October 28, 2019 | 3 | 2.11 | 11405 | 159 | 14068 | 13 | 59 | -2565 |
| October 28, 2019 | 4 | -0.95 | 11576 | 151 | 14298 | 13 | 85 | -2619 |
| October 28, 2019 | 5 | 1.5 | 12161 | 165 | 14367 | 13 | 9 | -2024 |
| October 28, 2019 | 6 | 8.49 | 13562 | 148 | 15271 | 13 | 593 | -2121 |
| October 28, 2019 | 7 | 12.16 | 15056 | 148 | 16359 | 13 | 384 | -1476 |
| October 28, 2019 | 8 | 13.36 | 15190 | 175 | 16492 | 13 | 213 | -1329 |
| October 28, 2019 | 9 | 14.83 | 14814 | 155 | 15998 | 13 | 522 | -1540 |
| October 28, 2019 | 10 | 19.08 | 14616 | 164 | 15901 | 13 | 635 | -1683 |
| October 28, 2019 | 11 | 10.68 | 14314 | 117 | 15912 | 18 | 326 | -1734 |
| October 28, 2019 | 12 | 0 | 14021 | 171 | 15534 | 18 | 417 | -1694 |
| October 28, 2019 | 13 | 1.26 | 13994 | 148 | 15694 | 13 | 119 | -1621 |
| October 28, 2019 | 14 | 1.23 | 13926 | 162 | 15863 | 13 | 87 | -1833 |
| October 28, 2019 | 15 | 2.36 | 14107 | 174 | 15978 | 13 | 109 | -1764 |
| October 28, 2019 | 16 | 5.54 | 14721 | 166 | 16158 | 13 | 601 | -1881 |
| October 28, 2019 | 17 | 10.92 | 15474 | 150 | 16476 | 13 | 1084 | -1929 |
| October 28, 2019 | 18 | 15.86 | 16066 | 132 | 16732 | 13 | 1332 | -1765 |
| October 28, 2019 | 19 | 15.93 | 16262 | 167 | 17034 | 13 | 1271 | -1837 |
| October 28, 2019 | 20 | 25.44 | 15908 | 121 | 16647 | 13 | 1053 | -1596 |
| October 28, 2019 | 21 | 28.91 | 15233 | 152 | 16198 | 13 | 1030 | -1761 |
| October 28, 2019 | 22 | 17.2 | 14184 | 209 | 15835 | 14 | 411 | -1711 |
| October 28, 2019 | 23 | 9.04 | 13097 | 173 | 14768 | 14 | 343 | -1685 |
| October 28, 2019 | 24 | 6.16 | 12346 | 191 | 14142 | 16 | 419 | -1942 |

# TAB I

This is Exhibit "I" referred to in the Revised Affidavit of Brian Rivard sworn before me this 21st day of November, 2019.

*A Commissioner for Taking Affidavits*

**Lauren Theresa Daniel, a Commissioner, etc.,**
**Province of Ontario, while a Student-at-Law.**
**Expires April 8, 2022.**

# Demand Response

Markets require both a supply side and a demand side to function effectively. The demand side of wholesale electricity markets is underdeveloped. Wholesale power markets will be more efficient when the demand side of the electricity market becomes fully functional without depending on special programs as a proxy for full participation.

## Overview

- **Demand Response Jurisdiction.** In a panel decision issued May 23, 2014, the U.S. Court of Appeals for the District of Columbia Circuit vacated in its entirety Order No. 745, which provided for payment of demand-side resources at full LMP.[1] The decision calls into question the jurisdictional foundation for all demand response programs currently subject to FERC oversight, and, in particular, for those programs that involve FERC regulated payments to demand resources. *EPSA v. FERC* is now subject to a stay pending the Supreme Court's review of the decision in its October 2015 term. The Supreme Court granted certiorari on May 4, 2015.

  FirstEnergy filed an amended complaint on September 22, 2014, that seeks to extend *EPSA v. FERC* to the PJM capacity markets, and would, if granted, eliminate tariff provisions that provide for the compensation of Demand Resources as a form of supply effective May 23, 2014, and require a rerun of the 2017/2018 Base Residual Auction.[2]

  On March 31, 2015, the FERC rejected as premature certain tariff revisions filed by PJM on January 14, 2015, which had been intended to adapt the PJM demand response rules depending on the outcomes and timing of the outcomes on potential review of EPSA v. FERC and PJM's pending capacity performance proposal.[3]

- **Demand Response Activity.** Demand response includes the economic program and the emergency program. Emergency program revenue includes both capacity and energy revenue. The capacity market is still the primary source of revenue to participants in PJM demand response programs, including both capacity market revenue and the associated emergency energy revenue. In the first six months of 2015, capacity market revenue increased by $70.0 million, or 24.4 percent, from $287.4 million in the first six months of 2014 to $357.4 million in the first six months of 2015.[4] Emergency energy revenue decreased by $42.5 million, from $43.0 million in the first six months of 2014 to $0.5 million in the first six months of 2015. Economic program revenue is energy revenue only. Economic program credits decreased by $9.3 million, from $14.3 million in the first six mo nths of 2014 to $5.0 million in the first six months of 2015, a 65.2 percent decrease.[5] Total revenue in the first six months of 2015 increased by 4.9 percent from $348.8 million in the first six months of 2014 to $365.9 million in the first six months of 2015. Not all DR activities in the first six months of 2015 have been reported to PJM at the time of this report.

  All demand response energy payments are uplift. LMP does not cover demand response energy payments. Emergency demand response energy costs are paid by PJM market participants in proportion to their net purchases in the real-time market. Economic demand response energy costs are paid by real-time exports from the PJM Region and real-time loads in each zone for which the load-weighted average real-time LMP for the hour during which the reduction occurred is greater than the price determined under the net benefits test for that month.[6]

- **Demand Response Market Concentration.** Economic demand response was highly concentrated in the first six months of 2014 and 2015. The HHI for economic demand response reductions increased from 7522 in the first six months of 2014 to 7852 in the first six months of 2015. Emergency demand response was moderately concentrated in the first six months of 2015. The HHI for emergency demand response registrations was 1760. In 2015, the four largest companies contributed 65.3 percent of all registered emergency demand response resources.

1 Electric Power Supply Association v. FERC, No. 11-1486, *petition for en banc review denied*; *see Demand Response Compensation in Organized Wholesale Energy Markets*, Order No. 745, FERC Stats. & Regs. ¶ 31,322 (2011); *order on reh'g*, Order No. 745-A, 137 FERC ¶ 61,215 (2011); *order on reh'g*, Order No. 745-B, 138 FERC 61,148 (2012).
2 See FirstEnergy Service Company complaint, FERC Docket No. EL14-55-000, amending the complaint filed May 23, 2014.
3 150 FERC ¶ 61,251.
4 The total credits and MWh numbers for demand resources were calculated as of July 27, 2015 and may change as a result of continued PJM billing updates.
5 Economic credits are synonymous with revenue received for reductions under the economic load response program.
6 PJM: "Manual 28: Operating Agreement Accounting," Revision 64 (April 11, 2014), p 70.

- **Locational Dispatch of Demand Resources.** Beginning with the 2014/2015 Delivery Year, demand resources are dispatchable for mandatory reduction on a subzonal basis, defined by zip codes, only if the subzone is defined at least one day before dispatched. More locational dispatch of demand resources in a nodal market improves market efficiency. The goal should be nodal dispatch of demand resources with no advance notice required.

## Recommendations

The MMU recognizes the substantial uncertainty related to the treatment of demand response in wholesale power markets which depends on Supreme Court review and on FERC treatment of PJM's Capacity Performance filing. The MMU recognizes that PJM has incorporated some of these recommendations in the Capacity Performance filing. The status of each recommendation reflects the status at June 30, 2015.

- The MMU recommends that the tariff rules for demand response clarify that a resource and its CSP, if any, must notify PJM of material changes affecting the capability of the resource to perform as registered and to terminate registrations that are no longer capable of responding to PJM dispatch directives, such as in the case of bankrupt and out of service facilities. (Priority: Medium. New recommendation. Status: Not adopted.)
- The MMU recommends that, if demand response remains in the PJM market, there be only one demand response product, with an obligation to respond when called for all hours of the year, and that the demand response be on the demand side of the capacity market. (Priority: High. First reported 2013. Status: Not Adopted.[7] Pending before FERC.)
- The MMU recommends that, if demand response remains in the PJM market, the emergency load response program be classified as an economic program, responding to economic price signals and not an emergency program responding only after an emergency is called and not triggering the definition of an emergency. (Priority: High. First reported 2012. Status: Partially adopted.)
- The MMU recommends that, if demand response remains in the PJM market, a daily energy market must offer requirement apply to demand resources, comparable to the rule applicable to generation capacity resources.[8] (Priority: High. First reported 2013. Status: Not adopted. Pending before FERC.)
- The MMU recommends that, if demand response remains in the PJM market, demand response programs adopt an offer cap equal to the offer cap applicable to energy offers from generation capacity resources, currently $1,000 per MWh.[9] (Priority: High. First reported 2013. Status: Not adopted. Pending before FERC.)
- The MMU recommends that, if demand response remains in the PJM market, the lead times for demand resources be shortened to 30 minutes with an hour minimum dispatch for all resources. (Priority: Medium. First reported 2013. Status: Adopted in full, Q1, 2014.)
- The MMU recommends that, if demand response remains in the PJM market, demand resources be required to provide their nodal location on the electricity grid. (Priority: High. First reported 2011. Status: Not adopted.)
- The MMU recommends that, if demand response remains in the PJM market, measurement and verification methods for demand resources be further modified to more accurately reflect compliance. (Priority: Medium. First reported 2009. Status: Not adopted.)
- The MMU recommends that, if demand response remains in the PJM market, compliance rules be revised to include submittal of all necessary hourly load data, and that negative values be included when calculating event compliance across hours and registrations. (Priority: Medium. First reported 2012. Status: Not adopted.)
- The MMU recommends that, if demand response remains in the PJM market, PJM adopt the ISO-NE five-minute metering requirements in order to ensure that dispatchers have the necessary information for reliability and that market payments to demand resources be calculated

7 PJM's Capacity Performance proposal includes this change. See "Reforms to the Reliability Pricing Market ("RPM") and Related Rules in the PJM Open Access Transmission Tariff ("Tariff") and Reliability Assurance Agreement Among Load Serving Entities ("RAA")," Docket No. ER15-632-000 and "PJM Interconnection, L.L.C." Docket No. EL15-29-000.

8 See "Complaint and Motion to Consolidate of the Independent Market Monitor for PJM," Docket No. EL14-20-000 (January 27, 2014) at 1.

9 *Id* at 1.

based on interval meter data at the site of the demand reductions.[10] (Priority: Medium. First reported 2013. Status: Not adopted.)

- The MMU recommends that, if demand response remains in the PJM market, demand response event compliance be calculated for each hour and the penalty structure reflect hourly compliance. (Priority: Medium. First reported 2013. Status: Not adopted. Pending before FERC.)
- The MMU recommends that, if demand response remains in the PJM market, demand resources whose load drop method is designated as "Other" explicitly record the method of load drop. (Priority: Low. First reported 2013. Status: Adopted in full, Q2, 2014.)
- The MMU recommends that, if demand response remains in the PJM market, load management testing be initiated by PJM with limited warning to CSPs in order to more accurately represent the conditions of an emergency event. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends, as a preferred alternative to having PJM demand side programs, that demand response be on the demand side of the markets and that customers be able to avoid capacity and energy charges by not using capacity and energy at their discretion and that customer payments be determined only by metered load. (Priority: High. First reported 2014. Status: Not adopted. Pending before FERC.)

## Conclusion

A fully functional demand side of the electricity market means that end use customers or their designated intermediaries will have the ability to see real-time energy price signals in real time, will have the ability to react to real time prices in real time and will have the ability to receive the direct benefits or costs of changes in real-time energy use. In addition, customers or their designated intermediaries will have the ability to see current capacity prices, will have the ability to react to capacity prices and will have the ability to receive the direct benefits or costs of changes in the demand for capacity. A functional demand side of these markets means that customers will have the ability to make decisions about levels of power consumption based both on the value of the uses of the power and on the actual cost of that power.

With exception of large wholesale customers in some areas, most customers in PJM are not on retail rates that directly expose them to the wholesale price of energy or capacity. As a result, most customers in PJM do not have the direct ability to see, respond to or benefit from a response to price signals in PJM's markets. PJM's demand side programs are generally designed to allow customers (or their intermediaries in the form of load serving entities (LSEs) or curtailment service providers (CSPs)) to either directly, or through intermediaries, be paid as if they were directly paying the wholesale price of energy and capacity and avoiding those prices when reducing load. PJM's demand side programs are designed to provide direct incentives for load resources to respond, via load reductions, to wholesale market price signals and/or system emergency events.

If retail markets reflected hourly wholesale locational prices and customers or their intermediaries received direct savings associated with reducing consumption in response to real-time prices, there would not be a need for a PJM economic load response program, or for extensive measurement and verification protocols. In the transition to that point, however, as long as there are demand side programs, there is a need for robust measurement and verification techniques to ensure that transitional programs incent the desired behavior. The baseline methods used in PJM programs today are not adequate to determine and quantify deliberate actions taken to reduce consumption.

If demand resources are to continue competing directly with generation capacity resources in the PJM Capacity Market, the product must be defined such that it can actually serve as a substitute for generation. That is a prerequisite to a functional market design.

In order to be a substitute for generation, demand resources should be defined in PJM rules as an economic resource, as generation is defined. Demand resources should be required to offer in the Day-Ahead Energy Market and

10 See ISO-NE Tariff, Section III, Market Rule 1, Appendix E1 and Appendix E2, "Demand Response," <http://www.iso-ne.com/regulatory/tariff/sect_3/mr1_append-e.pdf>. (Accessed February 17, 2015) ISO-NE requires that DR have an interval meter with five minute data reported to the ISO and each behind the meter generator is required to have a separate interval meter. After June 1, 2017, demand response resources in ISO-NE must also be registered at a single node.

should be called when the resources are required and prior to the declaration of an emergency. Demand resources should be available for every hour of the year and not be limited to a small number of hours.

In order to be a substitute for generation, demand resources should provide a nodal location and should be dispatched nodally to enhance the effectiveness of demand resources and to permit the efficient functioning of the energy market.

In order to be a substitute for generation, compliance by demand resources to PJM dispatch instructions should include both increases and decreases in load. The current method applied by PJM simply ignores increases in load and thus artificially overstates compliance.

In order to be a substitute for generation, any demand resource and its CSP, if any, should be required to notify PJM of material changes affecting the capability of the resource to perform as registered and to terminate registrations that are no longer capable of responding to PJM dispatch directives, such as in the case of bankrupt and out of service facilities. Generation resources are required to inform PJM of any change in availability status, including outages and shutdown status.

As a preferred alternative, demand response would be on the demand side of the Capacity Market rather than on the supply side. Rather than complex demand response programs with their attendant complex and difficult to administer rules, customers would be able to avoid capacity and energy charges by not using capacity and energy at their discretion.

The long term appropriate end state for demand resources in the PJM markets should be comparable to the demand side of any market. Customers should use energy as they wish and that usage will determine the amount of capacity and energy for which each customer pays. There would be no counterfactual measurement and verification.

Under this approach, customers that wish to avoid capacity payments would reduce their load during expected high load hours. Capacity costs would be assigned to LSEs and by LSEs to customers, based on actual load on the system during these critical hours. Customers wishing to avoid high energy prices would reduce their load during high price hours. Customers would pay for what they actually use, as measured by meters, rather than relying on flawed measurement and verification methods. No M&V estimates are required. No promises of future reductions which can only be verified by M&V are required. To the extent that customers enter into contracts with CSPs or LSEs to manage their payments, M&V can be negotiated as part of a bilateral commercial contract between a customer and its CSP or LSE.

This approach provides more flexibility to customers to limit usage at their discretion. There is no requirement to be available year round or every hour of every day. There is no 30 minute notice requirement. There is no requirement to offer energy into the day-ahead market. All decisions about interrupting are up to the customers only and they may enter into bilateral commercial arrangements with CSPs at their sole discretion. Customers would pay for capacity and energy depending solely on metered load.

A transition to this end state should be defined in order to ensure that appropriate levels of demand side response are incorporated in PJM's load forecasts and thus in the demand curve in the capacity market for the next three years. That transition should be defined by the PRD rules, modified as suggested by the Market Monitor.

This approach would work under the current RPM design and this approach would work under the CP design. This approach is entirely consistent with any Supreme Court decision on *EPSA* as it does not require FERC to have jurisdiction over the demand side. This approach will allow the Commission to more fully realize its overriding policy objective to create competitive and efficient wholesale energy markets.

## PJM Demand Response Programs

All demand response programs in PJM can be grouped into economic and emergency programs.[11] Table 6-1 provides an overview of the key features of PJM demand response programs. Demand response program is used here to refer to both emergency and economic programs. Demand resource is used here to refer to both resources participating in the capacity market and resources participating in the energy market. In both the economic and emergency programs, CSPs are companies that seek to sign up end-use customers, participants, that have the ability to reduce load. After a demand response event occurs, PJM compensates CSPs for their participants' load reductions and CSPs in turn compensates their participants. Only CSPs are eligible to participate in the PJM Demand Response program, but a participant can register as a PJM special member and become a CSP without any additional cost of entry.

### Table 6-1 Overview of demand response programs

| | Emergency Load Response Program | | | Economic Load Response Program |
|---|---|---|---|---|
| | Load Management (LM) | | | |
| Market | Capacity Only | Capacity and Energy | Energy Only | Energy Only |
| Capacity Market | DR cleared in RPM | DR cleared in RPM | Not included in RPM | Not included in RPM |
| Dispatch Requirement | Mandatory Curtailment | Mandatory Curtailment | Voluntary Curtailment | Dispatched Curtailment |
| Penalties | RPM event or test compliance penalties | RPM event or test compliance penalties | NA | NA |
| Capacity Payments | Capacity payments based on RPM clearing price | Capacity payments based on RPM price | NA | NA |
| Energy Payments | No energy payment. | Energy payment based on submitted higher of "minimum dispatch price" and LMP. Energy payment during PJM declared Emergency Event mandatory curtailments. | Energy payment based on submitted higher of "minimum dispatch price" and LMP. Energy payment only for voluntary curtailments. | Energy payment based on full LMP. Energy payment for hours of dispatched curtailment. |

In a panel decision issued May 23, 2014, the U.S. Court of Appeals for the District of Columbia Circuit vacated in its entirety Order No. 745, which provided for payment of demand-side resources at full LMP.[12] The court found Order No. 745 arbitrary and capricious on its merits.[13] More importantly, the court found that the FERC lacked jurisdiction to issue Order No. 745 because the "rule entails direct regulation of the retail market - a matter exclusively within state control."[14] The decision calls into question the jurisdictional foundation for all demand response programs currently subject to FERC oversight, and, in particular, for those programs that involve FERC regulated payments to demand resources. *EPSA v. FERC* is now subject to a stay pending the Supreme Court's review of the decision in the October 2015 term. The Supreme Court granted certiorari on May 4, 2015.

FirstEnergy filed an amended complaint on September 22, 2014, that seeks to extend the finding in *EPSA v. FERC* to the PJM capacity market, and would, if granted, eliminate tariff provisions that provide for the compensation of Demand Resources as a form of capacity supply effective May 23, 2014.[15] The complaint also seeks to void the results of the 2017/2018 Base Residual Auction conducted in May 2014 and to rerun the auction excluding Demand Resources. The Market Monitor issued a report on July 10, 2014, analyzing the worst case effects in the event that such relief were granted.[16] The report concludes that "should a legal or policy decision be made to eliminate Demand

11 Throughout this document, emergency demand response refers to both emergency and pre emergency demand response.
12 Electric Power Supply Association v. FERC, No. 11-1486.
13 *Id.*, slip. op. at 14.
14 *Id.*
15 See FirstEnergy Service Company complaint, FERC Docket No. EL14-55-000, amending the complaint filed May 23, 2014.
16 See Monitoring Analytics, LLC, The 2017/2018 RPM Base Residual Auction: Sensitivity Analyses, which can be accessed at: <http://www.monitoringanalytics.com/reports/Reports/2014/IMM_20172018_RPM_BRA_Sensitivity_Analyses_20140710.pdf>.

Resources from its current participation as supply in the PJM capacity market, PJM markets could adapt."[17] The proceeding is pending before the Commission.

On March 31, 2015, the FERC rejected as premature certain tariff revisions filed by PJM on January 14, 2015, which had been intended to adapt the PJM demand response rules depending on the outcomes and timing of the outcomes on potential review of *EPSA v. FERC* and PJM's pending capacity performance proposal.[18,19]

*EPSA* presents an opportunity to reform the rules for demand response to make them consistent with the functioning of an efficient and competitive market. The current rules for demand response have evolved to create a negative impact on market efficiency and pose obstacles to the growth of an effective demand component to the market. This negative impact is not the result of demand side resources which are an invaluable part of the markets but is a result of current PJM rules. These flaws have been well documented, and some are the subject of pending litigation at the Commission.[20] Now is an appropriate time for decisive steps away from the flawed approach of treating demand as a form of supply and toward treating demand response as changes in demand.

17 *Id.* at 10.
18 150 FERC ¶ 61,251.
19 See Comments of the Independent Market Monitor for PJM, ER15-852-000 (February 13, 2015).
20 The Market Monitor has documented in numerous reports the price suppressing effects and market design flaws attributable to the current treatment of Demand Resources in the PJM Capacity Market, including:
• The failure to require performance from Demand Resources that is comparable to the performance provided by Generation Capacity Resources and that would therefore make Demand Resources substitutes for Generation Resources while providing substantially the same compensation to both. *See, e.g.,* Monitoring Analytics, LLC, 2013 State of the Market Report for PJM (March 13, 2013) ("2013 SOM") at 197, 203; *see also*, Monitoring Analytics, LLC, Analysis of the 2016/2017 RPM Base Residual Auction (April 18, 2014) at 3, 35–27 ("2016/2017 BRA Report"), which can be accessed at: <http://www.monitoringanalytics.com/reports/Reports/2014/IMM_Analysis_of_the_20162017_RPM_Base_Residual_Auction_20140418.pdf>.
• The failure to remove inferior Demand Resource products from the capacity markets which cannot, by definition of the products, be substitutes for Generation Resources and the failure to require demand resource products to respond year round during any hour.
• The failure to eliminate the 2.5 shift in the demand curve used in RPM Base Residual Actions. *See, e.g.,* 2013 SOM at 157, 160; 2016/2017 BRA Report at 4–5.
• The failure to require Demand Resources to make physical offers. *See, e.g.,* 2013 SOM at 160, 171–172; Monitoring Analytics, LLC, Analysis of Replacement Capacity for RPM Commitments: June 1, 2007 to June 1, 2013 (September 13, 2013), which can be accessed at: <http://www.monitoringanalytics.com/reports/Reports/2013/IMM_Report_on_Capacity_Replacement_Activity_2_20130913.pdf>; Comments of the Independent Market Monitor for PJM, Docket No. ER14-1461 (April 1, 2014).
• The failure to require Demand Resources to make daily offers into the Day-Ahead Energy Market as required of Generation Capacity Resources. *See, e.g.,* 2013 SOM at 197, 203; Complaint and Motion to Consolidate of the Independent Market Monitor for PJM, Docket No. EL14-20 (January 27, 2014).
• The failure to apply a uniform system offer cap to Demand Resources and Generation Capacity Resources. *Id.*
• The failure to develop measurement and verification rules sufficient to ensure that Demand Resources do not consume capacity when it is needed by those who pay for it. *See, e.g.,* 2013 SOM at 197–198, 210; Comments of the Independent Market Monitor for PJM, Docket No. ER14-822 (January 1, 2014).

## Participation in Demand Response Programs

On April 1, 2012, FERC Order No. 745 was implemented in the PJM economic program, requiring payment of full LMP for dispatched demand resources when a net benefit test (NBT) price threshold is exceeded. This approach replaced the payment of LMP minus the charges for wholesale power and transmission already included in customers' tariff rates.

Figure 6-1 shows all revenue from PJM demand response programs by market for the first six months of each year for the period 2008 through 2015. Since the implementation of the RPM capacity market on June 1, 2007, demand response that participated through the capacity market, which includes emergency energy revenue, has been the primary source of revenue to demand response participants.[21]

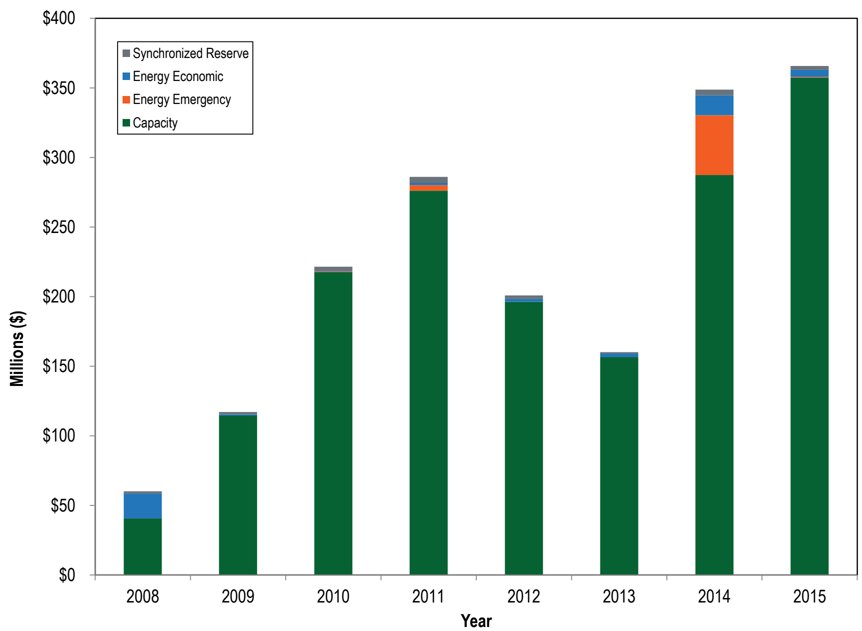
In the first six months of 2015, emergency revenue, which includes capacity and emergency energy revenue, accounted for 97.9 percent of all revenue received by demand response providers, credits from the economic program were 1.3 percent and revenue from synchronized reserve was 0.8 percent.

Total emergency revenue increased by $27.5 million, or 8.3 percent, from $330.4 million in the first six months of 2014 to $358.0 in 2015. Of the total emergency revenue, capacity market revenue increased by $70.0 million, or 24.4 percent, from $287.4 million in the first six months of 2014 to $357.4 million in the first six months of 2015, due to higher clearing prices and volumes in the capacity market for the 2013/2014 and 2014/2015 delivery years. The weighted average RPM price increased 23.1 percent from $99.39 per MW-day to $122.32 per MW-day.[22] Emergency energy revenue decreased by $42.5 million, from $43.0 million in the first six months of 2014 to $0.5 million in the first six months of 2015. Total revenue in the first six months of 2015 increased by 4.9 percent from $348.8 million in the first six months of 2014 to $365.9 million in the first six months of 2015.

21 This includes both capacity market revenue and emergency energy revenue for capacity resources.
22 *2014 State of the Market Report for PJM, Volume II,* Section 5: Capacity, Table 5-13.

Total credits under the economic program decreased by $9.3 million from $14.3 million in the first six months of 2014 to $5.0 million in the first six months of 2015, a 65.2 percent decrease.

Figure 6-1 Demand response revenue by market: January through June 2008 through 2015




## Economic Program

Table 6-2 shows registered sites and MW for the last day of each month for the period January 2010 through June 2015. Registration is a prerequisite for CSPs to participate in the economic program. The average number of registrations for economic demand response decreased and the average registered MW increased in the first six months of 2015 compared to the same time period in 2014. The average number of monthly registrations decreased by 42 from 1,068 in the first six months of 2014 to 1,026 in the first six months of 2015. The average monthly registered MW for the first six months of 2015 increased by 272 MW, or 10.5 percent, from 2,605 MW in the six months of 2014 to 2,877 MW in the first six months of 2015.

Several demand response resources are registered for both the economic and emergency demand response programs. There were 235 registrations and 1,409 nominated MW in the emergency program that were also registered in the economic program during the first six months of 2015.

### Table 6-2 Economic program registrations on the last day of the month: January 2010 through June 2015

| | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | | 2015 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | Registrations | Registered MW | Registrations | Registered MW | Registrations | Registered MW | Registrations | Registered MW | Registrations | Registered MW | Registrations | Registered MW |
| Jan | 1,841 | 2,623 | 1,609 | 2,432 | 1,993 | 2,385 | 841 | 2,314 | 1,180 | 2,325 | 1,078 | 2,960 |
| Feb | 1,842 | 2,624 | 1,612 | 2,435 | 1,995 | 2,384 | 843 | 2,327 | 1,174 | 2,330 | 1,076 | 2,956 |
| Mar | 1,845 | 2,623 | 1,612 | 2,519 | 1,996 | 2,356 | 788 | 2,284 | 1,185 | 2,692 | 1,075 | 2,949 |
| Apr | 1,849 | 2,587 | 1,611 | 2,534 | 189 | 1,318 | 970 | 2,346 | 1,194 | 2,827 | 1,076 | 2,938 |
| May | 1,875 | 2,819 | 1,687 | 3,166 | 371 | 1,669 | 1,375 | 2,414 | 745 | 2,511 | 980 | 2,846 |
| Jun | 813 | 1,608 | 1,143 | 1,912 | 803 | 2,347 | 1,302 | 2,144 | 928 | 2,943 | 871 | 2,614 |
| Jul | 1,192 | 2,159 | 1,228 | 2,062 | 942 | 2,323 | 1,315 | 2,443 | 1,036 | 3,006 | | |
| Aug | 1,616 | 2,398 | 1,987 | 2,194 | 1,013 | 2,373 | 1,299 | 2,527 | 1,080 | 3,033 | | |
| Sep | 1,609 | 2,447 | 1,962 | 2,183 | 1,052 | 2,421 | 1,280 | 2,475 | 1,077 | 2,919 | | |
| Oct | 1,606 | 2,444 | 1,954 | 2,179 | 828 | 2,269 | 1,210 | 2,335 | 1,060 | 2,943 | | |
| Nov | 1,605 | 2,444 | 1,988 | 2,255 | 824 | 2,267 | 1,192 | 2,307 | 1,063 | 2,995 | | |
| Dec | 1,598 | 2,439 | 1,992 | 2,259 | 846 | 2,283 | 1,192 | 2,311 | 1,071 | 2,923 | | |
| Avg. (Jan-Jun) | 1,678 | 2,481 | 1,546 | 2,500 | 1,225 | 2,077 | 1,020 | 2,305 | 1,068 | 2,605 | 1,026 | 2,877 |

### Table 6-3 Sum of peak MW reductions for all registrations per month: January through June, 2010 through 2015

| | Sum of Peak MW Reductions for all Registrations per Month | | | | | |
|---|---|---|---|---|---|---|
| Month | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| Jan | 183 | 132 | 110 | 193 | 450 | 169 |
| Feb | 121 | 89 | 101 | 119 | 307 | 336 |
| Mar | 115 | 81 | 72 | 127 | 369 | 198 |
| Apr | 111 | 80 | 108 | 133 | 146 | 143 |
| May | 172 | 98 | 143 | 192 | 151 | 154 |
| Jun | 209 | 561 | 954 | 433 | 483 | 605 |
| Annual (Jan - Jun) | 297 | 701 | 1,078 | 562 | 869 | 1,107 |

The registered MW in the economic load response program are not a good measure of the MW available for dispatch in the energy market. Economic resources can dispatch more, less or the same amount of MW registered in the program. Table 6-3 shows the sum of maximum economic MW dispatched by registration each month for January 2010 through June 2015. The monthly maximum is the sum of each registration's monthly noncoincident peak dispatched MW and the six month annual maximum is the sum of each registration's noncoincident peak dispatched MW during the first six months of the respective year. This aggregated maximum dispatched MW for all economic demand response registered resources in the first six months of 2015 increased by 238 MW, from 869 MW in the first six months of 2014 to 1,107 MW in the first six months of 2015.[23]

All demand response energy payments are uplift rather than market payments. Economic demand response energy costs are assigned to real-time exports from the PJM Region and real-time loads in each zone for which the load-weighted average real-time LMP for the hour during which the reduction occurred is greater than the price determined under the net benefits test for that month.[24] The zonal allocation is shown in Table 6-13.

Table 6-4 shows the total MW reductions made by participants in the economic program and the total credits paid for these reductions in the first six months of 2010 through 2015. The average credits per MWh paid in the first six months of 2015 decreased by $75.71 per MWh, or 45.3 percent, from $167.17 per MWh in 2014 to $91.45 per MWh dispatched in 2015. The average real-time load weighted PJM LMP decreased by $27.62 per MWh, from $69.92 per MWh during the first six months of 2014 to $42.30 per MWh during the first six months of 2015. Curtailed energy for the economic program was 54,342 MWh in the first six months of 2015 and the total payments were $4,969,863. Total credits paid for economic DR in the first six months of 2015 decreased by $9.3 million or 65.2 percent, compared to the first six months of 2014.

23 As a result of the 60 day data lag from event date to settlement, not all settlements for June 2015 are incorporated in this report.
24 PJM, "Manual 28: Operating Agreement Accounting," Revision 71 (June 1, 2015) p. 78.

**Table 6-4 Credits paid to the PJM economic program participants: January through June 2010 through 2015**

| Year (Jan-Jun) | Total MWh | Total Credits | $/MWh |
|---|---|---|---|
| 2010 | 20,225 | $761,854 | $37.67 |
| 2011 | 9,055 | $1,456,324 | $160.84 |
| 2012 | 38,714 | $2,165,599 | $55.94 |
| 2013 | 48,711 | $2,559,832 | $52.55 |
| 2014 | 85,530 | $14,297,951 | $167.17 |
| 2015 | 54,342 | $4,969,863 | $91.45 |

Economic demand response resources that are dispatched in both the economic and emergency programs at the same time are settled under emergency rules. For example, assume a demand resource has an economic strike price of $100 per MWh and an emergency strike price of $1,800 per MWh. If this resource were scheduled to reduce in the Day-Ahead Energy Market, the demand resource would receive $100 per MWh, but if an emergency event were called during the economic dispatch, the demand resource would receive its emergency strike price of $1,800 per MWh instead of the economic strike price of $100 per MWh. The rationale for this rule is not clear. All other resources that clear in the day-ahead market are financially firm at that clearing price.

Figure 6-2 shows monthly economic demand response credits and MWh, from January 2010 through June 2015. Higher energy prices and FERC Order No. 745 increased incentives to participate starting in April 2012. The high prices in the first three months of 2014 resulted in higher credits. Lower prices in the first three months of 2015 resulted in lower prices and lower credits.

**Figure 6-2 Economic program credits and MWh by month: January 2010 through June 2015**

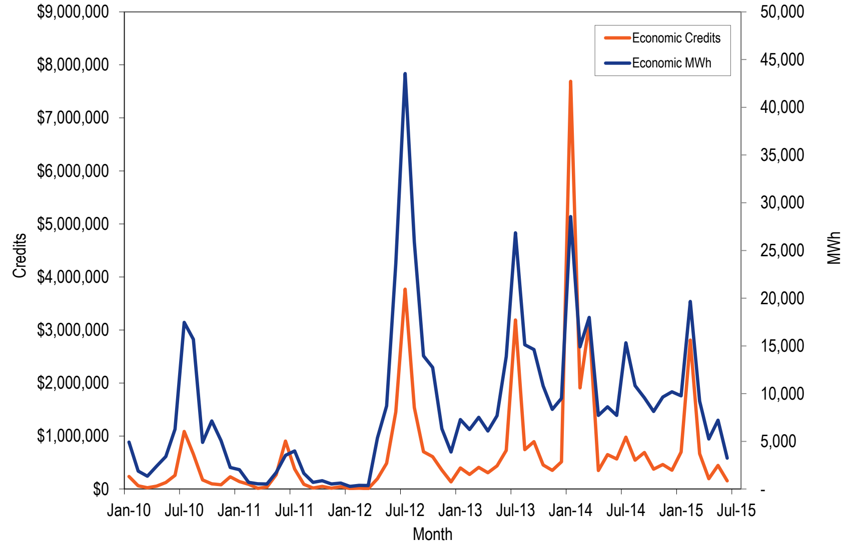



Table 6-5 shows performance for the first six months of 2014 and 2015 in the economic program by control zone and participation type. Total economic program reductions decreased 36.5 percent from 85,530 MW in the first six months of 2014 to 54,342 MW in the first six months of 2015. The economic credits decreased by 65.2 percent from $14,297,951 in the first six months of 2014, to $4,969,863 in the first six months of 2015.

## Table 6-5 PJM economic program participation by zone: January through June of 2014 and 2015[25]

| | Credits | | | MWh Reductions | | | Credits per MWh Reduction | | |
|---|---|---|---|---|---|---|---|---|---|
| Zones | 2014 | 2015 | Percent Change | 2014 | 2015 | Percent Change | 2014 | 2015 | Percent Change |
| AECO, JCPL, PECO, Pepco, RECO | $2,288,088 | $333,934 | (85.4%) | 7,887 | 1,618 | (79.5%) | $290.10 | $206.34 | (28.9%) |
| AEP, AP | $287,039 | $88,782 | (69.1%) | 2,867 | 953 | (66.7%) | $100.13 | $93.11 | (7.0%) |
| ATSI, ComEd, DAY, DEOK, DLCO, EKPC | $872,696 | $250,047 | (71.3%) | 6,568 | 5,365 | (18.3%) | $132.87 | $46.60 | (64.9%) |
| BGE, DPL, Met-Ed, PENELEC | $648,738 | $368,684 | (43.2%) | 4,965 | 6,416 | 29.2% | $130.67 | $57.47 | (56.0%) |
| Dominion | $7,901,371 | $3,262,696 | (58.7%) | 51,310 | 31,442 | (38.7%) | $153.99 | $103.77 | (32.6%) |
| PPL, PSEG | $2,300,020 | $665,718 | (71.1%) | 11,933 | 8,547 | (28.4%) | $192.74 | $77.89 | (59.6%) |
| Total | $14,297,951 | $4,969,863 | (65.2%) | 85,530 | 54,342 | (36.5%) | $167.17 | $91.45 | (45.3%) |

Table 6-6 shows total settlements submitted for the first six months of 2009 through 2015. A settlement is counted for every day on which a registration is dispatched in the economic program.

## Table 6-6 Settlements submitted by year in the economic program: January through June of 2009 through 2015

| Year (Jan - Jun) | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| Number of Settlements | 1,156 | 1,345 | 317 | 1,154 | 659 | 1,482 | 739 |

Table 6-7 shows the number of curtailment service providers (CSPs), and the number of participants in their portfolios, submitting settlements by year through the first six months of 2009 through 2015. There were 76 fewer active participants in the first six months of 2015 than in the first six months of 2014. All participants must be included in a CSP.

## Table 6-7 Participants and CSPs submitting settlements in the economic program by year: January through June of 2009 through 2015

| | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | | 2015 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Active CSPs | Active Participants | Active CSPs | Active Participants | Active CSPs | Active Participants | Active CSPs | Active Participants | Active CSPs | Active Participants | Active CSPs | Active Participants | Active CSPs | Active Participants |
| Total Distinct Active | 13 | 175 | 10 | 131 | 9 | 129 | 18 | 331 | 12 | 85 | 17 | 144 | 12 | 68 |

Parent companies may own one CSP or multiple CSPs. All HHI calculations in this section are at the parent company level.

Economic demand response was highly concentrated in the first six months of both 2014 and 2015. Table 6-8 shows the monthly HHI and the HHI for the first six months of 2015. The table also lists the share of reductions provided by, and the share of credits claimed by the four largest DR companies in each year. In the first six months of 2015, 88.4 percent of all Economic DR reductions and 91.1 percent of Economic DR revenue were attributable to the four largest DR companies. The HHI for demand response reductions increased 330 points, from 7522 in the first six months of 2014 to 7852 in the first six months of 2015.

## Table 6-8 HHI and market concentration in the economic program: January through June of 2014 and 2015

| | HHI | | | Top Four Companies Share of Reduction | | | Top Four Companies Share of Credit | | |
|---|---|---|---|---|---|---|---|---|---|
| Month | 2014 | 2015 | Percent Change | 2014 | 2015 | Change Percent | 2014 | 2015 | Change Percent |
| Jan | 7018 | 8081 | 15.1% | 88.0% | 96.8% | 8.8% | 84.2% | 98.6% | 14.4% |
| Feb | 6547 | 7358 | 12.4% | 84.1% | 91.4% | 7.4% | 77.5% | 87.8% | 10.3% |
| Mar | 7751 | 7539 | (2.7%) | 87.7% | 89.1% | 1.4% | 88.5% | 84.4% | (4.2%) |
| Apr | 8343 | 7216 | (13.5%) | 100.0% | 97.8% | (2.2%) | 100.0% | 97.8% | (2.2%) |
| May | 8090 | 7791 | (3.7%) | 98.8% | 98.8% | 0.1% | 99.1% | 99.4% | 0.3% |
| Jun | 8141 | 9344 | 14.8% | 91.5% | 100.0% | 8.5% | 87.9% | 100.0% | 12.1% |
| Total | 7522 | 7852 | 4.4% | 83.9% | 88.4% | 4.5% | 85.5% | 91.1% | 5.6% |

25 PJM and the MMU cannot publish more detailed information about the Economic Program Zonal Settlements as a result of confidentiality requirements.

Table 6-9 shows average MWh reductions and credits by hour for the first six months of 2014 and 2015. In the first six months of 2014, 84.2 percent of reductions and 82.9 percent of credits occurred from hours ending 0700 to 2100, and in the first six months of 2015, 92.2 percent of reductions and 88.4 percent of credits occurred from 0700 to 2100.

### Table 6-9 Hourly frequency distribution of economic program MWh reductions and credits: January through June 2014 and 2015

| | MWh Reductions | | | Program Credits | | |
|---|---|---|---|---|---|---|
| Hour Ending (EPT) | 2014 | 2015 | Percent Change | 2014 | 2015 | Percent Change |
| 1 | 739 | 265 | (64%) | $126,301 | $37,651 | (70%) |
| 2 | 707 | 253 | (64%) | $112,124 | $33,089 | (70%) |
| 3 | 863 | 277 | (68%) | $149,107 | $40,472 | (73%) |
| 4 | 1,453 | 345 | (76%) | $290,486 | $45,609 | (84%) |
| 5 | 1,512 | 335 | (78%) | $201,530 | $46,170 | (77%) |
| 6 | 2,184 | 660 | (70%) | $316,145 | $98,896 | (69%) |
| 7 | 5,110 | 3,408 | (33%) | $871,910 | $435,079 | (50%) |
| 8 | 6,072 | 4,951 | (18%) | $1,073,245 | $555,844 | (48%) |
| 9 | 6,287 | 5,348 | (15%) | $827,217 | $376,300 | (55%) |
| 10 | 6,107 | 3,903 | (36%) | $947,495 | $332,666 | (65%) |
| 11 | 4,329 | 2,816 | (35%) | $818,798 | $249,323 | (70%) |
| 12 | 3,244 | 2,533 | (22%) | $714,260 | $223,854 | (69%) |
| 13 | 3,513 | 2,441 | (31%) | $578,674 | $182,058 | (69%) |
| 14 | 4,123 | 2,553 | (38%) | $608,841 | $179,950 | (70%) |
| 15 | 4,595 | 2,663 | (42%) | $586,648 | $163,299 | (72%) |
| 16 | 4,877 | 2,985 | (39%) | $581,899 | $191,929 | (67%) |
| 17 | 4,962 | 3,437 | (31%) | $602,258 | $234,214 | (61%) |
| 18 | 5,477 | 3,739 | (32%) | $858,958 | $307,919 | (64%) |
| 19 | 4,712 | 4,082 | (13%) | $891,313 | $375,457 | (58%) |
| 20 | 4,522 | 2,881 | (36%) | $1,004,213 | $305,493 | (70%) |
| 21 | 4,057 | 2,390 | (41%) | $890,614 | $278,512 | (69%) |
| 22 | 2,857 | 1,089 | (62%) | $586,929 | $139,627 | (76%) |
| 23 | 1,760 | 517 | (71%) | $373,504 | $71,336 | (81%) |
| 24 | 1,471 | 473 | (68%) | $285,482 | $65,117 | (77%) |
| Total | 85,530 | 54,342 | (36%) | $14,297,951 | $4,969,863 | (65%) |

Table 6-10 shows the distribution of economic program MWh reductions and credits by ranges of real-time zonal, load-weighted, average LMP in the first six months of 2014 and 2015. Reductions occurred at all price levels. In the first six months of 2015, 1.3 percent of MWh reductions and 5.6 percent of program credits occurred during the hours when the applicable zonal LMP was higher than $400 per MWh.

### Table 6-10 Frequency distribution of economic program zonal, load-weighted, average LMP (By hours): January through June 2014 and 2015

| | MWh Reductions | | | Program Credits | | |
|---|---|---|---|---|---|---|
| LMP | 2014 | 2015 | Percent Change | 2014 | 2015 | Percent Change |
| $0 to $25 | 154 | 1,079 | 600% | $1,329 | $17,379 | 1,208% |
| $25 to $50 | 19,531 | 23,009 | 18% | $941,744 | $900,284 | (4%) |
| $50 to $75 | 14,921 | 8,712 | (42%) | $1,014,853 | $566,437 | (44%) |
| $75 to $100 | 9,116 | 6,231 | (32%) | $937,453 | $566,354 | (40%) |
| $100 to $125 | 4,373 | 3,963 | (9%) | $582,507 | $447,184 | (23%) |
| $125 to $150 | 4,061 | 2,334 | (43%) | $630,531 | $318,157 | (50%) |
| $150 to $175 | 3,820 | 1,625 | (57%) | $694,708 | $256,922 | (63%) |
| $175 to $200 | 3,515 | 1,703 | (52%) | $748,308 | $323,408 | (57%) |
| $200 to $225 | 3,064 | 1,465 | (52%) | $672,056 | $299,097 | (55%) |
| $225 to $250 | 3,039 | 921 | (70%) | $697,859 | $214,464 | (69%) |
| $250 to $275 | 2,537 | 613 | (76%) | $636,510 | $151,050 | (76%) |
| $275 to $300 | 1,944 | 611 | (69%) | $545,908 | $171,521 | (69%) |
| $300 to $325 | 1,538 | 363 | (76%) | $447,031 | $106,033 | (76%) |
| $325 to $350 | 1,229 | 233 | (81%) | $359,764 | $70,018 | (81%) |
| $350 to $375 | 1,404 | 609 | (57%) | $435,346 | $213,604 | (51%) |
| $375 to $400 | 1,080 | 194 | (82%) | $333,491 | $71,818 | (78%) |
| > $400 | 10,197 | 677 | (93%) | $4,618,554 | $276,133 | (94%) |
| Total | 85,524 | 54,341 | (36%) | $14,297,951 | $4,969,863 | (65%) |

Following Order No. 745, each month the NBT threshold price is calculated above which the net benefits of DR are deemed to exceed the cost to load. Demand resource (DR) reductions have two effects on the per MWh energy payment by loads and exports. DR reduces LMP by reducing demand in the energy market. At the same time, DR payments cause an additional uplift charge. The NBT threshold price is a monthly estimate calculated from the supply curve of PJM, and it does not incorporate the real-time or day-ahead prices. When the LMP is above the NBT threshold price, the demand response resource receives credit for the full LMP. Demand resources are not paid for any load reductions during hours where the LMP is below the NBT threshold price. About 0.75 percent of DR dispatch occurred during hours with LMP lower than the NBT threshold price.

Table 6-11 shows the NBT threshold price from April 2012, when FERC Order No. 745 was implemented in PJM, through June of 2015.

### Table 6-11 Result from net benefits tests: April 2012 through June 2015

| | Net Benefits Test Threshold Price ($/MWh) | | | |
|---|---|---|---|---|
| Month | 2012 | 2013 | 2014 | 2015 |
| Jan | | $25.72 | $29.51 | $29.63 |
| Feb | | $26.27 | $30.44 | $26.52 |
| Mar | | $25.60 | $34.93 | $24.99 |
| Apr | $25.89 | $26.96 | $32.59 | $24.92 |
| May | $23.46 | $27.73 | $32.08 | $23.79 |
| Jun | $23.86 | $28.44 | $31.62 | $23.80 |
| Jul | $22.99 | $29.42 | $31.62 | |
| Aug | $24.47 | $28.58 | $29.85 | |
| Sep | $24.93 | $28.80 | $29.83 | |
| Oct | $25.96 | $29.13 | $30.20 | |
| Nov | $25.63 | $31.63 | $29.17 | |
| Dec | $25.97 | $28.82 | $29.01 | |
| Average | $24.80 | $28.09 | $30.91 | $25.61 |

Table 6-12 shows the number of hours that at least one zone in PJM had day-ahead LMP or real-time LMP higher than the NBT threshold price. In the first six months of 2015, the highest zonal LMP in PJM was higher than the NBT threshold price 4,122 hours out of the entire 4,343 hours, or 94.9 percent of all hours. Reductions occurred in 3,660 hours, or 88.8 percent, of the 4,122 hours in the first six months of 2015. The last three columns illustrate how often economic demand response activity occurred when LMPs exceeded NBT threshold prices in the first six months 2014 and 2015.

### Table 6-12 Hours with price higher than NBT and DR occurrences in those hours: January through June 2014 and 2015

| | Number of Hours | Number of Hours with LMP Higher than NBT | | | Percent of NBT Hours with DR | | |
|---|---|---|---|---|---|---|---|
| Month | 2014/2015 | 2014 | 2015 | Percent Change | 2014 | 2015 | Change Percent |
| Jan | 744 | 742 | 669 | (9.8%) | 93.8% | 83.0% | (10.8%) |
| Feb | 672 | 672 | 670 | (0.3%) | 92.9% | 93.1% | 0.3% |
| Mar | 743 | 732 | 719 | (1.8%) | 81.8% | 90.8% | 9.0% |
| Apr | 720 | 661 | 713 | 7.9% | 86.5% | 96.6% | 10.1% |
| May | 744 | 694 | 692 | (0.3%) | 85.3% | 92.2% | 6.9% |
| Jun | 720 | 557 | 659 | 18.3% | 87.8% | 76.0% | (11.8%) |
| Total | 4,343 | 4,058 | 4,122 | 1.6% | 88.0% | 88.8% | 0.8% |

Following the implementation of FERC Order No. 745, DR in PJM is paid by real-time loads and real-time scheduled exports. Table 6-13 shows the sum of real-time DR charges and day-ahead DR charges for each zone and for exports. Real-time loads in AEP, Dominion, and ComEd paid the highest DR charges in the first six months of 2015.

### Table 6-13 Zonal DR charge: January through June 2015

| Zone | January | February | March | April | May | June | Total |
|---|---|---|---|---|---|---|---|
| AECO | $8,144 | $32,233 | $7,885 | $1,675 | $6,616 | $2,281 | $58,833 |
| AEP | $110,175 | $460,039 | $108,168 | $35,842 | $72,041 | $23,686 | $809,951 |
| AP | $46,313 | $186,348 | $43,950 | $14,169 | $28,086 | $8,842 | $327,707 |
| ATSI | $53,788 | $218,608 | $55,824 | $19,925 | $38,295 | $12,312 | $398,751 |
| BGE | $31,720 | $124,739 | $28,379 | $8,934 | $19,607 | $6,967 | $220,346 |
| ComEd | $58,545 | $275,905 | $69,202 | $18,046 | $41,958 | $17,432 | $481,087 |
| DAY | $14,864 | $56,946 | $14,135 | $4,813 | $9,766 | $3,325 | $103,849 |
| DEOK | $20,275 | $89,027 | $21,328 | $6,816 | $15,867 | $5,592 | $158,905 |
| DLCO | $93,812 | $388,679 | $84,586 | $26,191 | $58,781 | $21,378 | $673,427 |
| Dominion | $18,319 | $75,492 | $16,560 | $3,070 | $10,424 | $3,893 | $127,758 |
| DPL | $9,970 | $35,023 | $11,012 | $3,864 | $9,042 | $2,805 | $71,716 |
| EKPC | $11,403 | $54,120 | $11,522 | $2,788 | $6,373 | $2,386 | $88,592 |
| JCPL | $18,592 | $72,039 | $17,775 | $4,136 | $13,391 | $5,573 | $131,507 |
| Met-Ed | $13,736 | $53,971 | $13,034 | $2,642 | $8,469 | $2,246 | $94,097 |
| PECO | $34,695 | $137,349 | $32,562 | $6,487 | $22,784 | $6,665 | $240,543 |
| PENELEC | $15,541 | $60,547 | $15,391 | $4,838 | $9,408 | $2,849 | $108,575 |
| Pepco | $29,008 | $114,217 | $26,061 | $8,609 | $19,672 | $6,939 | $204,505 |
| PPL | $38,227 | $153,234 | $36,723 | $6,891 | $21,723 | $5,373 | $262,171 |
| PSEG | $36,731 | $133,282 | $33,547 | $8,416 | $24,227 | $9,509 | $245,712 |
| RECO | $1,231 | $4,301 | $1,110 | $291 | $1,053 | $360 | $8,347 |
| Export | $33,144 | $83,014 | $19,015 | $5,828 | $9,331 | $3,151 | $153,484 |
| Total | $698,233 | $2,809,114 | $667,768 | $194,270 | $446,913 | $153,565 | $4,969,863 |

Table 6-14 shows the total zonal DR charge per MWh of real-time load and exports during the first six months of 2015. On a dollar per MWh basis, real-time load and exports in EKPC paid the highest charges for economic demand response in the first six months of 2015. The highest average monthly per MWh charges for economic demand response occurred in February 2015, when real-time load and exports paid an average of $0.05/MWh.

### Table 6-14 Zonal DR charge per MWh of Load and Exports: January through June 2015

| Zone | January | February | March | April | May | June | Zonal Average |
|---|---|---|---|---|---|---|---|
| AECO | $0.016 | $0.046 | $0.013 | $0.005 | $0.010 | $0.006 | $0.016 |
| AEP | $0.021 | $0.046 | $0.013 | $0.005 | $0.010 | $0.004 | $0.017 |
| AP | $0.017 | $0.045 | $0.012 | $0.005 | $0.010 | $0.004 | $0.016 |
| ATSI | $0.018 | $0.043 | $0.012 | $0.005 | $0.010 | $0.004 | $0.015 |
| BGE | $0.016 | $0.046 | $0.012 | $0.005 | $0.010 | $0.004 | $0.016 |
| ComEd | $0.024 | $0.049 | $0.014 | $0.006 | $0.010 | $0.005 | $0.018 |
| DAY | $0.020 | $0.044 | $0.013 | $0.005 | $0.010 | $0.004 | $0.016 |
| DEOK | $0.022 | $0.049 | $0.015 | $0.006 | $0.010 | $0.004 | $0.018 |
| DLCO | $0.019 | $0.048 | $0.013 | $0.005 | $0.010 | $0.004 | $0.016 |
| Dominion | $0.017 | $0.048 | $0.013 | $0.005 | $0.009 | $0.006 | $0.016 |
| DPL | $0.019 | $0.048 | $0.012 | $0.005 | $0.010 | $0.004 | $0.017 |
| EKPC | $0.024 | $0.053 | $0.016 | $0.006 | $0.010 | $0.004 | $0.019 |
| JCPL | $0.017 | $0.047 | $0.013 | $0.005 | $0.011 | $0.007 | $0.017 |
| Met-Ed | $0.017 | $0.047 | $0.013 | $0.005 | $0.010 | $0.005 | $0.016 |
| PECO | $0.017 | $0.047 | $0.013 | $0.005 | $0.011 | $0.005 | $0.016 |
| PENELEC | $0.016 | $0.042 | $0.012 | $0.006 | $0.010 | $0.004 | $0.015 |
| Pepco | $0.017 | $0.047 | $0.012 | $0.005 | $0.010 | $0.004 | $0.016 |
| PPL | $0.017 | $0.047 | $0.013 | $0.005 | $0.010 | $0.005 | $0.016 |
| PSEG | $0.015 | $0.041 | $0.012 | $0.005 | $0.010 | $0.006 | $0.015 |
| RECO | $0.016 | $0.040 | $0.012 | $0.005 | $0.011 | $0.006 | $0.015 |
| Export | $0.012 | $0.031 | $0.009 | $0.004 | $0.005 | $0.002 | $0.011 |
| Monthly Average | $0.018 | $0.045 | $0.013 | $0.005 | $0.010 | $0.005 | $0.016 |

Table 6-15 shows the monthly day-ahead and real-time DR charges and the per MWh DR charges in the first six months of 2014 and 2015. The day-ahead DR charges decreased by $4.70 million, or 78.1 percent, from $6.02 million in the first six months of 2014 to $1.32 million in the first six months of 2015. The real-time DR charges decreased $4.63 million, or 55.9 percent, from $8.28 million in the first six months of 2014 to $3.65 million in the first six months of 2015. The per MWh charge paid by all real-time load and exports for economic DR decreased $0.05/MWh, or 90.7 percent, from $0.06/MWh in the first six months of 2014 to $0.01/MWh in the first six months of 2015.

Table 6-15 Monthly day-ahead and real-time DR charge: January through June 2014 and 2015

| | Day-ahead DR Charge | | | Real-time DR Charge | | | Per MWh Charge ($/MWh) | | |
|---|---|---|---|---|---|---|---|---|---|
| Month | 2014 | 2015 | Percent Change | 2014 | 2015 | Percent Change | 2014 | 2015 | Percent Change |
| Jan | $3,580,411 | $202,040 | (94%) | $4,108,903 | $496,193 | (88%) | $0.131 | $0.025 | (81%) |
| Feb | $1,148,053 | $647,566 | (44%) | $760,591 | $2,161,548 | 184% | $0.038 | $0.059 | 56% |
| Mar | $762,224 | $140,310 | (82%) | $2,366,688 | $527,458 | (78%) | $0.075 | $0.020 | (73%) |
| Apr | $67,996 | $58,036 | (15%) | $282,918 | $136,234 | (52%) | $0.012 | $0.008 | (35%) |
| May | $151,962 | $258,773 | 70% | $498,703 | $188,139 | (62%) | $0.024 | $0.015 | (38%) |
| Jun | $309,885 | $12,097 | (96%) | $259,651 | $141,468 | (46%) | $0.018 | $0.006 | (69%) |
| Total | $6,020,531 | $1,318,823 | (78%) | $8,277,454 | $3,651,040 | (56%) | $0.060 | $0.006 | (91%) |

## Emergency Program

The emergency load response program consists of the limited, extended summer and annual demand response product in the capacity market during the 2014/2015 Delivery Year. To participate as a limited demand resource, the provider must clear MW in an RPM auction. Emergency resources receive capacity revenue from the capacity market and also receive revenue from the energy market for reductions during a PJM initiated emergency event. The rules applied to demand resources in the current market design do not treat demand resources in a manner comparable to generation capacity resources, even though demand resources are sold in the same capacity market, are treated as a substitute for other capacity resources and displace other capacity resources in RPM auctions. The MMU recommends that if demand resources remain on the supply side of the capacity market, a daily must offer requirement in the Day-Ahead Energy Market apply to demand resources, comparable to the rule applicable to generation capacity resources. This will help to ensure comparability and consistency for demand resources. The MMU also recommends that demand resources have an offer cap equal to the offer cap applicable to energy offers from generation capacity resources, currently $1,000 per MWh.[26]

Emergency demand response was moderately concentrated in the first six months of 2015. The HHI for emergency demand response registrations was 1760 in 2014. In 2015 the four largest companies contributed 65.3 percent of all registered emergency demand response resources.

Table 6-16 shows zonal monthly capacity market revenue to demand resources for the first six months of 2015. Capacity market revenue increased in the first six months of 2015 by $70.0 million, or 24.4 percent, compared to the first six months of 2014, from $287.4 million to $357.4 million, as a result of higher RPM prices and more cleared DR in RPM for the 2013/2014 and 2014/2015 delivery years.

Table 6-16 Zonal monthly capacity revenue: January through June 2015

| Zone | January | February | March | April | May | June | Total |
|---|---|---|---|---|---|---|---|
| AECO | $411,097 | $371,313 | $411,097 | $805,435 | $832,282 | $985,380 | $3,816,604 |
| AEP, EKPC | $425,101 | $383,962 | $425,101 | $6,203,447 | $6,410,228 | $6,659,173 | $20,507,011 |
| AP | $185,478 | $167,528 | $185,478 | $3,380,132 | $3,492,803 | $3,174,034 | $10,585,454 |
| ATSI | $19,859 | $17,937 | $19,859 | $3,717,154 | $3,841,060 | $18,481,726 | $26,097,594 |
| BGE | $5,430,108 | $4,904,613 | $5,430,108 | $5,140,527 | $5,311,878 | $5,367,246 | $31,584,480 |
| ComEd | $405,926 | $366,643 | $405,926 | $5,846,358 | $6,041,237 | $6,463,717 | $19,529,806 |
| DAY | $63,670 | $57,508 | $63,670 | $872,987 | $902,087 | $736,289 | $2,696,212 |
| DEOK | $8,185 | $7,393 | $8,185 | $330,654 | $341,676 | $1,277,237 | $1,973,329 |
| DLCO | $49,718 | $44,907 | $49,718 | $840,774 | $868,800 | $849,964 | $2,703,881 |
| Dominion | $306,929 | $277,226 | $306,929 | $5,165,946 | $5,338,145 | $5,066,825 | $16,461,999 |
| DPL | $1,547,049 | $1,397,335 | $1,547,049 | $1,542,580 | $1,593,999 | $2,130,080 | $9,758,093 |
| JCPL | $1,495,628 | $1,350,890 | $1,495,628 | $1,709,946 | $1,766,944 | $1,665,010 | $9,484,045 |
| Met-Ed | $1,044,281 | $943,222 | $1,044,281 | $1,558,377 | $1,610,323 | $1,613,449 | $7,813,933 |
| PECO | $2,660,069 | $2,402,643 | $2,660,069 | $3,249,878 | $3,358,207 | $3,700,859 | $18,031,725 |
| PENELEC | $1,144,857 | $1,034,064 | $1,144,857 | $1,675,004 | $1,730,838 | $2,540,797 | $9,270,417 |
| Pepco | $1,906,591 | $1,722,082 | $1,906,591 | $3,467,834 | $3,583,429 | $4,096,205 | $16,682,731 |
| PPL | $3,247,272 | $2,933,020 | $3,247,272 | $5,215,729 | $5,389,586 | $5,411,083 | $25,443,961 |
| PSEG | $2,354,400 | $2,126,555 | $2,354,400 | $5,460,187 | $5,642,193 | $3,738,271 | $21,676,007 |
| RECO | $14,896 | $13,454 | $14,896 | $118,962 | $122,927 | $99,707 | $384,842 |
| Total | $22,721,111 | $20,522,294 | $22,721,111 | $56,301,913 | $58,178,643 | $74,057,052 | $254,502,124 |

Table 6-17 shows the amount of energy efficiency (EE) resources in PJM for 2012/2013 through 2015/2016 delivery years. Energy efficiency resources are offered in the PJM Capacity Market. The total MW of energy efficiency resources cleared in the capacity auction increased by 19.5 percent from 1,231.8 MW in the 2014/2015 delivery year to 1,471.4 MW in 2015/2016 Delivery Year.

26 See "Complaint and Motion to Consolidate of the Independent Market Monitor for PJM," Docket No. EL14-20-000 (January 28, 2014); "Comments of the Independent Market Monitor for PJM," Docket No. ER15-852-000 (February 13, 2015).

### Table 6-17 Energy efficiency resources by MW: 2012/2013 through 2015/2016 Delivery Year

| | EE ICAP (MW) | | | | EE UCAP (MW) | | | |
|---|---|---|---|---|---|---|---|---|
| | 2012/2013 | 2013/2014 | 2014/2015 | 2015/2016 | 2012/2013 | 2013/2014 | 2014/2015 | 2015/2016 |
| Total | 609.7 | 991.0 | 1,231.8 | 1,471.4 | 631.2 | 1,029.2 | 1,282.4 | 1,525.5 |

Table 6-18 shows the number of customers and the nominated MW by product type and lead time for the 2014/2015 Delivery Year. The annual and extended summer products are new for the 2014/2015 Delivery Year. The quick lead time product, which is obligated to respond within 30 minutes compared to short lead at 60 minutes and long lead at 120 minutes, is also new for the 2014/2015 Delivery Year. The quick lead time product has 7.5 percent of all nominated MW with 704.0 MW and only 22 locations.

The quick lead time product was defined after the auctions cleared. FERC accepted PJM's proposed 30 minute lead time as a phased in approach on May 9, 2014.[27] PJM submitted a filing on October 20, 2014, to allow DR that is unable to respond within 30 minutes to exit the market without penalty before the mandatory 30 minute lead time with the 2015/2016 Delivery Year.[28]

### Table 6-18 Lead time by product type: 2014/2015 Delivery Year

| Lead Type | Product Type | Locations | Nominated MW |
|---|---|---|---|
| Long Lead (120 Minutes) | Annual and Extended Summer | 2,079 | 1,130.9 |
| | Limited | 13,781 | 7,039.8 |
| Short Lead (60 Minutes) | Annual, Extended Summer and Limited | 55 | 485.7 |
| Quick Lead (30 Minutes) | Annual and Limited | 22 | 704.0 |
| Total | | 15,937 | 9,360.3 |

Table 6-19 shows the number of customers and nominated MW by product type and lead time during the 2015/2016 Delivery Year. The quick lead time product is the default lead time for the 2015/2016 Delivery Year, unless a CSP submits an exception request for 60 or 120 minute notification time due to a physical constraint.[29] There were 3,174 locations which have 4,334.6 MW of nominated MW capacity approved by PJM to respond in 60 or 120 minutes.

27 See "Order Rejecting, in part, and Accepting, in part, Proposed Tariff Changes, Subject to Conditions," Docket No. ER14-822-001 (May 9, 2014).
28 See "PJM Interconnection, L.L.C.," Docket No. ER14-135-000 (October 20, 2014).
29 See "Manual 18: Capacity Market," Revision 2 (August 3, 2015), p. 57.

### Table 6-19 Lead time by product type: 2015/2016 Delivery Year

| Lead Type | Product Type | Locations | Nominated MW |
|---|---|---|---|
| Long Lead (120 Minutes) | Annual and Extended Summer | 791 | 697 |
| | Limited | 1,957 | 3,058 |
| Short Lead (60 Minutes) | Extended Summer and Limited | 426 | 580 |
| Quick Lead (30 Minutes) | Annual | 191 | 174 |
| | Extended Summer | 3,723 | 2,043 |
| | Limited | 10,635 | 5,092 |
| Total | | 17,723 | 11,643 |

Table 6-20 shows the MW registered by measurement and verification method and by load drop method for the 2014/2015 Delivery Year. Of the DR MW committed, 2.4 percent use the guaranteed load drop (GLD) measurement and verification method, 91.2 percent use the firm service level (FSL) method and 6.3 percent use direct load control (DLC).

### Table 6-20 Reduction MW by each demand response method: 2014/2015 Delivery Year

| Program Type | On-site Generation MW | HVAC MW | Refrigeration MW | Lighting MW | Manufacturing MW | Water Heating or Other MW | Total | Percent by type |
|---|---|---|---|---|---|---|---|---|
| Firm Service Level | 2,119.6 | 1,970.8 | 207.4 | 740.6 | 3,428.5 | 69.9 | 8,536.8 | 91.2% |
| Guaranteed Load Drop | 25.2 | 152.9 | 1.8 | 12.2 | 33.9 | 0.5 | 226.6 | 2.4% |
| Non hourly metered sites (DLC) | 0.0 | 551.1 | 0.0 | 0.0 | 0.0 | 41.0 | 592.1 | 6.3% |
| Total | 2,144.7 | 2,674.8 | 209.2 | 752.8 | 3,462.4 | 111.4 | 9,355.4 | 100.0% |
| Percent by method | 22.9% | 28.6% | 2.2% | 8.0% | 37.0% | 1.2% | 100.0% | |

Table 6-21 shows the MW registered by measurement and verification method and by load drop method for the 2015/2016 Delivery Year. Of the DR MW committed, 1.6 percent use the guaranteed load drop (GLD) measurement and verification method, 94.3 percent use the firm service level (FSL) method and 4.1 percent use direct load control (DLC). FSL registrations increased by 2,437.9 MW while GLD registrations decreased by 38.8 MW and DLC registrations decreased by 111.9 MW from the 2014/2015 delivery year to the 2015/2016 delivery year.

### Table 6-21 Reduction MW by each demand response method: 2015/2016 Delivery Year

| Program Type | On-site Generation MW | HVAC MW | Refrigeration and Lighting MW | Manufacturing or Water Heating MW | Other, Batteries or Plug Load MW | Total MW | Percent by Type |
|---|---|---|---|---|---|---|---|
| Firm Service Level | 2,636.7 | 2,541.3 | 1,162.8 | 4,575.0 | 58.8 | 10,974.6 | 94.3% |
| Guaranteed Load Drop | 20.6 | 106.1 | 13.5 | 47.6 | 0.0 | 187.8 | 1.6% |
| Non hourly metered sites (DLC) | 0.0 | 444.9 | 0.0 | 35.3 | 0.0 | 480.1 | 4.1% |
| Total | 2,657.3 | 3,092.3 | 1,176.3 | 4,657.8 | 58.8 | 11,642.6 | 100.0% |
| Percent by method | 22.8% | 26.6% | 10.1% | 40.0% | 0.5% | 100.0% | |

Table 6-22 shows the fuel type used in the on-site generators identified in Table 6-20 for the 2014/2015 Delivery Year. Of the 22.9 percent of emergency demand response identified as using on-site generation, 85.5 percent of MW are diesel, 11.7 percent are natural gas and 2.8 percent is coal, gasoline, kerosene, oil, propane or waste products.

### Table 6-22 On-site generation fuel type by MW: 2014/2015 Delivery Year

| Fuel Type | MW | Percent |
|---|---|---|
| Coal, Gasoline, Kerosene, Oil, Propane, Waste Products | 59.6 | 2.8% |
| Diesel | 1,834.1 | 85.5% |
| Natural Gas | 251.0 | 11.7% |
| Total | 2,144.7 | 100.0% |

Table 6-23 shows the fuel type used in the on-site generators identified in Table 6-21 for the 2015/2016 Delivery Year. Of the 22.8 percent of emergency demand response identified as using on-site generation, 84.7 percent of MW are diesel, 12.0 percent are natural gas and 3.3 percent is coal, gasoline, kerosene, oil, propane or waste products.

### Table 6-23 On-site generation fuel type by MW: 2015/2016 Delivery Year

| Fuel Type | MW | Percent |
|---|---|---|
| Coal, Gasoline, Kerosene, Oil, Propane, Waste Products | 87.9 | 3.3% |
| Diesel | 2,250.9 | 84.7% |
| Natural Gas | 318.5 | 12.0% |
| Total | 2,657.3 | 100.0% |

## Emergency Event Reported Compliance

PJM declared two events in 2015, one on April 21, 2015 and one on April 22, 2015. There were two events during the 2014/2015 Delivery Year, 13 events during the 2013/2014 Delivery Year, two events during the 2012/2013 Delivery Year and one event in the 2011/2012 Delivery Year. Since all of the events in 2015 were called in PENELEC and there were no annual Demand Resources there, none were considered in PJM's compliance assessment.[30] Table 6-24 shows the demand response cleared UCAP MW for PJM by Delivery Year. Total demand response cleared in PJM increased by 3.4 percent from 14,943 MW in the 2014/2015 Delivery Year to 15,453.7 MW in the 2015/2016 Delivery Year. The total percent of capacity resources in the 2015/2016 Delivery Year decreased by 0.4 percent from 9.3 percent in the 2014/2015 Delivery Year to 8.9 percent in the 2015/2016 Delivery Year.

### Table 6-24 Demand response cleared MW UCAP for PJM: 2011/2012 through 2015/2016 Delivery Year

| | 2011/2012 Delivery Year | | 2012/2013 Delivery Year | | 2013/2014 Delivery Year | | 2014/2015 Delivery Year | | 2015/2016 Delivery Year | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DR Cleared MW UCAP | DR Percent of Capacity MW UCAP | DR Cleared MW UCAP | DR Percent of Capacity MW UCAP | DR Cleared MW UCAP | DR Percent of Capacity MW UCAP | DR Cleared MW UCAP | DR Percent of Capacity MW UCAP | DR Cleared MW UCAP | DR Percent of Capacity MW UCAP |
| Total | 1,826.6 | 1.4% | 8,740.9 | 6.2% | 10,779.6 | 6.7% | 14,943.0 | 9.3% | 15,453.7 | 8.9% |

Table 6-25 lists PJM pre-emergency and emergency load management events declared in PJM in 2015 and the affected zones. Subzonal dispatch was mandatory for the 2014/2015 Delivery Year but only if the subzone is defined no later than the day before. The Erie subzone was not defined the day before the PJM event and therefore it could not be dispatched. The Erie subzone was defined on April 21, 2015, which made it eligible for the April 22, 2015, call. The PENELEC Zone was the only zone called for both events. All demand response events called in 2015 were voluntary, so no penalties are assessed for under compliance.

### Table 6-25 PJM declared load management events: 2015

| Event Date | Event Times | Compliance Hours | Minutes not Measured for Compliance | Lead Time | Geographical Area |
|---|---|---|---|---|---|
| 21-Apr-15 | 20:20-21:30 | None | 70 | Long Lead | PENELEC |
| | 19:20-21:30 | None | 130 | Short Lead | PENELEC |
| | 18:50-21:30 | None | 160 | Quick Lead | PENELEC |
| 22-Apr-15 | 7:30-12:30 | None | 300 | Long Lead | PENELEC |
| | 6:30-12:30 | None | 360 | Short Lead | PENELEC |
| | 6:00-12:30 | None | 390 | Quick Lead | PENELEC |

Participants in the pre-emergency and emergency demand response program are paid based on the average performance by registration for the duration of a demand response event. Demand response should measure compliance hourly to accurately report reductions during demand response events. The current rules use the average reduction for the duration of an event. The average duration across multiple hours does not provide an accurate metric for each hour of the event. Measuring compliance hourly would provide accurate information to the PJM system. This would be consistent with the rules that apply to generation resources. The MMU recommends demand response event

30 Extended summer and limited demand response products do not need to respond in April.

compliance be calculated for each hour and the penalty structure reflect hourly compliance. With the new CP rules, demand response will be structured for hourly performance.

Subzonal dispatch by zip code is mandatory beginning on June 1, 2014, with the 2014/2015 Delivery Year only if the subzone is defined at least one day before dispatch. PJM allows compliance to be measured across zones within a compliance aggregation area (CAA). This changes the way CSPs dispatch resources when multiple electrically contiguous areas with the same RPM clearing prices are dispatched. The compliance rules determine how CSPs are paid and thus create incentives that CSPs will incorporate in their decisions about how to respond to PJM dispatch.[31] The multiple zone approach is less locational than the zonal and subzonal approach and creates larger mismatches between the locational need for the resources and the actual response. If multiple zones within a CAA are called by PJM, a CSP will dispatch the least cost resources across the zones to cover the CSP's obligation. This can result in more MW dispatched in one zone that are locationally distant from the need and 0 MW dispatched in another zone, yet the CSP could be considered 100 percent compliant and pay no penalties. More locational deployment of load management resources would improve efficiency. The MMU recommends that demand resources be required to provide their nodal location. Nodal dispatch of demand resources would be consistent with the nodal dispatch of generation.

Load increases are not netted against load decreases for dispatched demand resources across hours or across registrations within hours for compliance purposes, but are treated as zero. This skews the compliance results towards higher compliance since poorly performing demand resources are not used in the compliance calculation. When load is above the peak load contribution during a demand response event, the load reduction is negative; it is a load increase rather than a decrease. PJM ignores such negative reduction values and instead replaces the negative values with a zero MW reduction value. The PJM Tariff and PJM Manuals do not limit the compliance calculation value to a zero MW reduction value.[32] The compliance values PJM reports for demand response events are different than the actual compliance values accounting for both increases and decreases in load from demand resources that are called on and paid under the program.

The MMU recommends that compliance rules be revised to include submittal of all necessary hourly load data, and that negative values be included when calculating event compliance across hours and registrations.

Emergency demand response customers that registered for economic demand response had an adjusted baseline for the emergency event days. The change of baseline resulted in a greater calculated load reduction for the PJM system emergency event days. The changes in reported load reductions reflect emergency resources registering as economic resources to have modified baselines for measurement during the emergency voluntary event days.

Table 6-26 shows the performance for the April 21, 2015, event. The nominated value column shows the reduction capability indicated for each registration. The nominated MW are used to fulfill the committed MW capacity obligation and may exceed the committed MW. The committed MW are the MW cleared in the RPM auction. The sixth column shows the reported load reduction in MW during the hours of an event. The reported load reduction is reported by PJM and does not include load increases. The seventh column shows the observed load reduction in MWh, which includes all reported reduction values, including load increases. The observed load reduction is calculated by the MMU. The observed load reduction is a conservative estimate of what occurred during the demand response events as load increases are not required to be reported. Compliance is calculated by comparing the load reduction during an event to the committed MW value. The average row is the average results across both events for the PENELEC Zone.

The PENELEC Zone did not have any annual demand resources, resulting in voluntary compliance from the limited and extended summer products. The reported compliance for the PENELEC Control Zone on April 21, 2015, was 9.7 percent, or 27.4 MW out of 281.5 MW committed. The observed compliance for the PENELEC Control Zone on April 21, 2015 was 9.1 percent,

31 See "Manual 18: Capacity Market," Revision 28 (August, 3, 2015) p. 152.
32 PJM. OATT Attachment K § PJM Emergency Load Response Program at Reporting and Compliance.

or 25.5 MW out of 281.5 MW committed. The reported compliance for the PENELEC Control Zone on April 22, 2015 was 13.6 percent, or 38.3 MW out of 281.5 MW committed. The observed compliance for the PENELEC Control Zone on April 22, 2015 was 13.0 percent, or 36.7 MW out of 281.5 MW committed. Overall, the reported compliance for the PENELEC Control Zone was 11.7 percent, or 32.9 MW out of 281.5 MW committed. The observed compliance was 11.0 percent, or 31.1 MW, a difference of 1.8 MW compared to the reported load reduction.

### Table 6-26 Demand response event performance: April 21, 2015 and April 22, 2015

| Event Date | Zone | Product Type | Nominated ICAP (MW) | Committed MW | Load Reduction Reported (MW) | Load Reduction Observed (MW) | Difference | Percent Compliance Reported | Percent Compliance Observed |
|---|---|---|---|---|---|---|---|---|---|
| 21-Apr-15 | PENELEC | Limited and Extended Summer | 39.5 | 281.5 | 27.4 | 25.5 | 1.93 | 9.7% | 9.1% |
| 22-Apr-15 | PENELEC | Limited and Extended Summer | 40.8 | 281.5 | 38.3 | 36.7 | 1.67 | 13.6% | 13.0% |
| Average | PENELEC | Limited and Extended Summer | 40.1 | 281.5 | 32.9 | 31.1 | 1.80 | 11.7% | 11.0% |

Performance for specific customers varied significantly. Table 6-27 shows the distribution of participant event days by performance levels for the two events in the April 2015. Table 6-27 includes the participation for all resources dispatched for the emergency events. For these events, 45.9 percent of participant event days showed no reduction, load increased or participants did not report data. For these events, 61.4 percent of participants event days provided less than half of their nominated MW, while 58.7 percent of the nominated MW provided less than half of their nominated MW. There were 38.6 percent of participants that reduced more than 50 percent of their nominated MW, while 41.3 percent of the nominated MW reduced more than 50 percent of their nominated MW.

### Table 6-27 Distribution of participant event days and nominated MW across ranges of performance levels across the events: 2015

| Ranges of performance as a percent of nominated ICAP MW | Number of participant event days | Proportion of participant event days | Nominated MW | Proportion of Nominated MW |
|---|---|---|---|---|
| 0%, load increase, or no reporting | 101 | 45.9% | 37.4 | 40.9% |
| 0% - 50% | 34 | 15.5% | 16.4 | 17.9% |
| 50% - 300% | 85 | 38.6% | 37.8 | 41.3% |
| Total | 220 | 100.0% | 91.6 | 100.0% |

## Definition of Compliance

Currently, the calculation methods of event and test compliance do not provide reliable results. PJM's interpretation of load management event rules allows over compliance to be reported when there is no actual over compliance. Settlement locations with a negative load reduction value (load increase) are not netted by PJM within registrations or within demand response portfolios. A resource that has load above their baseline during a demand response event has a calculated negative performance value. PJM limits compliance shortfall values at the nominated MW value for underperformance. This is not explicitly stated in the Tariff or supporting Manuals. According to the Tariff, the compliance formulas for FSL and GLD customers allow for negative compliance values.[33] For example, if a registration had two locations, one with a 50 MWh load increase when called, and another with a 75 MWh load reduction when called, compliance for that registration is calculated as a 75

33 PJM. OATT. PJM Emergency Load Response Program.

MWh load reduction for that event hour. Settlement MWh are not netted across hours or across registrations for compliance purposes. A location with a load increase is set to a zero MW reduction. For example, in a two hour event, if a registration showed a 15 MWh load increase in hour one, but a 30 MWh reduction in hour two, the registration would show a 0 MWh reduction in hour one and a 30 MWh reduction in hour two and an average hourly 15 MWh load reduction for that two hour event. Reported compliance is less than actual compliance, as locations with load increases, negative reductions, are treated as zero for compliance purposes.

Settlements that are not submitted to PJM are treated as zero compliance for the event. Registrations with negative compliance are treated as zero for the purposes of imposing penalties and reporting.

Changing a demand resource compliance calculation from a negative value to 0 MW inaccurately values event performance and capacity performance. Inflated compliance numbers for an event overstates the true value and capacity of demand resources. A demand response capacity resource that performs negatively is also displacing another capacity resource that could supply capacity during a delivery year. By setting the negative compliance value to 0 MW, PJM is inaccurately calculating the value of demand resources.

An extreme example makes clear the fundamental problems with the use of measurement and verification methods to define the level of power that would have been used but for the DR actions, and the payments to DR customers that result from these methods. The current rules for measurement and verification for Demand Resources make a bankrupt company, a customer that no longer exists due to closing of a facility or a permanently shut down company, or a company with a permanent reduction in peak load due to a partial closing of a facility, an acceptable demand response customer under some interpretations of the tariff, although it is the view of the MMU that such customers should not be permitted to be included as registered demand resources. Companies that remain in business but with a substantially reduced load can maintain their pre-bankruptcy FSL (firm service level to which the customer agrees to reduce in an event) commitment which can be greater than or equal to the post-bankruptcy total load. The customer agrees to reduce to a level which is greater than or equal to its new peak load after bankruptcy. When demand response events occur the customer would receive credit for 100 percent reduction, even though the customer took no action and could take no action to reduce load. This problem exists regardless of whether the customer is still paying for capacity. Such a customer no longer has the ability to reduce load in response to price or a PJM demand response event. CSPs in PJM have and continue to register bankrupt customers as DR customers. PJM finds acceptable the practice of CSPs maintaining the registration of customers with a bankruptcy related reduction in demand that are unable, as a result, to respond to emergency events.

Table 6-28 shows the number of locations that did not report during the April 2015 event days. In total, 37.7 percent of locations did not report during the event days in 2015 and were assigned zero load response and as a result there is no way to know whether the load at those locations increased. These locations accounted for 30.1 percent of all nominated MW for those events. Response was voluntary as there was not any Annual Demand Resources in the PENELEC Control Zone.

**Table 6-28 Non-reporting locations and nominated ICAP: 2015 event days**

| | Locations not Reporting | Percent non Reporting | Nominated ICAP not Reporting | Percent non Reporting |
|---|---|---|---|---|
| Total | 83 | 37.7% | 34.6 | 30.1% |

## Emergency Energy Payments

For any PJM declared load management event in 2015, participants registered under the full option of the emergency load response program, which contains 99.6 percent of registrations, that were dispatched and demonstrated a load reduction were eligible to receive emergency energy payments. The emergency energy payments are equal to the higher of hourly zonal LMP or a strike price energy offer made by the participant, including a dollar per MWh minimum dispatch price and an associated shutdown cost. The new scarcity pricing rules increased the maximum DR energy price offer for the 2013/2014

Delivery Year to $1,800 per MWh. The maximum offer decreased to $1,599 per MWh for the 2014/2015 Delivery Year and increased to $1,849 per MWh for the 2015/2016 Delivery Year. The maximum generator offer will remain at $1,000 per MWh.[34,35]

Participants may elect to be paid their emergency offer, regardless of the zonal LMP.

Shutdown costs for demand response resources are not adequately defined in Manual 15. PJM's Cost Development Subcommittee (CDS) approved changes to Manual 15 to eliminate shutdown costs for demand response resources participating in the Synchronized Reserve Market, but not the emergency or economic demand response program.[36]

Table 6-29 shows the distribution of registrations and associated MW in the emergency full option across ranges of minimum dispatch prices for the 2014/2015 Delivery Year. The majority of participants, 94.7 percent, have a minimum dispatch price between $1,000 and $1,100 per MWh, and 0.1 percent of participants have a dispatch price between $1,276 and $1,549 per MWh, which is the maximum price allowed for the 2014/2015 Delivery Year. Energy offers are further increased by submitted shutdown costs, which, in the 2014/2015 Delivery Year, range from $0 to more than $10,000. Depending on the size of the registration, the shutdown costs can significantly increase the effective energy offer. The shutdown cost of resources with $1,101 to $1,275 per MWh strike prices had the highest average at $160.05 per location and $141.56 per MW..

### Table 6-29 Distribution of registrations and associated MW in the emergency full option across ranges of minimum dispatch prices: 2014/2015 Delivery Year[37]

| Ranges of Strike Prices ($/MWh) | Locations | Percent of Total | Nominated MW (ICAP) | Percent of Total | Shutdown Cost per Location |
|---|---|---|---|---|---|
| $0-$1 | 570 | 3.6% | 630.0 | 6.7% | $0.00 |
| $1-$999 | 218 | 1.4% | 160.9 | 1.7% | $28.54 |
| $1,000-$1,100 | 15,101 | 94.7% | 7,497.1 | 80.1% | $72.88 |
| $1,101-$1,275 | 29 | 0.2% | 368.7 | 3.9% | $160.05 |
| $1,276-$1,549 | 21 | 0.1% | 703.6 | 7.5% | $66.67 |
| Total | 15,939 | 100.0% | 9,360.3 | 100.0% | $69.81 |

Table 6-30 shows the distribution of registrations and associated MW in the emergency full option across ranges of minimum dispatch prices for the 2015/2016 Delivery Year. The majority of participants, 77.0 percent, have a minimum dispatch price between $1,550 and $1,850 per MWh, which is the maximum price allowed for the 2015/2016 Delivery Year, and 3.4 percent of participants have a dispatch price between $0 and $1 per MWh. Energy offers are further increased by submitted shutdown costs, which, in the 2014/2015 Delivery Year, range from $0 to more than $10,000. Depending on the size of the registration, the shutdown costs can significantly increase the effective energy offer. The shutdown cost of resources with $1,000 to $1,100 per MWh strike prices had the highest average at $183.69 per location.

34 139 FERC ¶ 61,057 (2012).
35 FERC accepted proposed changes to have the maximum strike price for 30 minute demand response to be $1,000/MWh + 1*Shortage penalty - $1.00 from ER14-822-000.
36 PJM. "Manual 15: Cost Development Guidelines," Revision 26 (November 5, 2014), p. 54.
37 In this analysis nominated MW does not include capacity only resources, which do not receive energy market credits.

### Table 6-30 Distribution of registrations and associated MW in the emergency full option across ranges of minimum dispatch prices: 2015/2016 Delivery Year[38]

| Ranges of Strike Prices ($/MWh) | Locations | Percent of Total | Nominated MW (ICAP) | Percent of Total | Shutdown Cost per Location | Shutdown Cost Per Nominated MW (ICAP) |
|---|---|---|---|---|---|---|
| $0-$1 | 609 | 3.4% | 562.9 | 4.8% | $0.00 | $0.00 |
| $1-$999 | 192 | 1.1% | 217.0 | 1.9% | $136.08 | $120.42 |
| $1,000-$1,100 | 2,850 | 16.1% | 3,698.1 | 31.8% | $183.69 | $141.56 |
| $1,101-$1,275 | 0 | 0.0% | 0.0 | 0.0% | $0.00 | $0.00 |
| $1,276-$1,549 | 422 | 2.4% | 514.0 | 4.4% | $59.11 | $48.53 |
| $1,550-$1,850 | 13,650 | 77.0% | 6,651.3 | 57.1% | $26.97 | $55.35 |
| Total | 17,723 | 100.0% | 11,643.2 | 100.0% | $53.19 | $80.97 |

Table 6-31 includes the energy reduction MWh and average real time LMP during the two demand response event days. The first column shows the hour for each event day. The second column has the emergency demand response MWh reductions, which are calculated by comparing each resource's CBL to their actual load during the demand response event.[39] If a resource is registered for both the economic and emergency program, the economic CBL is used for the emergency CBL. If a resource is only registered under the emergency option, the CBL is the load during the hour before the reductions occur.[40] If a resource could reduce prior to their designated lead time, that resource was eligible for energy settlements. The average LMP columns show the average LMP for each hour of the event day based on the zones that were called. The hourly LMP during the demand response events peaked at $51.66 per MWh in the hour beginning 20 on April 21, 2015.

38 In this analysis nominated MW does not include capacity only resources, which do not receive energy market credits.
39 This table assumes that PJM's CBL calculation is correct.
40 See "PJM Manual 11: Energy & Ancillary Services," Revision 76 (August 3, 2015) p. 134.

### Table 6-31 Energy reduction MWh and average real-time LMP during demand response event days: 2015

| | April 21, 2015 | | April 22, 2015 | |
|---|---|---|---|---|
| Hour Beginning | MWh Reduction | Average LMP ($/MWh) | MWh Reduction | Average LMP ($/MWh) |
| 0 | | 23.02 | | 25.71 |
| 1 | | 23.07 | | 24.53 |
| 2 | | 21.10 | | 22.90 |
| 3 | | 21.81 | | 22.32 |
| 4 | | 23.85 | | 23.79 |
| 5 | | 26.28 | | 24.18 |
| 6 | | 30.72 | 30.9 | 48.87 |
| 7 | | 30.01 | 42.3 | 37.34 |
| 8 | | 30.07 | 50.3 | 27.57 |
| 9 | | 26.12 | 53.8 | 28.64 |
| 10 | | 28.01 | 50.9 | 29.87 |
| 11 | | 28.22 | 52.1 | 31.96 |
| 12 | | 26.83 | 44.0 | 30.09 |
| 13 | | 27.34 | | 33.10 |
| 14 | | 27.02 | | 29.43 |
| 15 | | 27.11 | | 30.45 |
| 16 | | 29.29 | | 27.44 |
| 17 | | 29.62 | | 30.83 |
| 18 | 7.6 | 27.76 | | 27.32 |
| 19 | 11.8 | 27.32 | | 30.38 |
| 20 | 19.6 | 51.66 | | 43.51 |
| 21 | 34.9 | 31.02 | | 38.22 |
| 22 | | 23.28 | | 25.84 |
| 23 | | 18.88 | | 23.84 |
| Total | 73.9 | 27.48 | 324.2 | 29.92 |

Table 6-32 shows emergency energy revenue for each event day in the first six months of 2015. Energy payments in the emergency program differ significantly from energy payments in the economic program and from capacity payments through the emergency load response program in that they are not based on or tied to any market price signal. Once an emergency demand response event is called for a zone or sub zone, payments are guaranteed if a resource is determined to have responded. Emergency demand response energy costs are paid by PJM market participants in proportion to their net purchases in the Real-Time Energy Market.[41] Emergency demand response energy costs are not

41 PJM. "Manual 28: Operating Agreement Account," Revision 71 (June 1, 2015) p. 72.

covered by LMP. All demand response energy payments and shutdown costs are out of market payments. These payments are 100 percent uplift.

The events in April were both voluntary events since there were not any annual demand resources in PENELEC. April 22, 2015 had the longest event and the most MWh reductions, resulting in total emergency revenue of $416,883. The total emergency revenue for the two voluntary emergency event days were $510,860.

### Table 6-32 Emergency Revenue by event: 2015

| Event Date | Total |
|---|---|
| April 21, 2015 | $93,976 |
| April 22, 2015 | $416,883 |
| Total | $510,860 |

# TAB J

This is Exhibit **"J"** referred to in the Revised Affidavit of Brian Rivard sworn before me this 21st day of November, 2019

*A Commissioner for Taking Affidavits*

Lauren Theresa Daniel, a Commissioner, etc.,
Province of Ontario, while a Student-at-Law.
Expires April 8, 2022.

# Demand Response

Markets require both a supply side and a demand side to function effectively. The demand side of wholesale electricity markets is underdeveloped. Wholesale power markets will be more efficient when the demand side of the electricity market becomes fully functional without depending on special programs as a proxy for full participation.

## Overview

- **Demand Response Activity.** Demand response activity includes economic demand response (economic resources), emergency and pre-emergency demand response (demand resources), synchronized reserves and regulation. Economic demand response participates in the energy market. Emergency and pre-emergency demand response participates in the capacity market and energy market.[1] Demand response resources participate in the Synchronized Reserve Market. Demand response resources participate in the Regulation Market.

  In the first six months of 2019, total demand response revenue increased by $25.6 million, 9.4 percent, from $271.9 million in the first six months of 2018 to $297.5 million in the first six months of 2019. Emergency demand response revenue accounted for 99.0 percent of all demand response revenue, economic demand response for 0.2 percent, demand response in the Synchronized Reserve Market for 0.4 percent and demand response in the regulation market for 0.4 percent.

  Total emergency demand response revenue increased by $29.1 million, 10.9 percent, from $265.5 million in the first six months of 2018 to $294.6 million in the first six months of 2019. This increase consisted entirely of capacity market revenue.[2]

  Economic demand response revenue decreased by $1.0 million, 66.7 percent, from $1.6 million in the first six months of 2018 to $0.5 million in the first six months of 2019.[3] Demand response revenue in the Synchronized Reserve Market decreased by $2.0 million, 62.3 percent, from $3.2 million in the first six months of 2018 to $1.2 million in the first six months of 2019. Demand response revenue in the regulation market decreased by $0.5 million, 62.3 percent, from $1.6 million in the first six months of 2018 to $1.2 million in the first six months of 2019.

- **Demand Response Energy Payments are Uplift.** Energy payments to emergency and economic demand response resources are uplift. LMP does not cover energy payments although emergency and economic demand response can and does set LMP. Energy payments to emergency demand resources are paid by PJM market participants in proportion to their net purchases in the real-time market. Energy payments to economic demand resources are paid by real-time exports from PJM and real-time loads in each zone for which the load-weighted, average real-time LMP for the hour during which the reduction occurred is greater than or equal to the net benefits test price for that month.[4]

- **Demand Response Market Concentration.** The ownership of economic demand response resources was highly concentrated in 2018 and the first six months of 2019. The HHI for economic resource reductions increased by 373 points from 7541 in 2018 to 7914 in the first six months of 2019. The ownership of emergency demand response resources was moderately concentrated in the first six months of 2019. The HHI for emergency demand response committed MW was 1808 for the 2018/2019 Delivery Year and 1838 for the 2019/2020 Delivery Year. In the 2018/2019 Delivery Year, the four largest companies owned 78.1 percent of all committed demand response UCAP MW. In the 2019/2020 Delivery Year, the four largest companies owned 78.8 percent of all committed demand response UCAP MW.

- **Limited Locational Dispatch of Demand Resources.** Beginning with the 2014/2015 Delivery Year, demand resources that are not Capacity Performance, are dispatchable for mandatory reductions on a subzonal basis, defined by zip codes, but only if the subzone is defined at least one day before it is dispatched and only until PJM removes the definition of the subzone. Nodal dispatch of demand resources in a nodal market would

1 Emergency demand response refers to both emergency and pre-emergency demand response. With the implementation of the Capacity Performance design, there is no functional difference between the emergency and pre-emergency demand response resource.

2 The total credits and MWh numbers for demand resources were calculated as of July 23, 2019 and may change as a result of continued PJM billing updates.

3 Economic credits are synonymous with revenue received for reductions under the economic load response program.

4 "PJM Manual 28: Operating Agreement Accounting," § 11.2.2, Rev. 82 (July 25, 2019).

improve market efficiency. The goal should be nodal dispatch of demand resources with no advance notice required, as is the case for generation resources. With full implementation of the Capacity Performance rules in the capacity market starting with the 2020/2021 Delivery Year, PJM will be able to individually dispatch demand resources with no advanced notice, although PJM does not know the nodal location of demand resources.

## Recommendations

The MMU recognizes that PJM incorporated some of the recommendations related to demand response in the Capacity Performance filing. The status of each recommendation reflects the status at June 30, 2019.

- The MMU recommends, as a preferred alternative to including demand resources as supply in the capacity market, that demand resources be on the demand side of the markets, that customers be able to avoid capacity and energy charges by not using capacity and energy at their discretion, that customer payments be determined only by metered load, and that PJM forecasts immediately incorporate the impacts of demand side behavior. (Priority: High. First reported 2014. Status: Not adopted.)
- The MMU recommends that the option to specify a minimum dispatch price (strike price) for demand resources be eliminated and that participating resources receive the hourly real-time LMP less any generation component of their retail rate. (Priority: Medium. First reported 2010. Status: Not adopted.)
- The MMU recommends that the maximum offer for demand resources be the same as the maximum offer for generation resources. (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends that the demand resources be treated as economic resources, responding to economic price signals like other capacity resources. The MMU recommends that demand resources not be treated as emergency resources, not trigger a PJM emergency and not trigger a Performance Assessment Interval. (Priority: High. First reported 2012. Status: Not adopted.)
- The MMU recommends that the Emergency Program Energy Only option be eliminated because the opportunity to receive the appropriate energy market incentive is already provided in the economic program. (Priority: Low. First reported 2010. Status: Not adopted.)
- The MMU recommends that, if demand resources remain in the capacity market, a daily energy market must offer requirement apply to demand resources, comparable to the rule applicable to generation capacity resources.[5] (Priority: High. First reported 2013. Status: Not adopted.)
- The MMU recommends that demand resources be required to provide their nodal location, comparable to generation resources. (Priority: High. First reported 2011. Status: Not adopted.)
- The MMU recommends that PJM require nodal dispatch of demand resources with no advance notice required or, if nodal location is not required, subzonal dispatch of demand resources with no advance notice required. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends that PJM not remove any defined subzones and maintain a public record of all created and removed subzones. (Priority: Low. First reported 2016. Status: Not adopted.)
- The MMU recommends that PJM eliminate the measurement of compliance across zones within a compliance aggregation area (CAA). The multiple zone approach is less locational than the zonal and subzonal approach and creates larger mismatches between the locational need for the resources and the actual response. (Priority: High. First reported 2015. Status: Not adopted.)
- The MMU recommends that measurement and verification methods for demand resources be modified to reflect compliance more accurately. (Priority: Medium. First reported 2009. Status: Not adopted.)
- The MMU recommends that compliance rules be revised to include submittal of all necessary hourly load data, and that negative values be included when calculating event compliance across hours and registrations. (Priority: Medium. First reported 2012. Status: Not adopted.)

5 See "Complaint and Motion to Consolidate of the Independent Market Monitor for PJM," Docket No. EL14-20-000 (January 27, 2014) at 1.

- The MMU recommends that PJM adopt the ISO-NE five-minute metering requirements in order to ensure that operators have the necessary information for reliability and that market payments to demand resources be calculated based on interval meter data at the site of the demand reductions.[6] (Priority: Medium. First reported 2013. Status: Not adopted.)
- The MMU recommends limited, extended summer and annual demand response event compliance be calculated on an hourly basis for noncapacity performance resources and on a five minute basis for all capacity performance resources and that the penalty structure reflect five minute compliance. (Priority: Medium. First reported 2013. Status: Partially adopted.)
- The MMU recommends that load management testing be initiated by PJM with limited warning to CSPs in order to more accurately represent the conditions of an emergency event. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends that shutdown cost be defined as the cost to curtail load for a given period that does not vary with the measured reduction or, for behind the meter generators, be the start cost defined in Manual 15 for generators. (Priority: Low. First reported 2012. Status: Not adopted.)
- The MMU recommends that the Net Benefits Test be eliminated and that demand response resources be paid LMP less any generation component of the applicable retail rate. (Priority: Low. First reported 2015. Status: Not adopted.)
- The MMU recommends that the tariff rules for demand response clarify that a resource and its CSP, if any, must notify PJM of material changes affecting the capability of the resource to perform as registered and must terminate or modify registrations that are no longer capable of responding to PJM dispatch directives at defined levels because load has been reduced or eliminated, as in the case of bankrupt and/or out of service facilities. (Priority: Medium. First reported 2015. Status: Not adopted.)

6 See ISO-NE Tariff, Section III, Market Rule 1, Appendix E1 and Appendix E2, "Demand Response," <http://www.iso-ne.com/regulatory/tariff/sect_3/mr1_append-e.pdf>. (Accessed October 17, 2017) ISO-NE requires that DR have an interval meter with five-minute data reported to the ISO and each behind the meter generator is required to have a separate interval meter. After June 1, 2017, demand response resources in ISO-NE must also be registered at a single node.

- The MMU recommends that there be only one demand response product in the capacity market, with an obligation to respond when called for any hour of the delivery year. (Priority: High. First reported 2011. Status: Partially adopted.[7])
- The MMU recommends that the lead times for demand resources be shortened to 30 minutes with an hour minimum dispatch for all resources. (Priority: Medium. First reported 2013. Status: Partially adopted.)
- The MMU recommends setting the baseline for measuring capacity compliance under winter compliance at the customers' PLC, similar to GLD, to avoid double counting. (Priority: High. First reported 2010. Status: Partially adopted.)
- The MMU recommends the Relative Root Mean Squared Test be required for all demand resources with a CBL. (Priority: Low. First reported 2017. Status: Partially adopted.)
- The MMU recommends that PRD be required to respond during a PAI to be consistent with all CP resources. (Priority: High. First reported 2017. Status: Not adopted.)
- The MMU recommends that the limits imposed on the pre-emergency and emergency demand response share of the Synchronized Reserve Market be eliminated. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that 30 minute pre-emergency and emergency demand response be considered to be 30 minute reserves. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that energy efficiency MW not be included in the PJM capacity market and that PJM should ensure that the impact of EE measures on the load forecast is incorporated immediately rather than with the existing lag. (Priority: Medium. First reported 2018. Status: Not adopted.)
- The MMU recommends that demand reductions based entirely on behind the meter generation be capped at the lower of economic maximum or actual generation output. (Priority: High. New recommendation. Status: Not adopted.)

7 PJM's Capacity Performance design requires resources to respond when called for any hour of the delivery year.

## Conclusion

A fully functional demand side of the electricity market means that end use customers or their designated intermediaries will have the ability to see real-time energy price signals in real time, will have the ability to react to real-time prices in real time and will have the ability to receive the direct benefits or costs of changes in real-time energy use. In addition, customers or their designated intermediaries will have the ability to see current capacity prices, will have the ability to react to capacity prices and will have the ability to receive the direct benefits or costs of changes in the demand for capacity in the same year in which demand for capacity changes. A functional demand side of these markets means that customers will have the ability to make decisions about levels of power consumption based both on how customers value the power and on the actual cost of that power.

In the energy market, if there is to be a demand side program, demand resources should be paid the value of energy, which is LMP less any generation component of the applicable retail rate. There is no reason to have the net benefits test. The necessity for the net benefits test is an illustration of the illogical approach to demand side compensation embodied in paying full LMP to demand resources. The benefit of demand side resources is not that they suppress market prices, but that customers can choose not to consume at the current price of power, that individual customers benefit from their choices and that the choices of all customers are reflected in market prices. If customers face the market price, customers should have the ability to not purchase power and the market impact of that choice does not require a test for appropriateness.

If demand resources are to continue competing directly with generation capacity resources in the PJM Capacity Market, the product must be defined such that it can actually serve as a substitute for generation. This is a prerequisite to a functional market design. The Capacity Performance demand response product definition in the PJM Capacity Performance capacity market design is a significant step in that direction, although performance obligations are still not identical to other capacity resources. Demand resources do not have a must offer requirement into the day-ahead energy market, are able to offer above $1,000 per MWh without providing a fuel cost policy, or any rationale for the offer. PJM automatically triggers a PAI when demand resources are dispatched and demand resources do not have telemetry requirements similar to other Capacity Performance resources.

In order to be a substitute for generation, demand resources should be defined in PJM rules as an economic resource, as generation is defined. Demand resources should be required to offer in the Day-Ahead Energy Market and should be called when the resources are required and prior to the declaration of an emergency. Demand resources should be available for every hour of the year. The fact that PJM currently defines demand resources as emergency resources and the fact that calling on demand resources triggers a performance assessment interval (PAI) under the Capacity Performance design, both serve as a significant disincentive to calling on demand resources and mean that demand resources are underused. Demand resources should be treated as economic resources like any other capacity resource. Demand resources should be called when economic and paid the LMP rather than an inflated strike price up to $1,849 per MWh that is set by the seller.

In order to be a substitute for generation, demand resources should be subject to robust measurement and verification techniques to ensure that transitional DR programs incent the desired behavior. The methods used in PJM programs today are not adequate to determine and quantify deliberate actions taken to reduce consumption.

In order to be a substitute for generation, demand resources should provide a nodal location and should be dispatched nodally to enhance the effectiveness of demand resources and to permit the efficient functioning of the energy market. Both subzonal and multi-zone compliance should be eliminated because they are inconsistent with an efficient nodal market.

In order to be a substitute for generation, compliance by demand resources with PJM dispatch instructions should include both increases and decreases in load. The current method applied by PJM simply ignores increases in load and thus artificially overstates compliance.

In order to be a substitute for generation, reductions should be calculated hourly for dispatched DR. The current rules use the average reduction for the duration of an event. The average reduction across multiple hours does not provide an accurate metric for each hour of the event and is inconsistent with the measurement of generation resources. Measuring compliance hourly would provide accurate information to the PJM system. Under the new CP rules, the performance of demand response during Performance Assessment Interval (PAI) will be measured on a five-minute basis.

In order to be a substitute for generation, any demand resource and its Curtailment Service Provider (CSP), should be required to notify PJM of material changes affecting the capability of the resource to perform as registered and to terminate or modify registrations that are no longer capable of responding to PJM dispatch directives at the specified level, such as in the case of bankrupt and out of service facilities. Generation resources are required to inform PJM of any change in availability status, including outages and shutdown status.

As a preferred alternative, demand response resources should be on the demand side of the capacity market rather than on the supply side. Rather than detailed demand response programs with their attendant complex and difficult to administer rules, customers would be able to avoid capacity and energy charges by not using capacity and energy at their discretion and the level of usage paid for would be defined by metered usage rather than a complex and inaccurate measurement protocol.

The MMU peak shaving proposal at the Summer-Only Demand Response Senior Task Force (SODRSTF) is an example of how to create a demand side product that is on the demand side of the market and not on the supply side.[8] The MMU proposal was based on the BGE load forecasting program and Pennsylvania Act 129 Utility Program.[9] [10] Under the MMU proposal, participating load would inform PJM prior to an RPM auction of the MW participating, the months and hours of participation and the temperature humidity index (THI) threshold at which load would be reduced. PJM would reduce the load forecast used in the RPM auction based on the designated reductions. Load would agree to curtail demand to at or below a defined FSL, less than the customer PLC, when the THI exceeds a defined level or load exceeds a specified threshold. By relying on metered load and the PLC, load can reduce its demand for capacity and that reduction can be verified without complicated and inaccurate metrics to estimate load reductions. Under PJM's weakened version of the program, performance will be measured under the current economic demand response CBL rules which means relying on load estimates rather than actual metered load.[11] PJM's proposal includes only a THI curtailment trigger and not an overall load curtailment trigger.

The long term appropriate end state for demand resources in the PJM markets should be comparable to the demand side of any market. Customers should use energy as they wish and that usage will determine the amount of capacity and energy for which each customer pays. There would be no counterfactual measurement and verification.

Under this approach, customers that wish to avoid capacity payments would reduce their load during expected high load hours. Capacity costs would be assigned to LSEs and by LSEs to customers, based on actual load on the system during these critical hours. Customers wishing to avoid high energy prices would reduce their load during high price hours. Customers would pay for what they actually use, as measured by meters, rather than relying on flawed measurement and verification methods. No M&V estimates are required. No promises of future reductions which can only be verified by M&V are required. To the extent that customers enter into contracts with CSPs or LSEs to manage their payments, M&V can be negotiated as part of a bilateral commercial contract between a customer and its CSP or LSE.

This approach provides more flexibility to customers to limit usage at their discretion. There is no requirement to be available year round or every hour of every day. There is no 30 minute notice requirement. There is no requirement

8 See the MMU package within the *SODRSTF Matrix*, <http://www.pjm.com/-/media/committees-groups/task-forces/sodrstf/20180802/20180802-item-04-sodrstf-matrix.ashx>.

9 *Advance signals that can be used to foresee demand response days*, BGE, <https://www.pjm.com/-/media/committees-groups/task-forces/sodrstf/20180309/20180309-item-05-bge-load-curtailment-programs.ashx> (Accessed March 6, 2019).

10 *Pennsylvania ACT 129 Utility Program*, CPower, <https://www.pjm.com/-/media/committees-groups/task-forces/sodrstf/20180413/20180413-item-03-pa-act-129-program.ashx> (Accessed March 6, 2019).

11 The PJM proposal from the SODRSTF weakened the proposal but was approved at the October 25, 2018 Members Committee meeting and PJM filed Tariff changes on December 7, 2018. See "Peak Shaving Adjustment Proposal," Docket No. ER19-511-000 (December 7, 2018).

to offer energy into the day-ahead market. All decisions about interrupting are up to the customers only and they may enter into bilateral commercial arrangements with CSPs at their sole discretion. Customers would pay for capacity and energy depending solely on metered load.

A transition to this end state should be defined in order to ensure that appropriate levels of demand side response are incorporated in PJM's load forecasts and thus in the demand curve in the capacity market for the next three years. That transition should be defined by the PRD rules, modified as proposed by the MMU.

This approach would work under the CP design in the capacity market. This approach is entirely consistent with the Supreme Court decision in *EPSA* as it does not depend on whether FERC has jurisdiction over the demand side. This approach will allow FERC to more fully realize its overriding policy objective to create competitive and efficient wholesale energy markets. The decision of the Supreme Court addressed jurisdictional issues and did not address the merits of FERC's approach. The Supreme Court's decision has removed the uncertainty surrounding the jurisdictional issues and created the opportunity for FERC to revisit its approach to demand side.

## PJM Demand Response Programs

All PJM demand response programs can be grouped into economic, emergency and pre-emergency programs, or Price Responsive Demand (PRD). Under current rules, there is no functional difference between pre-emergency and emergency demand resources. Table 6-1 provides an overview of the key features of PJM demand response programs.

The current PRD rules do not align with the definition of capacity under the Capacity Performance construct despite PJM's attempt to create alignment.[12] The PJM proposed rule changes do not require reductions during PAI unless LMP is above the specified price threshold. PJM incorrectly values PRD capacity and measured performance.[13] Similar to emergency and pre-emergency demand response, PJM would limit the nominated MW for PRD resources to the lower of the Peak Load Contribution (PLC) minus the Firm Service Level (FSL) times the loss factor (LF) or the Winter Peak Load (WPL) multiplied by the Zonal Winter Weather Adjustment Factor (ZWWAF) minus the winter Firm Service Level (wFSL) times the loss factor for each zone.

$$PRD\ Value = Min\{(PLC - FSL * LF), (WPL * ZWWAF - wFSL)\} * zonal\ loss\ factor$$

Use of the WPL would artificially limit the amount of MW that can participate as PRD if the WPL is less than the PLC. The Commission rejected PJM's filing regarding PRD on June 27, 2019 for these reasons.[14]

Demand response activity includes economic demand response (economic resources), emergency and pre-emergency demand response (demand resources), synchronized reserves and regulation. Economic demand response participates in the energy market. Emergency and pre-emergency demand response participate in the capacity market and energy market.[15] Demand response resources participate in the Synchronized Reserve Market. Demand response resources participate in the regulation market.

All demand resources must register as pre-emergency unless the participant relies on behind the meter generation and the resource has environmental restrictions that limit the resource's ability to operate only in emergency conditions.[16] Under current rules, PJM will declare an emergency if pre-emergency or emergency demand response is dispatched. In all demand response programs, CSPs are companies that sign up customers that have the ability to reduce load. After a demand response event occurs, PJM compensates CSPs for their participants' load reductions and CSPs in turn compensate their participants. Only CSPs are eligible to participate in the PJM demand response programs, but a participant can register as a PJM special member and become a CSP without any additional cost.

12 See "Proposed Amendments to Price Response Demand Rules," Docket No. ER19-1012-000 (February 7, 2019).
13 See "Comments of the Independent Market Monitor for PJM," Docket No. ER19-1012 (February 28, 2019).
14 See 167 FERC ¶ 61,268 (June 27, 2019).
15 Emergency demand response refers to both emergency and pre-emergency demand response. With the implementation of the Capacity Performance design, there is no functional difference between the emergency and pre-emergency demand response resource.
16 OA Schedule 1 § 8.5.

PRD does not receive direct capacity or energy payments. PRD reduces the amount of capacity that must be purchased by the LSE and therefore reduces the LSE's payments for capacity. When PRD load is not on the system, that load also avoids paying for the associated energy. PRD meets its obligation by responding when LMP is at or above price thresholds defined in the PRD plan.[17] PRD does not have to respond during performance assessment intervals (PAI) and therefore is inferior to other capacity resources and is not a substitute for other capacity resources in the capacity performance construct. The MMU recommends that PRD be required to respond during a PAI to be consistent with all CP resources. PRD first cleared the capacity market in the BRA for the 2020/2021 Delivery Year, and cleared for the 2021/2022 Delivery Year.[18]

## Non-PJM Demand Response Programs

Within the PJM footprint, states may have additional demand response programs as part of a Renewable Portfolio Standard (RPS) or a separate program. Indiana, Ohio, Pennsylvania and North Carolina include demand response in their RPS. If demand response is dispatched by a state run program, the demand response resources are ineligible to receive payments from PJM during the state dispatch.

### Table 6-1 Overview of demand response programs

| | Emergency and Pre-Emergency Load Response Program | | | Economic Load Response Program | Price Responsive Demand |
|---|---|---|---|---|---|
| | Load Management (LM) | | | | |
| Market | Capacity Only | Capacity and Energy | Energy Only | Energy Only | Capacity Only |
| Capacity Market | DR cleared in RPM | DR cleared in RPM | Not included in RPM | Not included in RPM | PRD cleared in RPM |
| Dispatch Requirement | Mandatory Curtailment | Mandatory Curtailment | Voluntary Curtailment | Dispatched Curtailment | Price Threshold |
| Penalties | RPM event or test compliance penalties | RPM event or test compliance penalties | NA | NA | RPM event or test compliance penalties |
| Capacity Payments | Capacity payments based on RPM clearing price | Capacity payments based on RPM clearing price | NA | NA | Avoided capacity costs |
| Energy Payments | No energy payment | Energy payment based on submitted higher of "minimum dispatch price" and LMP. Energy payment during PJM declared Emergency Event mandatory curtailments. | Energy payment based on submitted higher of "minimum dispatch price" and LMP. Energy payment only for voluntary curtailments. | Energy payment based on full LMP. Energy payment for hours of dispatched curtailment. | NA |

17 The Demand Response Subcommittee (DRS) is currently working to align PRD with the CP designed products.
18 There were a total of 558 MW of cleared PRD in the 2020/2021 Delivery Year. See PJM Auction Results <https://www.pjm.com/-/media/markets-ops/rpm/rpm-auction-info/2020-2021-base-residual-auction-results.ashx?la=en>.

## Participation in Demand Response Programs

On April 1, 2012, FERC Order No. 745 was implemented in the PJM economic program, requiring payment of full LMP for dispatched demand resources when a net benefits test (NBT) price threshold is exceeded. This approach replaced the payment of LMP minus the charges for wholesale power and transmission included in customers' tariff rates.

Order No. 719 required PJM and other RTOs to amend their market rules to accept bids from aggregators of retail customers of utilities unless the laws or regulations of the relevant electric retail regulatory authority ("RERRA") do not permit the customers aggregated in the bid to participate.[19] PJM implemented rules that require PJM to verify with EDCs that no law or regulation of a RERRA prohibits an end use customers' participation.[20] EDCs and their end use customers are categorized as small and large based on whether the EDC distributed more or less than 4 million MWh in the previous fiscal year. End use customers within a large EDC must provide verification of any other contractual obligations or laws or regulations that prohibit participation, but end use customers within a small EDC do not need to provide additional verification.[21] RERRAs have permitted EDCs, in a number of cases, to participate in the PJM Economic Load Response Program. There are 188 active RERRAs within PJM.

Figure 6-1 shows all revenue from PJM demand response programs by market for the first six months of 2008 through 2019. Since the implementation of the RPM Capacity Market on June 1, 2007, the capacity market (demand resources) has been the primary source of demand response revenue.[22] In the first six months of 2019, total demand response revenue increased by $25.6 million, 9.4 percent, from $272.0 million in the first six months of 2018 to $297.5 million in the first six months of 2019. Total emergency demand response revenue increased by $29.1 million, 10.9 percent, from $265.5 million in the first six months of 2018 to $294.6 million in the first six months of 2019. This increase consisted entirely of capacity market revenue.[23] In the first six months of 2019, demand resource revenue, which includes capacity and emergency energy revenue, accounted for 99.0 percent of all revenue received by demand response providers, the economic program for 0.2 percent, synchronized reserve for 0.4 percent and the regulation market for 0.4 percent.

Economic demand response revenue decreased by $1.0 million, 66.7 percent, from $1.6 million in the first six months of 2018 to $0.5 million in the first six months of 2019.[24] Demand response revenue in the Synchronized Reserve Market decreased by $2.0 million, 62.3 percent, from $3.2 million in the first six months of 2018 to $1.2 million in the first six months of 2019. Demand response revenue in the regulation market decreased by $0.5 million, 28.8 percent, from $1.6 million in the first six months of 2018 to $1.2 million in the first six months of 2019.

Higher demand resource revenues were in part a result of higher capacity market prices in the 2018/2019 RPM auction clearing price. The capacity revenue in 2018 is from 2017/2018 RPM auction clearing prices and the capacity revenue in 2019 is from 2018/2019 RPM auction clearing prices. The annual capacity market prices increased $13.20 per MW-day from $151.50 in the 2017/2018 Delivery Year to $164.77 in the 2018/2019 Delivery Year, a 8.7 percent increase.

19 *Wholesale Competition in Regions with Organized Electric Markets*, Order No. 719, FERC Stats. & Regs. ¶ 31,281 at P 154 (2008), *order on reh'g*, Order No. 719-A, FERC Stats. & Regs. ¶ 31,292, *order on reh'g*, Order No. 719-B, 129 FERC ¶ 61,252 (2009).

20 The evidence supplied by LDCs must take the form of an order, resolution or ordinance of the RERRA, an opinion of the RERRA's legal counsel attesting to existence of an order, resolution, or ordinance, or an opinion of the state attorney general on behalf of the RERRA attesting to existence of an order, resolution or ordinance.

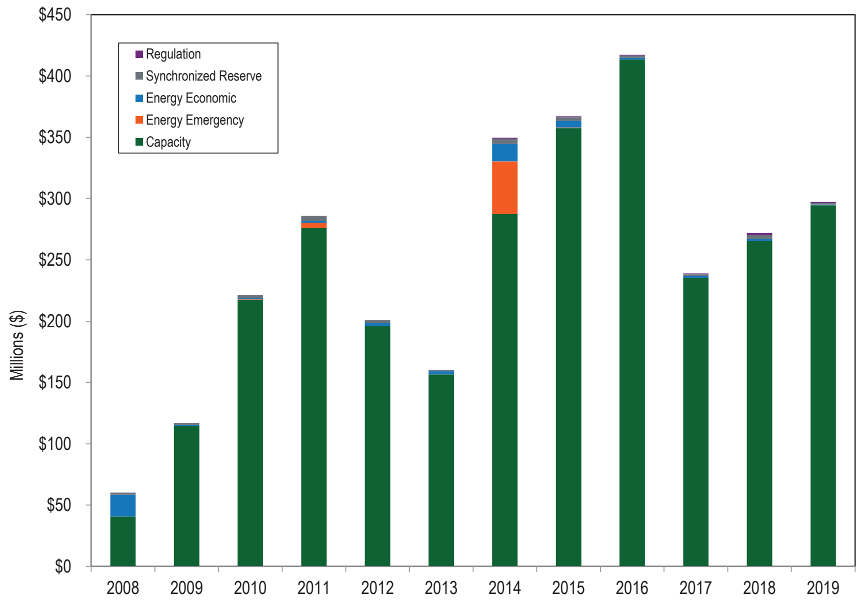
21 PJM Operating Agreement Schedule 1 § 1.5A.3.1.

22 This includes both capacity market revenue and emergency energy revenue for capacity resources.

23 The total credits and MWh for demand resources were calculated as of July 17, 2019 and may change as a result of continued PJM billing updates. There was no emergency energy revenue in the first six months of 2019.

24 Economic credits are synonymous with revenue received for reductions under the economic load response program.

Figure 6-1 Demand response revenue by market: January through June, 2008 through 2019




## Economic Program

FERC Order No. 831 requires all energy offers above $1,000 per MWh to provide supporting documentation.[25] Economic resources offer into the energy market and must provide supporting documentation to offer above $1,000 per MWh. FERC stated, "[t]he offer cap reforms, however, do not apply to capacity-only demand response resources that do not submit incremental energy offers into energy markets."[26] Demand resources participate in both the capacity and energy markets and are not capacity only resources. It is not clear whether FERC intended to exclude demand resources with high strike prices from the requirements of Order No. 831. Demand resources should not be permitted to make offers above $1,000 per MWh without the same verification requirements applied to economic resources or generation resources. The MMU recommends that the rules for maximum offer for the emergency and pre-emergency program match the maximum offer for generation resources.

Table 6-2 shows registered sites and MW for the last day of each month for the period January 1, 2015, through June 30, 2019. Registration is a prerequisite for CSPs to participate in the economic program. The monthly average number of registrations for economic demand response decreased and the monthly average registered MW increased in the first six months of 2019 compared to the first six months of 2018. Average monthly registrations decreased by 121, 24.4 percent, from 494 in the first six months of 2018 to 373 in the first six months of 2019. Average monthly registered MW increased by 192 MW, 7.4 percent, from 2,609 MW in the first six months of 2018 to 2,801 MW in the first six months of 2019.

Most economic demand response resources are registered in the emergency demand response program. Resources registered in both programs do not need to register for the same amount of MW. There are 144 registrations and 991 nominated MW in the economic program, or 183 registrations and 573 nominated MW in the emergency program.

25 157 FERC ¶ 61,115 (2016).
26 *Id.* at 8.

## Table 6-2 Economic program registrations on the last day of the month: 2015 through 2019[27]

| | 2015 | | 2016 | | 2017 | | 2018 | | 2019 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | Registrations | Registered MW | Registrations | Registered MW | Registrations | Registered MW | Registrations | Registered MW | Registrations | Registered MW |
| Jan | 1,078 | 2,960 | 838 | 2,557 | 871 | 2,603 | 537 | 2,570 | 375 | 2,702 |
| Feb | 1,076 | 2,956 | 835 | 2,557 | 842 | 2,578 | 537 | 2,628 | 371 | 2,690 |
| Mar | 1,075 | 2,949 | 834 | 2,556 | 850 | 2,576 | 519 | 2,641 | 379 | 2,698 |
| Apr | 1,076 | 2,938 | 832 | 2,556 | 897 | 2,574 | 501 | 2,624 | 367 | 2,645 |
| May | 980 | 2,846 | 829 | 2,545 | 977 | 2,626 | 471 | 2,615 | 374 | 3,248 |
| Jun | 871 | 2,614 | 518 | 2,500 | 577 | 1,305 | 397 | 2,576 | 372 | 2,823 |
| Jul | 870 | 2,609 | 519 | 2,421 | 589 | 1,548 | 374 | 2,591 | | |
| Aug | 869 | 2,609 | 805 | 2,569 | 590 | 1,541 | 382 | 2,609 | | |
| Sep | 867 | 2,608 | 831 | 2,608 | 588 | 1,663 | 378 | 2,580 | | |
| Oct | 858 | 2,568 | 822 | 2,564 | 574 | 1,660 | 382 | 2,584 | | |
| Nov | 851 | 2,566 | 820 | 2,564 | 559 | 1,662 | 381 | 2,581 | | |
| Dec | 850 | 2,566 | 807 | 2,561 | 556 | 1,659 | 392 | 2,671 | | |
| Avg | 974 | 2,788 | 774 | 2,547 | 706 | 2,000 | 438 | 2,606 | 373 | 2,801 |

The registered MW in the economic load response program are not a good measure of the MW available for dispatch in the energy market. Economic resources can dispatch up to the amount of MW registered in the program, but are not required to offer any MW. Table 6-3 shows the sum of peak economic MW dispatched by registration each month from January 1, 2010, through June 30, 2019. The monthly peak is the sum of each registration's monthly noncoincident peak dispatched MW and annual peak is the sum of each registration's annual noncoincident peak dispatched MW. The peak dispatched MW for all economic demand response registered resources decreased by 97 MW, 49.7 percent, from 195 MW in the first six months of 2018 to 98 MW in the first six months of 2019.[28] The peak dispatched MW in the first six months of 2019, 98 MW, were 2,703 MW less than the average MW registered in the first six months of 2019, 2,801 MW.

## Table 6-3 Sum of peak MW reductions for all registrations per month: 2010 through June 2019

| | Sum of Peak MW Reductions for all Registrations per Month | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| Jan | 183 | 132 | 110 | 193 | 446 | 169 | 139 | 123 | 142 | 88 |
| Feb | 121 | 89 | 101 | 119 | 307 | 336 | 128 | 83 | 70 | 58 |
| Mar | 115 | 81 | 72 | 127 | 369 | 198 | 120 | 111 | 71 | 38 |
| Apr | 111 | 80 | 108 | 133 | 146 | 143 | 118 | 54 | 71 | 41 |
| May | 172 | 98 | 143 | 192 | 151 | 161 | 131 | 169 | 70 | 21 |
| Jun | 209 | 561 | 954 | 433 | 483 | 833 | 121 | 240 | 105 | 5 |
| Jul | 999 | 561 | 1,631 | 1,088 | 665 | 1,362 | 1,316 | 936 | 518 | |
| Aug | 794 | 161 | 952 | 497 | 358 | 272 | 249 | 141 | 581 | |
| Sep | 276 | 84 | 451 | 530 | 795 | 816 | 263 | 140 | 112 | |
| Oct | 118 | 81 | 242 | 168 | 214 | 136 | 150 | 88 | 69 | |
| Nov | 111 | 86 | 165 | 155 | 166 | 127 | 116 | 81 | 54 | |
| Dec | 114 | 88 | 98 | 168 | 155 | 122 | 147 | 83 | 11 | |
| Annual | 1,202 | 840 | 1,942 | 1,486 | 1,739 | 1,858 | 1,451 | 1,217 | 758 | 98 |

27 Data for years 2010 through 2014 are available in the *2018 State of the Market Report for PJM.*
28 The total credits and MWh numbers for demand resources were calculated as of July 17, 2019 and may change as a result of continued PJM billing updates.

Emergency and economic demand response energy payments are uplift and not compensated by LMP revenues. Economic demand response energy costs are assigned to real-time exports from the PJM Region and real-time loads in each zone for which the load-weighted average real-time LMP for the hour during which the reduction occurred is greater than the price determined under the net benefits test for that month.[29] The zonal allocation is shown in Table 6-13.

Table 6-4 shows the total MW reductions made by participants in the economic program and the total credits paid for these reductions in the first six months of 2010 through 2019. The average credits per MWh paid decreased by $10.24 per MWh, 19.1 percent, from $53.74 per MWh in the first six months of 2018 to $43.50 per MWh in the first six months of 2019. The PJM real-time, load-weighted, average LMP was 35.2 percent lower in the first six months of 2019 than in the first six months of 2018, $27.49 per MWh versus $42.44 per MWh. Curtailed energy for the economic program decreased by 17,167 MWh, 58.9 percent, from 29,155 MWh in the first six months of 2018 to 11,988 MWh in the first six months of 2019. Total credits paid for economic DR in the first six months of 2018 decreased by $1.0 million, 66.7 percent, from $1.6 million in the first six months of 2018 to $0.5 million in the first six months of 2019.

## Table 6-4 Credits paid to the PJM economic program participants: January through June, 2010 through 2019

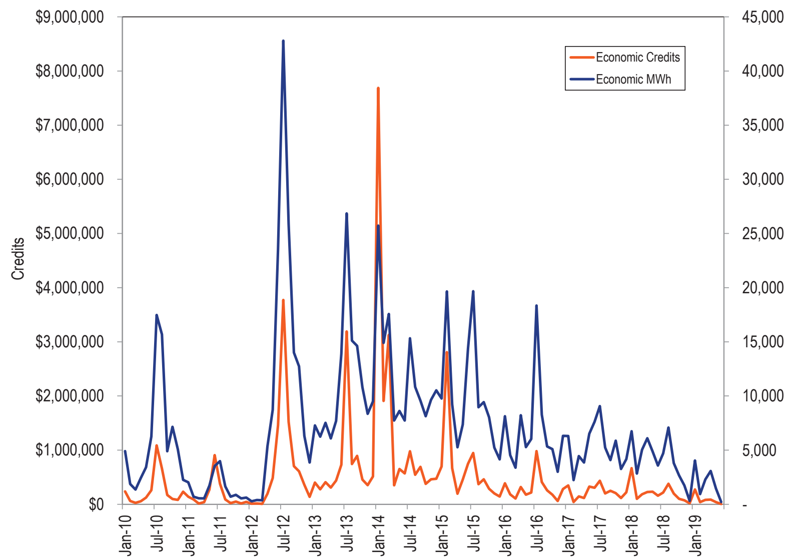
| (Jan-Jun) | Total MWh | Total Credits | $/MWh |
|---|---|---|---|
| 2010 | 20,225 | $761,854 | $37.67 |
| 2011 | 9,055 | $1,456,324 | $160.84 |
| 2012 | 38,692 | $2,172,454 | $56.15 |
| 2013 | 48,711 | $2,559,831 | $52.55 |
| 2014 | 82,273 | $14,298,502 | $173.79 |
| 2015 | 65,653 | $5,576,152 | $84.93 |
| 2016 | 35,559 | $1,381,972 | $38.86 |
| 2017 | 30,954 | $1,281,762 | $41.41 |
| 2018 | 29,155 | $1,566,879 | $53.74 |
| 2019 | 11,988 | $521,491 | $43.50 |

29 "PJM Manual 28: Operating Agreement Accounting," § 11.2.2, Rev. 82 (July 25, 2019).

Economic demand response resources that are dispatched by PJM in both the economic and emergency programs are paid the higher price defined in the emergency rules.[30] For example, assume a demand resource has an economic offer price of $100 per MWh and an emergency strike price of $1,800 per MWh. If this resource were scheduled to reduce in the Day-Ahead Energy Market, the demand resource would receive $100 per MWh, but if an emergency event were called during the economic dispatch, the demand resource would receive its emergency strike price of $1,800 per MWh instead. The rationale for this rule is not clear.[31] All other resources that clear in the day-ahead market are financially firm at the clearing price. Payment at a guaranteed strike price and the ability to set energy market prices at the strike price effectively grant the seller the right to exercise market power.

Figure 6-2 shows monthly economic demand response credits and MWh, from January 1, 2010 through June 30, 2019.

## Figure 6-2 Economic program credits and MWh by month: 2010 through June 2019




30 PJM. "Manual 11: Energy & Ancillary Services Market Operations," § 10.4.5, Rev. 106 (May 30, 2019).
31 FERC Order No. 831.

Table 6-5 shows performance for the first six months of 2018 and 2019 in the economic program by control zone. Total reductions under the economic program decreased by 17,167 MWh, 58.9 percent, from 29,155 MW in the first six months of 2018 to 11,988 MW in the first six months of 2019. Total revenue under the economic program decreased by $1.0 million, 66.7 percent, from $1.6 million in the first six months of 2018 to $0.5 million in the first six months of 2019.[32]

### Table 6-5 PJM economic program participation by zone: January through June, 2018 and 2019

| | Credits | | | MWh Reductions | | | Credits per MWh Reduction | | |
|---|---|---|---|---|---|---|---|---|---|
| Zones | 2018 (Jan-Jun) | 2019 (Jan-Jun) | Percent Change | 2018 (Jan-Jun) | 2019 (Jan-Jun) | Percent Change | 2018 (Jan-Jun) | 2019 (Jan-Jun) | Percent Change |
| AECO | $0.00 | $0.00 | NA | 0 | 0 | NA | NA | NA | NA |
| AEP | $0.00 | $1,057.59 | NA | 0 | 17 | NA | NA | $63.38 | NA |
| APS | $43,300.32 | $70.19 | (99.8%) | 710 | 1 | (99.9%) | $60.97 | $87.88 | 44.1% |
| ATSI | $589,795.33 | $0.00 | NA | 10,691 | 0 | NA | $55.17 | NA | NA |
| BGE | $0.00 | $0.00 | NA | 0 | 0 | NA | NA | NA | NA |
| ComEd | $147,867.75 | $246.50 | (99.8%) | 4,024 | 15 | (99.6%) | $36.74 | $16.08 | (56.3%) |
| DAY | $0.00 | $0.00 | NA | 0 | 0 | NA | NA | NA | NA |
| DEOK | $0.00 | $0.00 | NA | 0 | 0 | NA | NA | NA | NA |
| Dominion | $37,747.59 | $267.33 | (99.3%) | 162 | 4 | (97.7%) | $232.46 | $71.78 | (69.1%) |
| DPL | $0.00 | $0.00 | NA | 0 | 0 | NA | NA | NA | NA |
| DLCO | $0.00 | $0.00 | NA | 0 | 0 | NA | NA | NA | NA |
| JCPL | $137,431.03 | $0.00 | NA | 1,711 | 0 | NA | $80.35 | NA | NA |
| Met-Ed | $10,761.24 | $15,173.32 | 41.0% | 209 | 295 | 41.4% | $51.56 | $51.41 | (0.3%) |
| OVEC | $0.00 | $0.00 | NA | 0 | 0 | NA | NA | NA | NA |
| PECO | $37,866.04 | $117,734.28 | 210.9% | 542 | 1,914 | 253.0% | $69.85 | $61.52 | (11.9%) |
| PENELEC | $120,679.73 | $63,832.92 | (47.1%) | 4,000 | 2,050 | (48.8%) | $30.17 | $31.15 | 3.2% |
| Pepco | $0.00 | $842.53 | NA | 0 | 14 | NA | NA | $58.46 | NA |
| PPL | $116,662.68 | $125,578.93 | 7.6% | 920 | 1,936 | 110.3% | $126.76 | $64.87 | (48.8%) |
| PSEG | $324,767.12 | $196,687.75 | (39.4%) | 6,185 | 5,743 | (7.2%) | $52.51 | $34.25 | (34.8%) |
| Total | $1,566,878.84 | $521,491.34 | (66.7%) | 29,155 | 11,988 | (58.9%) | $53.74 | $43.50 | (19.1%) |

Table 6-6 shows total settlements submitted for the first six months of 2010 through 2019. A settlement is counted for every day on which a registration is dispatched in the economic program.

### Table 6-6 Settlements submitted in the economic program: January through June, 2010 through 2019

| (Jan-Jun) | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of Settlements | 1,345 | 317 | 1,348 | 820 | 1,806 | 1,091 | 652 | 800 | 737 | 426 |

Table 6-7 shows the number of CSPs, and the number of participants in their portfolios, submitting settlements for the first six months of 2010 through 2019. The number of active participants decreased by six, 20.0 percent, from 30 in the first six months of 2018 to 24 in the first six months of 2019. All participants must be registered through a CSP.

32 Economic demand response reductions that are submitted to PJM for payment but have not received payment are not included in Table 6-5. Payments for Economic demand response reductions are settled monthly.

### Table 6-7 Participants and CSPs submitting settlements in the economic program by year: January through June, 2010 through 2019

| (Jan-Jun) | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| Active CSPs | 10 | 9 | 18 | 12 | 17 | 12 | 6 | 8 | 11 | 9 |
| Active Participants | 131 | 129 | 331 | 85 | 144 | 68 | 20 | 42 | 30 | 24 |

The ownership of economic demand response resources was highly concentrated in 2018 through June 2019.[33] Table 6-8 shows the average hourly HHI for each month and the average hourly HHI for January 1, 2018 through June 30, 2019. Table 6-8 also lists the share of reductions provided by, and the share of credits claimed by the four largest companies in each year. In the first six months of 2019, 91.4 percent of all economic DR reductions and 87.0 percent of economic DR revenue were attributable to the four largest companies. The HHI for economic demand response increased by 373 from 7541 for the first six months of 2018 to 7914 for the first six months of 2019.

### Table 6-8 Average hourly MWh HHI and market concentration in the economic program: January 2018 through June 2019[34]

| | Average Hourly MWh HHI | | | Top Four Companies Share of Reduction | | | Top Four Companies Share of Credit | | |
|---|---|---|---|---|---|---|---|---|---|
| Month | 2018 | 2019 | Percent Change | 2018 | 2019 | Change in Percent | 2018 | 2019 | Change in Percent |
| Jan | 6576 | 6884 | 4.7% | 92.3% | 82.1% | 10.2% | 88.6% | 78.1% | 10.5% |
| Feb | 8304 | 9382 | 13.0% | 99.2% | 94.7% | 4.5% | 99.1% | 90.7% | 8.4% |
| Mar | 7498 | 7758 | 3.5% | 96.1% | 99.3% | (3.3%) | 95.7% | 99.1% | (3.4%) |
| Apr | 6828 | 7457 | 9.2% | 97.3% | 99.4% | (2.1%) | 97.2% | 99.8% | (2.6%) |
| May | 6688 | 8410 | 25.7% | 98.3% | 99.9% | (1.6%) | 97.9% | 99.9% | (2.0%) |
| Jun | 8375 | 9817 | 17.2% | 97.4% | | | 96.2% | | |
| Jul | 8256 | | | 90.2% | | | 82.7% | | |
| Aug | 7588 | | | 90.0% | | | 87.0% | | |
| Sep | 9306 | | | 97.4% | | | 97.2% | | |
| Oct | 6805 | | | 95.6% | | | 93.9% | | |
| Nov | 7038 | | | 91.6% | | | 91.8% | | |
| Dec | 8082 | | | | | | | | |
| Total | 7541 | 7914 | 5.0% | 84.9% | 91.4% | 6.5% | 83.0% | 87.0% | 3.9% |

Table 6-9 shows average MWh reductions and credits by hour for the first six months of 2018 and 2019. In the first six months of 2018, 84.7 percent of reductions and 80.5 percent of credits occurred in hours ending 0900 to 2100, and in the first six months of 2019, 83.5 percent of reductions and 78.0 percent of credits occurred in hours ending 0900 to 2100.

### Table 6-9 Hourly frequency distribution of economic program MWh reductions and credits: January through June, 2018 and 2019

| | MWh Reductions | | | Program Credits | | |
|---|---|---|---|---|---|---|
| Hour Ending (EPT) | 2018 (Jan-Jun) | 2019 (Jan-Jun) | Percent Change | 2018 (Jan-Jun) | 2019 (Jan-Jun) | Percent Change |
| 1 through 6 | 1,161 | 522 | (55%) | $90,825 | $31,808 | (65%) |
| 7 | 834 | 264 | (68%) | $59,819 | $17,158 | (71%) |
| 8 | 1,349 | 471 | (65%) | $88,784 | $29,210 | (67%) |
| 9 | 1,652 | 731 | (56%) | $90,224 | $31,811 | (65%) |
| 10 | 1,756 | 722 | (59%) | $83,119 | $29,203 | (65%) |
| 11 | 1,848 | 722 | (61%) | $88,347 | $30,837 | (65%) |
| 12 | 1,932 | 734 | (62%) | $89,095 | $27,179 | (69%) |
| 13 | 1,908 | 734 | (62%) | $89,811 | $25,938 | (71%) |
| 14 | 1,984 | 731 | (63%) | $89,446 | $25,236 | (72%) |
| 15 | 1,913 | 712 | (63%) | $89,385 | $22,225 | (75%) |
| 16 | 1,908 | 721 | (62%) | $89,760 | $22,289 | (75%) |
| 17 | 1,967 | 763 | (61%) | $101,573 | $28,154 | (72%) |
| 18 | 2,062 | 831 | (60%) | $121,824 | $40,782 | (67%) |
| 19 | 2,121 | 842 | (60%) | $122,001 | $38,946 | (68%) |
| 20 | 2,008 | 901 | (55%) | $109,663 | $40,187 | (63%) |
| 21 | 1,620 | 866 | (47%) | $96,513 | $43,745 | (55%) |
| 22 | 713 | 437 | (39%) | $41,820 | $22,273 | (47%) |
| 23 through 24 | 419 | 284 | (32%) | $24,868 | $14,510 | (42%) |
| Total | 29,155 | 11,988 | (59%) | $1,566,879 | $521,491 | (67%) |

Table 6-10 shows the distribution of economic program MWh reductions and credits by ranges of real-time zonal, load-weighted, average LMP in the first six months of 2018 and 2019. In the first six months of 2019, 1.4 percent of MWh reductions and 5.2 percent of program credits occurred during hours when the applicable zonal LMP was higher than $175 per MWh.

33 All HHI calculations in this section are at the parent company level. Parent companies may own one CSP or multiple CSPs.
34 December 2018 and June 2019 reduction and credit share percent are redacted based on confidentiality rules.

### Table 6-10 Frequency distribution of economic program zonal, load-weighted, average LMP (By hours): January through June, 2018 and 2019

| | MWh Reductions | | | Program Credits | | |
|---|---|---|---|---|---|---|
| LMP | 2018 (Jan-Jun) | 2019 (Jan-Jun) | Percent Change | 2018 (Jan-Jun) | 2019 (Jan-Jun) | Percent Change |
| $0 to $25 | 3,287 | 3,053 | (7%) | $60,329 | $70,492 | 17% |
| $25 to $50 | 16,675 | 6,139 | (63%) | $581,930 | $217,350 | (63%) |
| $50 to $75 | 3,504 | 1,473 | (58%) | $196,110 | $97,130 | (50%) |
| $75 to $100 | 1,725 | 620 | (64%) | $144,758 | $53,732 | (63%) |
| $100 to $125 | 1,223 | 350 | (71%) | $122,616 | $35,097 | (71%) |
| $125 to $150 | 869 | 81 | (91%) | $103,389 | $10,207 | (90%) |
| $150 to $175 | 420 | 99 | (76%) | $59,225 | $10,274 | (83%) |
| > $175 | 1,452 | 173 | (88%) | $298,522 | $27,209 | (91%) |
| Total | 29,155 | 11,988 | (59%) | $1,566,879 | $521,491 | (67%) |

Following Order No. 745, all ISO/RTOs are required to calculate an NBT threshold price each month above which the net benefits of DR are deemed to exceed the cost to load. PJM calculates the NBT price threshold by first taking the generation offers from the same month of the previous year. For example, the NBT price calculation for February 2017 was calculated using generation offers from February 2016. PJM then adjusts these offers to account for changes in fuel prices and uses these adjusted offers to create an average monthly supply curve. PJM estimates a function that best fits this supply curve and then finds the point on this curve where the elasticity is equal to one.[35] The price at this point is the NBT threshold price.

The NBT test is a crude tool that is not based in market logic. The NBT threshold price is a monthly estimate calculated from a monthly supply curve that does not incorporate real-time or day-ahead prices. In addition, it is a single threshold price used to trigger payments to economic demand response resources throughout the entire RTO, regardless of their location and regardless of locational prices.

The necessity for the NBT test is an illustration of the illogical approach to demand side compensation embodied in paying full LMP to demand resources. The benefit of demand side resources is not that they suppress market prices, but that customers can choose not to consume at the current price of power, that individual customers benefit from their choices and that the choices of all customers are reflected in market prices. If customers face the market price, customers should have the ability to not purchase power and the market impact of that choice does not require a test for appropriateness.

When the zonal LMP is above the NBT threshold price, economic demand response resources that reduce their power consumption are paid the full zonal LMP. When the zonal LMP is below the NBT threshold price, economic demand response resources are not paid for any load reductions.

Table 6-11 shows the NBT threshold price for the historical test from August 2010 through July 2011, and April 2012, when Order No. 745 was implemented in PJM, through June 2019. The NBT threshold price has never exceeded the lowest historical test result of $34.07 per MWh.

### Table 6-11 Net benefits test threshold prices: August 2010 through June 2019

| | Historical Test ($/MWh) | | Net Benefits Test Threshold Price ($/MWh) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| Jan | | $40.27 | | $25.72 | $29.51 | $29.63 | $23.67 | $32.60 | $26.27 | $29.44 |
| Feb | | $40.49 | | $26.27 | $30.44 | $26.52 | $26.71 | $31.57 | $24.65 | $23.49 |
| Mar | | $38.48 | | $25.60 | $34.93 | $24.99 | $22.10 | $30.56 | $25.50 | $22.15 |
| Apr | | $36.76 | $25.89 | $26.96 | $32.59 | $24.92 | $19.93 | $30.45 | $25.56 | $22.36 |
| May | | $34.68 | $23.46 | $27.73 | $32.08 | $23.79 | $20.69 | $29.77 | $25.52 | $21.01 |
| Jun | | $35.09 | $23.86 | $28.44 | $31.62 | $23.80 | $20.62 | $27.14 | $23.59 | $20.20 |
| Jul | | $36.78 | $22.99 | $29.42 | $31.62 | $23.03 | $20.73 | $24.42 | $23.57 | |
| Aug | $35.57 | | $24.47 | $28.58 | $29.85 | $23.17 | $23.24 | $22.75 | $23.53 | |
| Sep | $34.07 | | $24.93 | $28.80 | $29.83 | $21.69 | $24.70 | $21.51 | $22.23 | |
| Oct | $38.10 | | $25.96 | $29.13 | $30.20 | $21.48 | $26.50 | $21.70 | $23.84 | |
| Nov | $36.83 | | $25.63 | $31.63 | $29.17 | $22.28 | $29.27 | $26.41 | $23.89 | |
| Dec | $37.04 | | $25.97 | $28.82 | $29.01 | $22.31 | $29.71 | $29.16 | $26.35 | |
| Average | $36.32 | $37.51 | $24.80 | $28.09 | $30.91 | $23.97 | $23.99 | $27.34 | $24.54 | $23.11 |

Table 6-12 shows the number of hours that at least one zone in PJM had day-ahead LMP or real-time LMP higher than the NBT threshold price. In the first six months of 2019, the highest zonal LMP in PJM was higher than the NBT threshold price 3,422 hours out of 4,343 hours, or 78.8 percent of all hours. Reductions occurred in 1,309 hours, 38.3 percent, of those 3,422 hours in the

35 "PJM Manual 11: Energy & Ancillary Services Market Operations," §10.3.1, Rev. 106 (May 30, 2019).

first six months of 2019. The last three columns illustrate how often economic demand response activity occurred when LMPs exceeded NBT threshold prices for January 1, 2018 through June 30, 2019. There are no economic payments when demand response occurs and zonal LMP is below the NBT threshold. Demand response reductions occurred in 0.08 percent (1 hour) of the hours in which LMP was below the NBT threshold price in the first six months of 2019, and none of the hours in which LMP was below the NBT threshold price in 2018.

### Table 6-12 Hours with price higher than NBT and DR occurrences in those hours: 2018 through June 2019

| | Number of Hours | | Number of Hours with LMP Higher than NBT | | | Percent of NBT Hours with DR | | |
|---|---|---|---|---|---|---|---|---|
| Month | 2018 | 2019 | 2018 | 2019 | Percent Change | 2018 | 2019 | Percent Change |
| Jan | 744 | 744 | 665 | 503 | (24.4%) | 62.9% | 51.9% | (11.0%) |
| Feb | 672 | 672 | 485 | 582 | 20.0% | 44.7% | 22.9% | (21.9%) |
| Mar | 743 | 743 | 713 | 711 | (0.3%) | 58.3% | 40.5% | (17.8%) |
| Apr | 720 | 720 | 663 | 559 | (15.7%) | 73.8% | 55.1% | (18.7%) |
| May | 744 | 744 | 611 | 579 | (5.2%) | 62.7% | 42.5% | (20.2%) |
| Jun | 720 | 720 | 503 | 488 | (3.0%) | 64.0% | 15.0% | (49.1%) |
| Jul | 744 | | 549 | | | 74.0% | | |
| Aug | 744 | | 560 | | | 72.5% | | |
| Sep | 720 | | 643 | | | 64.2% | | |
| Oct | 744 | | 699 | | | 50.9% | | |
| Nov | 721 | | 702 | | | 43.9% | | |
| Dec | 744 | | 627 | | | 12.1% | | |
| Total | 8,760 | 4,343 | 7,420 | 3,422 | (53.9%) | 56.7% | 38.3% | (18.5%) |

Economic DR revenues are paid by real-time loads and real-time scheduled exports as an uplift charge. Table 6-13 shows the sum of real-time DR charges and day-ahead DR charges paid in each zone and paid by exports. Real-time loads in AEP paid the highest DR charges in the first six months of 2019.

### Table 6-13 Zonal DR charge: January through June, 2019

| Zone | January | February | March | April | May | June | Total |
|---|---|---|---|---|---|---|---|
| AECO | $3,107 | $402 | $813 | $712 | $276 | $65 | $5,374 |
| AEP | $43,073 | $6,115 | $12,606 | $14,331 | $6,825 | $803 | $83,754 |
| APS | $18,269 | $2,567 | $5,104 | $5,370 | $2,610 | $310 | $34,229 |
| ATSI | $20,920 | $3,150 | $6,706 | $7,709 | $3,483 | $392 | $42,360 |
| BGE | $12,438 | $1,635 | $3,148 | $3,355 | $1,634 | $227 | $22,436 |
| ComEd | $18,936 | $4,237 | $8,395 | $9,312 | $4,522 | $593 | $45,994 |
| DAY | $6,000 | $837 | $1,776 | $2,122 | $932 | $117 | $11,784 |
| DEOK | $7,798 | $1,224 | $2,557 | $2,943 | $1,463 | $183 | $16,169 |
| Dominion | $36,308 | $4,935 | $9,651 | $10,745 | $5,710 | $722 | $68,069 |
| DPL | $7,438 | $901 | $1,691 | $1,522 | $508 | $118 | $12,178 |
| DLCO | $4,108 | $623 | $1,264 | $1,464 | $752 | $90 | $8,301 |
| EKPC | $4,559 | $614 | $1,299 | $1,289 | $634 | $76 | $8,472 |
| JCPL | $7,427 | $911 | $1,989 | $1,863 | $667 | $145 | $13,003 |
| Met-Ed | $5,815 | $775 | $1,522 | $1,530 | $638 | $102 | $10,382 |
| OVEC | $38 | $6 | $13 | $13 | $6 | $1 | $78 |
| PECO | $14,213 | $1,755 | $3,650 | $3,583 | $1,110 | $239 | $24,550 |
| PENELEC | $5,304 | $860 | $1,751 | $1,940 | $848 | $103 | $10,807 |
| Pepco | $11,147 | $1,511 | $2,897 | $3,118 | $1,629 | $218 | $20,520 |
| PPL | $15,052 | $2,006 | $4,004 | $3,848 | $1,327 | $237 | $26,472 |
| PSEG | $15,476 | $1,711 | $3,783 | $3,709 | $1,323 | $274 | $26,276 |
| RECO | $424 | $59 | $125 | $136 | $50 | $11 | $804 |
| Exports | $14,962 | $1,827 | $4,862 | $5,507 | $2,436 | $255 | $29,849 |
| Total | $272,811 | $38,661 | $79,605 | $86,121 | $39,382 | $5,280 | $521,861 |

Table 6-14 shows the total zonal DR charge per MWh of real-time load and exports in the first six months of 2019.

Table 6-14 Zonal DR charge per MWh of load and exports: January through June 2019

| Zone | January | February | March | April | May | June | Zonal Average |
|---|---|---|---|---|---|---|---|
| AECO | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 |
| AEP | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 |
| APS | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 |
| ATSI | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 |
| BGE | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 |
| ComEd | $0.002 | $0.002 | $0.002 | $0.002 | $0.002 | $0.002 | $0.002 |
| DAY | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 |
| DEOK | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 |
| Dominion | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 |
| DPL | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 |
| DLCO | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 |
| EKPC | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 |
| JCPL | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 |
| Met-Ed | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 |
| OVEC | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 |
| PECO | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 |
| PENELEC | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 | $0.003 |
| Pepco | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 |
| PPL | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 |
| PSEG | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 |
| RECO | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 |
| Exports | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 |
| Monthly Average | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 | $0.004 |

Table 6-15 shows the monthly day-ahead and real-time DR charges and the per MWh DR charges for 2018 through June 2019. The day-ahead DR charges decreased by $0.2 million, 38.1 percent, from $0.6 million in the first six months of 2018 to $0.4 million in the first six months of 2019. The real-time DR charges decreased $0.8 million, 84.4 percent, from $1.0 million in the first six months of 2018 to $0.2 million in the first six months of 2019.

Table 6-15 Monthly day-ahead and real-time economic DR charge: 2018 through June 2019

| | Day-ahead DR Charge | | | Real-time DR Charge | | |
|---|---|---|---|---|---|---|
| Month | 2018 | 2019 | Percent Change | 2018 | 2019 | Percent Change |
| Jan | $287,093 | $150,139 | (47.7%) | $381,071 | $122,303 | (67.9%) |
| Feb | $22,479 | $22,811 | 1.5% | $77,584 | $15,850 | (79.6%) |
| Mar | $58,245 | $71,143 | 22.1% | $125,482 | $8,462 | (93.3%) |
| Apr | $85,711 | $84,808 | (1.1%) | $140,688 | $1,313 | (99.1%) |
| May | $87,376 | $35,897 | (58.9%) | $143,598 | $3,485 | (97.6%) |
| Jun | $56,538 | $5,280 | (90.7%) | $101,014 | $0 | (100.0%) |
| Jul | $63,540 | | | $153,191 | | |
| Aug | $70,708 | | | $308,315 | | |
| Sep | $44,648 | | | $152,727 | | |
| Oct | $57,842 | | | $40,317 | | |
| Nov | $32,131 | | | $42,017 | | |
| Dec | $9,890 | | | $6,369 | | |
| Total | $876,201 | $370,078 | (57.8%) | $1,672,373 | $151,413 | (90.9%) |

## Emergency and Pre-Emergency Programs

The emergency and pre-emergency load response programs consist of the limited, extended summer, annual and capacity performance demand response products. Full implementation of the Capacity Performance design in the 2020/2021 Delivery Year will require all emergency or pre-emergency demand resource to be registered as an annual capacity resource. Summer period demand response resources are allowed to aggregate with winter period capacity resources to fulfill the annual requirement of the CP design.[36] With the implementation of Capacity Performance, a performance assessment interval (PAI) occurs when emergency or pre-emergency is dispatched. PJM effectively eliminated the difference between pre-emergency and emergency by making both trigger a PAI. To participate as an emergency or pre-emergency demand resource, the CSP must clear MW in an RPM auction. Emergency and pre-emergency resources receive capacity revenue from the capacity market and also receive energy revenue at a predefined strike price from the energy market for reductions during a PJM initiated emergency or pre-emergency event. The rules applied to demand resources in the current market design do not treat demand resources in a manner comparable to

36 Summer period demand response has the same obligations as extended summer demand response. It must be available for June through October and the following May between 10:00AM and 10:00PM. *See* PJM OATT RAA Article 1.

generation capacity resources, even though demand resources are sold in the same capacity market, are treated as a substitute for other capacity resources and displace other capacity resources in RPM auctions.

The MMU recommends that if demand resources remain on the supply side of the capacity market, a daily must offer requirement in the Day-Ahead Energy Market apply to demand resources, comparable to the rule applicable to generation capacity resources. This will help to ensure comparability and consistency for demand resources.

The MMU recommends that the option to specify a minimum dispatch price under the Emergency and Pre-Emergency Program Full option be eliminated and that participating resources receive the hourly real-time LMP less any generation component of their retail rate.[37]

The HHI for demand resources showed that ownership was highly concentrated for the 2018/2019 and 2019/2020 delivery years, with an HHI value of 1807 and 1838. In the 2018/2019 Delivery Year, the four largest companies contributed 78.1 percent of all committed demand resources UCAP MW and 78.8 percent of all committed demand resources UCAP MW in the 2019/2020 Delivery Year.

Table 6-16 shows the HHI value for committed UCAP MW by LDA by delivery year. The HHI values are calculated by the committed UCAP MW in each delivery year for demand resources.

### Table 6-16 HHI value for committed UCAP MW by LDA by delivery year: 2018/2019 and 2019/2020 delivery years[38]

| Delivery Year | LDA | Committed UCAP MW | HHI Value | HHI Concentration |
|---|---|---|---|---|
| 2018/2019 | RTO | 3,387.6 | 2018 | High |
| | MAAC | 447.5 | 2473 | High |
| | EMAAC | 1,315.5 | 2156 | High |
| | PSEG | 143.4 | 2252 | High |
| | PS-NORTH | 95.6 | 2924 | High |
| | PEPCO | 533.7 | 5464 | High |
| | ATSI | 622.8 | 2573 | High |
| | ATSI-CLEVELAND | 150.5 | 4050 | High |
| | COMED | 1,938.6 | 2438 | High |
| | BGE | 493.2 | 5597 | High |
| | PPL | 496.2 | 2264 | High |
| | DPL-SOUTH | 500.4 | 8707 | High |
| 2019/2020 | RTO | 3,576.3 | 2018 | High |
| | MAAC | 463.8 | 2473 | High |
| | EMAAC | 900.3 | 2156 | High |
| | PSEG | 149.8 | 2252 | High |
| | PS-NORTH | 89.9 | 2924 | High |
| | PEPCO | 479.8 | 5464 | High |
| | ATSI | 705.9 | 2573 | High |
| | ATSI-CLEVELAND | 210.8 | 4050 | High |
| | COMED | 2,016.5 | 2438 | High |
| | BGE | 208.2 | 5597 | High |
| | PPL | 532.5 | 2264 | High |
| | DPL-SOUTH | 50.4 | 8707 | High |

Table 6-17 shows the committed demand response UCAP MW by delivery year. Total committed demand response UCAP MW in PJM increased by 257.6 MW, or 3.0 percent, from 8,727.0 MW in the 2018/2019 Delivery Year to 8,984.6 MW in the 2019/2020 Delivery Year. The DR percent of capacity increased by 0.1 percent, from 4.9 percent in the 2018/2019 Delivery Year to 5.0 percent in the 2019/2020 Delivery Year.

37 See "Complaint and Motion to Consolidate of the Independent Market Monitor for PJM," Docket No. EL14-20-000 (January 28, 2014), "Comments of the Independent Market Monitor for PJM," Docket No. ER15-852-000 (February 13, 2015).

38 The RTO LDA refers to the rest of RTO.

### Table 6-17 Committed demand response UCAP MW for PJM: 2011/2012 through 2019/2020 delivery year

| Delivery Year | DR Cleared MW UCAP | DR Percent of Capacity MW UCAP |
|---|---|---|
| 2011/2012 | 2,509.1 | 1.4% |
| 2012/2013 | 7,632.4 | 4.4% |
| 2013/2014 | 8,218.3 | 4.6% |
| 2014/2015 | 8,665.9 | 4.8% |
| 2015/2016 | 11,340.2 | 6.4% |
| 2016/2017 | 8,862.6 | 5.0% |
| 2017/2018 | 8,458.4 | 4.6% |
| 2018/2019 | 8,727.0 | 4.9% |
| 2019/2020 | 8,984.6 | 5.0% |

Table 6-18 shows zonal monthly capacity market revenue to demand resources for the first six months of 2019. Capacity market revenue increased in the first six months of 2019 by $29.1 million, 10.9 percent, from $265.5 million in the first six months of 2018 to $294.6 million in the first six months of 2019. Higher demand resource revenues were in part a result of higher capacity market prices in the 2018/2019 RPM auction clearing price. The capacity revenue in the first quarter of 2018 is from 2017/2018 RPM auction clearing prices and the capacity revenue in the first quarter of 2019 is from 2018/2019 RPM auction clearing prices. The annual capacity market prices increased $13.20 per MW-day from $151.50 in the 2017/2018 Delivery Year to $164.77 in the 2018/2019 Delivery Year, a 8.7 percent increase.

### Table 6-18 Zonal monthly capacity revenue: January through June, 2019

| Zone | January | February | March | April | May | June | Total |
|---|---|---|---|---|---|---|---|
| AECO | $1,063,052 | $960,176 | $1,063,052 | $1,028,760 | $1,063,052 | $436,515 | $5,614,605 |
| AEP, EKPC | $7,363,738 | $6,651,118 | $7,363,738 | $7,126,198 | $7,363,738 | $3,867,902 | $39,736,430 |
| APS | $4,638,234 | $4,189,373 | $4,638,234 | $4,488,614 | $4,638,234 | $2,285,119 | $24,877,807 |
| ATSI | $4,254,499 | $3,842,773 | $4,254,499 | $4,117,257 | $4,254,499 | $2,344,392 | $23,067,919 |
| BGE | $1,471,812 | $1,329,378 | $1,471,812 | $1,424,334 | $1,471,812 | $630,148 | $7,799,295 |
| ComEd | $11,763,628 | $10,625,212 | $11,763,628 | $11,384,156 | $11,763,628 | $9,639,882 | $66,940,134 |
| DAY | $1,082,665 | $977,891 | $1,082,665 | $1,047,740 | $1,082,665 | $533,882 | $5,807,508 |
| DEOK | $996,130 | $899,730 | $996,130 | $963,997 | $996,130 | $608,291 | $5,460,409 |
| DLCO | $3,841,793 | $3,470,007 | $3,841,793 | $3,717,864 | $3,841,793 | $1,760,122 | $20,473,372 |
| Dominion | $2,760,840 | $2,493,662 | $2,760,840 | $2,671,780 | $2,760,840 | $1,133,435 | $14,581,397 |
| DPL | $1,229,930 | $1,110,904 | $1,229,930 | $1,190,255 | $1,229,930 | $599,460 | $6,590,408 |
| JCPL | $1,324,124 | $1,195,983 | $1,324,124 | $1,281,410 | $1,324,124 | $605,867 | $7,055,632 |
| Met-Ed | $1,527,708 | $1,379,865 | $1,527,708 | $1,478,427 | $1,527,708 | $775,740 | $8,217,157 |
| OVEC | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| PECO | $3,342,110 | $3,018,680 | $3,342,110 | $3,234,300 | $3,342,110 | $1,582,953 | $17,862,263 |
| PENELEC | $1,811,449 | $1,636,148 | $1,811,449 | $1,753,015 | $1,811,449 | $830,090 | $9,653,600 |
| Pepco | $806,881 | $728,796 | $806,881 | $780,853 | $806,881 | $142,570 | $4,072,863 |
| PPL | $2,314,965 | $2,090,936 | $2,314,965 | $2,240,289 | $2,314,965 | $1,801,961 | $13,078,082 |
| PSEG | $2,521,890 | $2,277,836 | $2,521,890 | $2,440,539 | $2,521,890 | $1,157,439 | $13,441,484 |
| RECO | $48,971 | $44,232 | $48,971 | $47,392 | $48,971 | $30,889 | $269,427 |
| Total | $54,164,419 | $48,922,701 | $54,164,419 | $52,417,179 | $54,164,419 | $30,766,656 | $294,599,792 |

Table 6-19 shows the amount of energy efficiency (EE) resources in PJM on June 1 for the 2012/2013 through 2018/2019 delivery years. EE resources may participate in PJM without restrictions imposed by a state unless the Commission authorizes a state to impose restrictions.[39] Only Kentucky has been authorized by the Commission.[40] Energy efficiency resources are offered in the PJM Capacity Market. The total MW of energy efficiency resources committed increased by 20.2 percent from 2,117.9 MW in the 2017/2018 Delivery Year to 2,545.1 MW in the 2018/2019 Delivery Year.[41]

39 *See* 161 FERC ¶ 61,245 at P 57 (2017); 107 FERC ¶ 61,272 at P 8 (2008).
40 The Commission made an exception for Kentucky when it determined that RERRAs must obtain FERC approval prior to excluding EE, explaining that "the Commission accepted such condition at the time the Kentucky Commission approved the integration of Kentucky Power into PJM." 161 FERC ¶ 61,245 at P 67.
41 See the *2018 State of the Market Report for PJM*, Vol. 2, Section 5: Capacity Market, Table 5-13.

### Table 6-19 Energy efficiency resources (MW): June 1, 2012 to June 1, 2018

| | UCAP (MW) |
|---|---|
| | RPM Commitments |
| 01-Jun-12 | 631.2 |
| 01-Jun-13 | 1,024.8 |
| 01-Jun-14 | 1,282.4 |
| 01-Jun-15 | 1,525.5 |
| 01-Jun-16 | 1,784.3 |
| 01-Jun-17 | 2,117.9 |
| 01-Jun-18 | 2,545.1 |

Figure 6-3 shows the amount of installed EE MW in PJM by technology for the 2018/2019 and 2019/2020 delivery years. An installed EE resource may participate as a capacity resource for up to a maximum of four consecutive delivery years.[42] The lighting category consists of more efficient lighting technology installed, HVAC consists of more efficient HVAC technology installed, new construction consists of more efficient equipment than the industry average for individual components, appliances consists of more efficient appliances and prescriptive consists of more efficient equipment procured by an incentive program for lighting, HVAC or appliances. Prescriptive energy efficiency MW have an assumed savings calculated by an expected installation rate dependent on units sold and the difference between the current average electricity usage of what is being replaced and the new product. For example, if 100 lights are sold, an expected installation rate could be that 95 are installed and replacing a light that consumes more electricity. Instead of measuring each light replaced, the EE provider takes the difference between the industry average and the new light. Prescriptive energy efficiency MW comprise 87.2 percent of all energy efficiency MW in the 2018/2019 Delivery Year and 86.5 percent in the 2019/2020 Delivery Year. The measurement and verification method for prescriptive energy efficiency projects relies on unverified assumptions and is too imprecise to rely on as a source of capacity comparable to capacity from a power plant.

All EE resources must submit pre and post installation M&V plans that include the variables that affect the project's electrical demand, baseline consumption, post installation consumption, and specifications of the equipment or types of equipment used in the project. The nonprescriptive measurement and verification methods do not use full metering but rely on samples and assumptions and only for limited periods.[43] The nominated EE value is the expected average demand reduction during: the peak hours ending 15:00 EPT through 18:00 EPT for June 1 through August 31; and the peak hours ending 8:00 EPT through 9:00 EPT and 19:00 EPT through 20:00 EPT for all days between January 1 and February 28, of the relevant delivery year.[44] The calculated MW are offered in PJM's Capacity Market as EE. The installed EE resources for the 2018/2019 Delivery Year include any installed EE resource between June 1, 2014 and May 31, 2018, and installed EE resources for the 2019/2020 Delivery Year include any installed EE resources between June 1, 2015 and May 31, 2019.

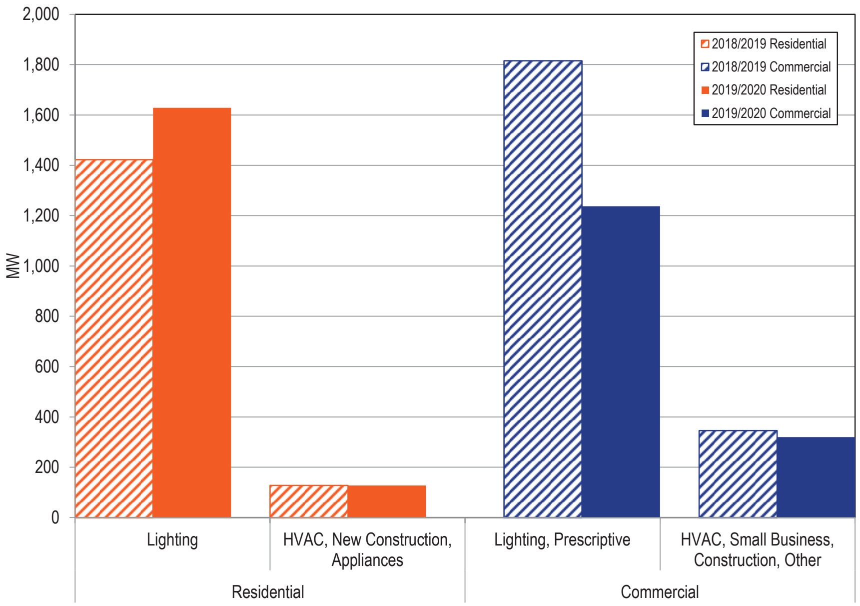
The MMU recommends that energy efficiency MW not be included in the PJM capacity market. The measurement and verification protocols for energy efficiency are too imprecise to rely on as a source of capacity. Energy efficiency measures reduce energy usage and capacity usage directly. The reduced market payments are the appropriate compensation. PJM should ensure that the impact of EE measures on the load forecast is incorporated immediately rather than with the existing lag.

42 PJM. "Manual 18: Capacity Market," § 4.4, Rev. 41 (Jan. 1, 2019).

43 PJM. "Manual 18B: Energy Efficiency Measurement & Verification," § 2.2 Rev. 3 (November 17, 2016).

44 PJM. "Manual 18B: Energy Efficiency Measurement & Verification," § 1.1 Rev. 3 (November 17, 2016).

**Figure 6-3 Installed energy efficiency MW by type: 2018/2019 and 2019/2020 delivery years**




FERC accepted PJM's proposed 30 minute lead time as a phased in approach on May 9, 2014, effective on June 1, 2015.[45] The quick lead time demand response was defined after demand resources cleared in the RPM base residual auctions for the 2014/2015, 2015/2016, 2016/2017 and 2017/2018 delivery years. PJM submitted a filing on October 20, 2014, to allow DR that is unable to respond within 30 minutes to exit the market without penalty before the mandatory 30 minute lead time with the 2015/2016 Delivery Year.[46] The quick lead time is the default lead time starting June 1, 2015, unless a CSP submits an exception request for 60 or 120 minute notification time due to a physical constraint.[47] The exception requests must clearly state why the resource is unable to respond within 30 minutes based on the defined reasons for exception listed in Manual 18.[48] Once a location is granted a longer lead time, the resource does not need to resubmit for a longer lead time each delivery year. Resources that request longer lead times without a physical constraint are rejected.

Table 6-20 shows the amount of nominated MW and locations by product type and lead time for the 2018/2019 Delivery Year. PJM approved 3,022 locations, or 20.6 percent of all locations, which have 3,944.1 nominated MW, or 43.9 percent of all nominated MW, for exceptions to the 30 minute lead time rule for the 2018/2019 Delivery Year.[49]

45 See 147 FERC ¶ 61,103 (2014).
46 See PJM Interconnection, L.L.C., Docket No. ER14-135-000 (October 20, 2014).
47 See "PJM Manual 18: Capacity Market," § 4.3.1, Rev. 41 (Jan. 1, 2019).
48 "PJM Manual 18: PJM Capacity Market," § 4.3.1, Rev. 41 (January 1, 2019).
49 For analysis of the 2017/2018 Delivery Year, *see 2018 Quarterly State of the Market Report: January through September*, Section 6 Demand Response, at Emergency and Pre-Emergency Programs. <http://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2018/2018q3-som-pjm-sec6.pdf>.

## Table 6-20 Nominated MW and locations by product type and lead time: 2018/2019 Delivery Year

| Lead Type | Limited | Annual | Base | Capacity Performance | Pre-Emergency Total | Limited | Annual | Base | Capacity Performance | Emergency Total | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-Emergency MW | | | | | Emergency MW | | | | | |
| Quick Lead (30 Minutes) | 311.9 | 6.8 | 4,179.5 | 305.2 | 4,803.3 | 0.2 | 0.0 | 221.6 | 18.9 | 240.7 | 5,044.0 |
| Short Lead (60 Minutes) | 23.2 | 0.0 | 367.8 | 65.5 | 456.5 | 0.0 | 0.0 | 26.4 | 0.0 | 26.4 | 483.0 |
| Long Lead (120 Minutes) | 122.8 | 0.0 | 2,666.4 | 527.7 | 3,316.9 | 0.0 | 0.0 | 144.2 | 0.0 | 144.2 | 3,461.1 |
| Total | 457.8 | 6.8 | 7,213.6 | 898.4 | 8,576.7 | 0.2 | 0.0 | 392.3 | 18.9 | 411.4 | 8,988.1 |
| | Pre-Emergency Locations | | | | | Emergency Locations | | | | | |
| Lead Type | Limited | Annual | Base | Capacity Performance | Pre-Emergency Total | Limited | Annual | Base | Capacity Performance | Emergency Total | Total |
| Quick Lead (30 Minutes) | 167 | 2 | 10,154 | 732 | 11,055 | 4 | 0 | 518 | 57 | 579 | 11,634 |
| Short Lead (60 Minutes) | 12 | 0 | 297 | 30 | 339 | 0 | 0 | 42 | 0 | 42 | 381 |
| Long Lead (120 Minutes) | 33 | 0 | 2,010 | 379 | 2,422 | 0 | 0 | 219 | 0 | 219 | 2,641 |
| Total | 212 | 2 | 12,461 | 1,141 | 13,816 | 4 | 0 | 779 | 57 | 840 | 14,656 |

Table 6-21 shows the amount of nominated MW and locations by product type and lead time for the 2019/2020 Delivery Year. PJM approved 3,106 locations, or 20.9 percent of all locations, which have 3,902.1 nominated MW, or 40.6 percent of all nominated MW, for exceptions to the 30 minute lead time rule for the 2019/2020 Delivery Year.

## Table 6-21 Nominated MW and locations by product type and lead time: 2019/2020 Delivery Year

| Lead Type | Base | Capacity Performance | Pre-Emergency Total | Base | Capacity Performance | Emergency Total | Total |
|---|---|---|---|---|---|---|---|
| | Pre-Emergency MW | | | Emergency MW | | | |
| Quick Lead (30 Minutes) | 5,298.4 | 159.1 | 5,457.5 | 238.4 | 17.7 | 256.1 | 5,713.6 |
| Short Lead (60 Minutes) | 326.7 | 36.3 | 363.0 | 27.2 | 0.0 | 27.2 | 390.3 |
| Long Lead (120 Minutes) | 2,933.8 | 428.2 | 3,362.0 | 148.3 | 1.4 | 149.8 | 3,511.8 |
| Total | 8,558.9 | 623.6 | 9,182.6 | 414.0 | 19.1 | 433.1 | 9,615.7 |
| | Pre-Emergency Locations | | | Emergency Locations | | | |
| Lead Type | Base | Capacity Performance | Pre-Emergency Total | Base | Capacity Performance | Emergency Total | Total |
| Quick Lead (30 Minutes) | 10,886 | 356 | 11,242 | 514 | 26 | 540 | 11,782 |
| Short Lead (60 Minutes) | 288 | 8 | 296 | 53 | 0 | 53 | 349 |
| Long Lead (120 Minutes) | 2,048 | 425 | 2,473 | 281 | 3 | 284 | 2,757 |
| Total | 13,222 | 789 | 14,011 | 848 | 29 | 877 | 14,888 |

There are two different ways to measure load reductions of demand resources. The Firm Service Level (FSL) method, applied to the summer, measures the difference between a customer's peak load contribution (PLC) and real-time load, multiplied by the loss factor (LF).[50] The Guaranteed Load Drop (GLD) method measures the minimum of: the comparison load minus real-time load multiplied by the loss factor; or the PLC minus the real-time load multiplied by the loss factor. The comparison load estimates what the load would have been if PJM did not declare a Load Management Event, similar to a CBL, by using a comparable day, same day, customer baseline, regression analysis or backup generation method. Limiting the GLD method to the minimum of the two calculations ensures

50 Real-time load is hourly metered load.

reductions occur below the PLC, thus avoiding double counting of load reductions.[51] With the introduction of the Winter Peak Load (WPL) concept, effective for the 2017/2018 Delivery Year, both the FSL and GLD methods are modified for the non-summer period. The FSL method measures compliance during the non-summer period as the difference between a customer's WPL multiplied by the Zonal Winter Weather Adjustment Factor (ZWWAF) and the LF, rather than the PLC, and real-time load, multiplied by the LF. PJM calculates and posts on the PJM website the ZWWAF as the zonal winter weather normalized peak divided by the zonal average of the five coincident peak loads in December through February.[52] The Winter Peak Load is adjusted up for transmission and distribution line loss factors because one MW of load would be served by more than one MW of generation to account for transmission losses. The Winter Peak Load is normalized based on the winter conditions during the five coincident peak loads in winter using the ZWWAF to account for an extreme temperatures or a mild winter. The GLD method measures compliance during the non-summer period as the minimum of: the comparison load minus real-time load multiplied by the loss factor; or the WPL multiplied by the ZWWAF and the LF, rather than the PLC, minus the real-time load multiplied by the LF.[53]

The Capacity Market is an annual market. A Capacity Performance resource has an annual commitment. Load is allocated capacity obligations based on the annual peak load which is a summer load. The amount of MW allocated to load does not vary based on winter demand. The principle is that a customer's actual use of capacity should be compared to the level of capacity that a customer is required to pay for. Capacity costs are allocated to LSEs by PJM based on the single coincident peak load method. In PJM, the single coincident peak occurs in the summer.[54] LSEs generally allocate capacity costs to customers based on the five coincident peak method.[55] The allocation of capacity costs to customers uses each customer's PLC. Customers pay for capacity based on the PLC, not the WPL. The MMU recommends setting the baseline for measuring capacity compliance under summer and winter compliance at the customer's PLC, similar to GLD, to avoid double counting, to avoid under counting and to ensure that a customer's purchase of capacity is calculated correctly. The FSL and GLD equations for calculating load reductions are:

$$FSL\ Compliance_{Summer} = PLC - (Load \cdot LF)$$

$$FSL\ Compliance_{Non-Summer} = (WPL \cdot ZWWAF \cdot LF) - (Load \cdot LF)$$

$$GLD\ Compliance_{Summer} = Minimum\{(comparison\ load - Load) \cdot LF; PLC - (Load \cdot LF)\}$$

$$GLD\ Compliance_{Non-Summer} = Minimum\{(comparison\ load - Load) \cdot LF; (WPL \cdot ZWWAF \cdot LF) - (Load \cdot LF)\}$$

Table 6-22 shows the MW registered by measurement and verification method and by technology type for the 2018/2019 Delivery Year. For the 2018/2019 Delivery Year, 99.7 percent use the FSL method and 0.3 percent use the GLD measurement and verification method.

51 135 FERC ¶ 61,212.
52 "PJM Manual 18: PJM Capacity Market," § 4.3.7, Rev. 41 (January 1, 2019).
53 "PJM Manual 18: PJM Capacity Market," § 8.7A, Rev.41 (January 1, 2019).
54 OATT Attachment DD.5.11.
55 OATT Attachment M-2.

## Table 6-22 Reduction MW by each demand response method: 2018/2019 Delivery Year

| | Technology Type | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Measurement and Verification Method | On-site Generation MW | HVAC MW | Refrigeration MW | Lighting MW | Manufacturing MW | Water Heating MW | Batteries and Plug Load MW | Total | Percent by type |
| Firm Service Level | 1,056.4 | 2,857.5 | 178.8 | 849.5 | 3,856.2 | 116.6 | 45.7 | 8,960.6 | 99.7% |
| Guaranteed Load Drop | 0.8 | 8.8 | 0.0 | 0.7 | 16.4 | 0.1 | 0.5 | 27.4 | 0.3% |
| Total | 1,057.2 | 2,866.3 | 178.8 | 850.2 | 3,872.6 | 116.6 | 46.2 | 8,988.0 | 100.0% |
| Percent by method | 11.8% | 31.9% | 2.0% | 9.5% | 43.1% | 1.3% | 0.5% | 100.0% | |

Table 6-23 shows the MW registered by measurement and verification method and by technology type for the 2019/2020 Delivery Year. For the 2019/2020 Delivery Year, 99.7 percent use the FSL method and 0.3 percent use the GLD measurement and verification method.

## Table 6-23 Reduction MW by each demand response method: 2019/2020 Delivery Year

| | Technology Type | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Measurement and Verification Method | On-site Generation MW | HVAC MW | Refrigeration MW | Lighting MW | Manufacturing MW | Water Heating MW | Other, Batteries or Plug Load MW | Total | Percent by type |
| Firm Service Level | 1,053.1 | 3,239.0 | 187.8 | 940.3 | 3,923.8 | 122.5 | 51.1 | 9,517.6 | 99.7% |
| Guaranteed Load Drop | 0.4 | 12.3 | 0.0 | 1.4 | 15.1 | 0.1 | 0.3 | 29.5 | 0.3% |
| Total | 1,053.5 | 3,251.2 | 187.8 | 941.8 | 3,938.8 | 122.6 | 51.4 | 9,547.1 | 100.0% |
| Percent by method | 11.0% | 34.1% | 2.0% | 9.9% | 41.3% | 1.3% | 0.5% | 100.0% | |

Table 6-24 shows the fuel type used in the onsite generators for the 2018/2019 Delivery Year in the emergency and pre-emergency programs. During the 2018/2019 Delivery Year, 1,057.2 MW of the 8,988.0 MW of nominated MW, 11.8 percent, used onsite generation. Of the 1,057.2 MW, 82.7 percent of MW are diesel and 17.3 percent of MW are natural gas, gasoline, oil, propane or waste products. For the 2018/2019 Delivery Year, there was 354.5 MW of the 411.4 MW, 86.2 percent, registered with an onsite generator in the emergency program.

## Table 6-24 Onsite generation fuel type (MW): 2018/2019 Delivery Year

| | 2018/2019 | |
|---|---|---|
| Fuel Type | MW | Percent |
| Diesel | 874.4 | 82.7% |
| Natural Gas, Gasoline, Oil, Propane, Waste Products | 182.8 | 17.3% |
| Total | 1,057.2 | 100.0% |

Table 6-25 shows the fuel type used in the onsite generators for the 2019/2020 Delivery Year in the emergency and pre-emergency programs. During the 2019/2020 Delivery Year, 1,053.5 MW of the 9,547.1 MW of nominated MW, 11.0 percent, used onsite generation. Of the 1,053.5 MW, 85.9 percent of MW are diesel and 14.1 percent of MW are natural gas, gasoline, oil, propane or waste products. For the 2019/2020 Delivery Year, there were 284.9 MW of the 433.1 MW, 65.7 percent, registered with an onsite generator in the emergency program.

Table 6-25 Onsite generation fuel type (MW): 2019/2020 Delivery Year

| | 2019/2020 | |
|---|---|---|
| Fuel Type | MW | Percent |
| Diesel | 905.3 | 85.9% |
| Natural Gas, Gasoline, Oil, Propane, Waste Products | 148.2 | 14.1% |
| Total | 1,053.5 | 100.0% |

## Emergency and Pre-Emergency Event Reported Compliance

Subzonal dispatch became mandatory for emergency demand resources in the 2014/2015 Delivery Year, if the subzone was defined by PJM no later than the day before the dispatch.[56] PJM does not measure compliance when demand response is dispatched in a subzone created on the same day as the dispatch. There are thirteen dispatchable subzones in PJM effective September 21, 2018: AEP_CANTON, ATSI_CLE, DPL_SOUTH, PS_NORTH, ATSI_NEWCASOE, PPL_WESCO, ATSI_BLKRIVER, PENELEC_ERIC, APS_EAST, DOM_CHES, DOM_YORKTOWN, AECO_ENGLAND, JCPL_REDBANK.[57] Effective with the 2020/2021 Delivery Year, PJM will procure a single capacity product, Capacity Performance, which does not require predefined subzones for mandatory dispatch.[58]

PJM can remove a defined subzone, and make changes to the subzone, at their discretion. Subzones should not be removed once defined, as the subzone may need to be dispatched again in the future. The METED_EAST, PENELEC_EAST, PPL_EAST and DOM_NORFOLK subzones were removed by PJM. More subzones may have been removed by PJM but PJM does not keep a record of created and removed subzones. The MMU recommends that PJM not remove any defined subzones and maintain a public record of all created and removed subzones.

The subzone design and closed loop interfaces are related. PJM implemented closed loop interfaces with the stated purpose of improving the incorporation of reactive constraints into energy prices and to allow emergency DR to set price.[59] PJM applies closed loop interfaces so that it can use units needed for reactive support to set the energy price when they would not otherwise set price under the LMP algorithm. PJM also applies closed loop interfaces so that it can use emergency DR resources to set the real-time LMP when DR resources would not otherwise set price under the fundamental LMP logic. Of the 20 closed loop interface definitions, 11 (55 percent) were created for the purpose of allowing emergency DR to set price.[60] The closed loop interfaces created for the purpose of allowing emergency DR to set price are located in the RTO, MAAC, EMAAC, SWMAAC, DPL-SOUTH, ATSI, ATSI-CLEVELAND and BGE LDAs.

Demand resources can be dispatched for voluntary compliance during any hour of any day, but dispatched resources are not measured for compliance outside of the mandatory compliance window for each demand product. A demand response event during a product's mandatory compliance window also may not result in a compliance score. When limited, extended summer and annual demand response events occur for partial hours under 30 minutes or for a subzone dispatch that was not defined one business day before dispatch, the events are not measured for compliance.

Capacity Performance demand resources currently estimate five minute compliance with an hourly interval meter during PAIs. To accurately measure compliance on a five minute basis, a five minute interval meter is required. All other Capacity Performance resources require five minute interval meters, and demand resources should be no different. Limited, extended summer and annual demand resources are paid based on the average performance by registration for the duration of a demand response event. Each capacity performance demand response product should measure compliance on a five minute basis to accurately report reductions during demand response

56 OATT Attachment DD, Section 11.
57 See "Load Management Subzones," <http://www.pjm.com/~/media/markets-ops/demand-response/subzone-definition-workbook.ashx> (Accessed February 25, 2019).
58 OATT Attachment DD, Section 10A.

59 See PJM/Alstom. "Approaches to Reduce Energy Uplift and PJM Experiences," presented at the FERC Technical Conference: Increasing Real-Time and Day-Ahead Market Efficiency Through Improved Software in Docket No. AD10-12-006 <http://www.ferc.gov/june-tech-conf/2015/presentations/m2-3.pdf> (June 23, 2015).
60 See the *2018 State of the Market Report for PJM*, Volume 2, Section 4, Energy Uplift, for additional information regarding all closed loop interfaces and the impacts to the PJM markets.

events. The current rules for limited, extended summer and annual demand response use the average reduction for the duration of an event. The average duration across multiple hours does not provide an accurate metric for each five minute interval of the event and is inconsistent with the measurement of generation resources. Measuring compliance on a five minute basis would provide accurate information to the PJM system. The MMU recommends limited, extended summer and annual demand response event compliance be calculated on an hourly basis for noncapacity performance resources and on a five minute basis for all capacity performance resources and that the penalty structure reflect five minute compliance.[61]

Annual and capacity performance demand response currently assign annual reduction capability by registration, which is measured as the lower of the summer and winter reduction capability. Starting with the 2019/2020 Delivery Year, CSPs will assign the annual reduction capability by portfolio rather than registration, which is measured as the lower of the summer and winter reduction capability by portfolio.[62] Allowing CSPs to aggregate to the portfolio level further weakens the locational aspect of registered demand resources and artificially inflates the level of demand response. For example, imagine a CSP has two registrations in a zonal portfolio, with one registration capable of reducing 5 MW in summer and 2 MW in winter, and the second registration capable of reducing 1 MW in summer and 5 MW in winter. Before the 2019/2020 Delivery Year, the first registration would have an annual capability of 2 MW and the second registration would have an annual capability of 1 MW resulting in a 3 MW total reduction capability. After the 2019/2020 Delivery Year, individual registration capability is ignored resulting in the portfolio capability of 6 MW in summer and 7 MW in winter. This creates a 6 MW total reduction capability within the zone. Without any change to either registration, the CSP was able to add 3 MW to their annual reduction capability. The locational availability of demand resources, at a nodal level, will vary. This treatment is unique to demand resources.

61 "PJM Manual 18: Capacity Market," § 8.7A, Rev. 41 (Jan. 1, 2019).
62 The seasonal DR registration aggregation received endorsement at the September 27, 2018 MRC meeting, <https://www.pjm.com/-/media/committees-groups/committees/mc/20180927/20180927-consent-agenda-item-b-seasonal-dr-registration-aggregation-draft-oatt-revisions.ashx>.

Under the capacity performance design of the PJM Capacity Market, compliance for potential penalties will be measured for DR only during performance assessment intervals (PAI).[63] When pre-emergency or emergency demand response is dispatched, a PAI is triggered for PJM. PJM cannot dispatch pre-emergency or emergency demand response without triggering a PAI and measuring compliance. Before PJM created PAI to measure compliance, pre-emergency demand response could be dispatched without calling an emergency event. As a result, PJM now effectively classifies all demand response as an emergency resource.

The MMU recommends that demand response resources be treated as economic resources like all other capacity resources and therefore that the dispatch of demand response resources not automatically trigger a performance assessment interval (PAI) for CP compliance. Emergencies should be triggered only when PJM has exhausted all economic resources including demand response resources. Table 6-26 shows the amount of nominated demand response MW, the required reserve margin and actual reserve margin as of June 1, for 2017, 2018 and 2019. There are 8,988.1 nominated MW of demand response for the 2018/2019 Delivery Year, which is 40.0 percent of the required reserve margin and 28.1 percent of the actual reserve margin on June 1, 2018.[64] There are 9,547.1 nominated MW of demand response for the 2019/2020 Delivery Year, which is 42.8 percent of the required reserve margin and 24.2 percent of the actual reserve margin on June 1, 2019.

63 OATT § 1 (Performance Assessment Hour).
64 *2018 State of the Market Report for PJM*, Volume 2, Section 5: Capacity, Table 5-7.

Table 6-26 Demand response nominated MW compared to reserve margin: June 1, 2017 through 2019

| | Demand Response Nominated MW | Required Reserve Margin | Demand Response Percent of Required Reserve Margin | Actual Reserve Margin | Demand Response Percent of Actual Reserve Margin |
|---|---|---|---|---|---|
| 01-Jun-17 | 9,154.7 | 23,305.2 | 39.3% | 33,828.1 | 27.1% |
| 01-Jun-18 | 8,998.1 | 22,487.7 | 40.0% | 31,987.5 | 28.1% |
| 01-Jun-19 | 9,547.1 | 22,297.5 | 42.8% | 39,401.6 | 24.2% |

PJM will dispatch demand resources by zone or subzone for limited, extended summer and annual demand resources, or within a PAI area for Capacity Performance resources. When PJM dispatches all demand resources in multiple connecting zones, PJM further degrades the nodal design of electricity markets. PJM allows compliance to be measured across zones within a compliance aggregation area (CAA) or Emergency Action Area (EAA).[65] [66] A CAA, or EAA, is an electrically connected area that has the same capacity market price. This changes the way CSPs dispatch resources when multiple electrically contiguous areas with the same RPM clearing prices are dispatched. The compliance rules determine how CSPs are paid and thus create incentives that CSPs will incorporate in their decisions about how to respond to PJM dispatch. The multiple zone approach is even less locational than the zonal and subzonal approaches and creates larger mismatches between the locational need for the resources and the actual response. If multiple zones within a CAA are called by PJM, a CSP will dispatch the least cost resources across the zones to cover the CSP's obligation. This can result in more MW dispatched in one zone that are locationally distant from the relief needed and no MW dispatched in another zone, yet the CSP could be considered 100 percent compliant and pay no penalties. More locational deployment of load management resources would improve efficiency. With full implementation of capacity performance, demand response will be dispatched by registrations within an area for which an Emergency Action is declared by PJM. PJM does not have the nodal location of each registration, meaning PJM will need to guess as to the useful demand response registration by registered location.

65 CAA is "a geographic area of Zones or sub-Zones that are electrically contiguous and experience for the relevant Delivery Year, based on Resource Clear Prices of, for Delivery Years through May 31, 2018, Annual Resources and for the 2018/2019 Delivery Year and subsequent Delivery Years, Capacity Performance Resources, the same locational price separation in the Base Residual Auction, the same locational price separation in the First Incremental Auction, the same locational price separation in the Second Incremental Auction, or the same locational price separation in the Third Incremental Auction." OATT § 1.

66 PJM. "Manual 18: Capacity Market," § 8.7.2, Rev. 41 (Jan. 1, 2019).

The MMU recommends that demand resources be required to provide their nodal location. Nodal dispatch of demand resources would be consistent with the nodal dispatch of generation.

## Definition of Compliance

Currently, the calculation methods of event and test compliance do not provide reliable results. PJM's interpretation of load management event rules allows over compliance to be reported when there is no actual over compliance. Settlement locations with a negative load reduction value (load increase) are not netted by PJM within registrations or within demand response portfolios. A resource that has load above their baseline during a demand response event has a negative performance value. PJM limits compliance shortfall values to zero MW. This is not explicitly stated in the Tariff or supporting Manuals and the compliance formulas for FSL and GLD customers do allow negative values.[67]

Limiting compliance to only positive values incorrectly calculates compliance. For example, if a registration had two locations, one with a 50 MWh load increase when called, and another with a 75 MWh load reduction when called, PJM calculates compliance for that registration as a 75 MWh load reduction for that event hour. Negative settlement MWh are not netted across hours or across registrations for compliance purposes. A location with a load increase is set to a zero MW reduction. For example, in a two hour event, if a registration showed a 15 MWh load increase in hour one, but a 30 MWh reduction in hour two, the registration would have a calculated 0 MWh reduction in hour one and a 30 MWh reduction in hour two. This has compliance calculated at an average hourly 15 MWh load reduction for that two hour event, compared to a 7.5 MWh observed reduction. Reported compliance is greater than observed compliance, as locations with load increases, i.e. negative reductions, are treated as zero for compliance purposes.

Changing a demand resource compliance calculation from a negative value to 0 MW inaccurately values event performance and capacity performance.

67 OA Schedule 1 § 8.9.

Inflated compliance numbers for an event overstates the true value and capacity of demand resources. A demand response capacity resource that performs negatively is also displacing another capacity resource that could supply capacity during a delivery year. By setting the negative compliance value to 0 MW, PJM is inaccurately calculating the value of demand resources.

Load increases are not netted against load decreases for dispatched demand resources across hours or across registrations within hours for compliance purposes, but are treated as zero. This skews the compliance results towards higher compliance since poorly performing demand resources are not used in the compliance calculation. When load is above the peak load contribution during a demand response event, the load reduction is negative; it is a load increase rather than a decrease. PJM ignores such negative reduction values and instead replaces the negative values with a zero MW reduction value. The PJM Tariff and PJM Manuals do not limit the compliance calculation value to a zero MW reduction value.[68] The compliance values PJM reports for demand response events are different than the actual compliance values accounting for both increases and decreases in load from demand resources that are called on and paid under the program.

The MMU recommends that compliance rules be revised to include submittal of all necessary hourly load data, and that negative values be included when calculating event compliance across hours and registrations.

Demand resources that are also registered as economic resources have a calculated CBL for the emergency event days. Demand resources that are not registered as Economic Resources use the three day CBL type with the symmetrical additive adjustment for measuring energy reductions without the requirements of a Relative Root Mean Squared Error (RRMSE) Test required for all economic resources.[69] The CBL must use the RRMSE test to verify that it is a good approximation for real time load usage. The MMU recommends the RRMSE test be required for all demand resources with a CBL.

68 OA Schedule 1 § 8.9.
69 157 FERC ¶ 61,067 (2016).

The CBL for a customer is an estimate of what load would have been if the customer had not responded to LMP and reduced load. The difference between the CBL and real time load is the energy reduction. When load responds to LMP by using a behind the meter generator, the energy reduction should be capped at the generation output. Any additional energy reduction is a result of inaccuracy in the CBL estimate rather than an actual reduction. The MMU recommends that demand reductions based entirely on behind the meter generation be capped at the lower of economic maximum or actual generation output.

An extreme example makes clear the fundamental problems with the use of measurement and verification methods to define the level of power that would have been used but for the DR actions, and the payments to DR customers that result from these methods. The current rules for measurement and verification for demand resources make a bankrupt company, a customer that no longer exists due to closing of a facility or a permanently shut down company, or a company with a permanent reduction in peak load due to a partial closing of a facility, an acceptable demand response customer under some interpretations of the tariff, although it is the view of the MMU that such customers should not be permitted to be included as registered demand resources. Companies that remain in business, but with a substantially reduced load, can maintain their pre-bankruptcy FSL (firm service level to which the customer agrees to reduce in an event) commitment, which can be greater than or equal to the post-bankruptcy peak load. The customer agrees to reduce to a level which is greater than or equal to its new peak load after bankruptcy. When demand response events occur the customer would receive credit for 100 percent reduction, even though the customer took no action and could take no action to reduce load. This problem exists regardless of whether the customer is still paying for capacity. To qualify and participate as a demand resource, the customer must have the ability to reduce load. "A participant that has the ability to reduce a measurable and verifiable portion of its load, as metered on an EDC account basis."[70] Such a customer no longer has the ability to reduce load in response to price or a PJM demand response event. CSPs in PJM have and continue to register bankrupt customers as DR customers.

70 OA Schedule 1 § 8.2.

PJM finds acceptable the practice of CSPs maintaining the registration of customers with a bankruptcy related reduction in demand that are unable, as a result, to respond to emergency events. Three proposals that included language to remove bankrupt customers from a CSP's portfolio failed at the June 7, 2017, Market Implementation Committee.[71] The registered customers that are bankrupt and the amount of registered MW cannot be released for reasons of confidentiality.

The metering requirement for demand resources is outdated, and has not kept up with the changes to PJM's market design. PJM moved to five minute settlements, but the metering requirement for demand resources remained at an hourly interval meter. It is impossible to measure energy usage on a five-minute basis using an hourly interval meter. PJM will estimate real time usage by prorating the hourly interval meter and assume if load is less than the CBL, that the reduction occurred during the required dispatch window. The meter reading is not telemetered to PJM in real time. The resource is allowed up to 60 days to report the data to PJM. The MMU recommends that PJM adopt the ISO-NE five-minute metering requirements in order to ensure that dispatchers have the necessary information for reliability and that market payments to demand resources be calculated based on interval meter data at the site of the demand reductions so that they can accurately measure compliance.[72]

When demand resources are not dispatched during a mandatory response window, each CSP must test their portfolio to the levels of capacity commitment.[73] A CSP picks the testing day, for one hour, on any non-holiday weekday during the applicable mandatory window. A CSP is able to retest if a resource fails to provide the required reduction by less than 25 percent. The ability of CSPs to pick the test time does not simulate emergency conditions. As a result, test compliance is not an accurate representation of the capability of the resource to respond to an actual PJM dispatch of the resource. Given that demand resources are now an annual product, multiple tests are required to ensure reduction capability year round. The MMU recommends that load management testing be initiated by PJM with limited warning to CSPs in order to more accurately represent the conditions of an emergency event.

Table 6-27 shows the test penalties by delivery year by product type for the 2015/2016 Delivery Year through the 2018/2019 Delivery Year. The shortfall MW are calculated for each CSP by zone. The weighted rate per MW is the average penalty rate paid per MW. The total penalty column is the sum of the daily test penalties by delivery year and type. The testing window for the limited product is open through September. The testing window for the extended summer, annual and Capacity Performance product is open through the end of the delivery year.

71 There was one proposal from PJM, one proposal from a market participant and one proposal from the MMU. See *Approved Minutes from the Market Implementation Committee*, <http://www.pjm.com/-/media/committees-groups/committees/mic/20170607/20170607-minutes.ashx>.

72 See ISO-NE Tariff, Section III, Market Rule 1, Appendix E1 and Appendix E2, "Demand Response," <http://www.iso-ne.com/regulatory/tariff/sect_3/mr1_append-e.pdf>. (Accessed October 17, 2017) ISO-NE requires that DR have an interval meter with five-minute data reported to the ISO and each behind the meter generator is required to have a separate interval meter. After June 1, 2017, demand response resources in ISO-NE must also be registered at a single node.

73 The mandatory response time for Limited DR is June through September between 12:00PM to 8:00PM EPT, for Extended Summer is June through October and the following May between 10:00AM to 10:00PM EPT, for Annual DR is June through October and the following May between 10:00AM to 10:00PM and is November through April between 6:00AM to 9:00PM EPT, for Base Capacity DR is June through September between 10:00AM to 10:00PM EPT, Capacity Performance DR is June through October and the following May between 10:00AM to 10:00PM EPT and November through April between 6:00AM through 9:00PM EPT. *See* PJM. "Manual 18: Capacity Market," Rev. 41 (Jan. 1, 2019).

Table 6-27 Test penalties by delivery year by product type: 2015/2016 through 2018/2019

| | 2015/2016 | | | 2016/2017 | | | 2017/2018 | | | 2018/2019 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Product Type | Shortfall MW | Weighted Rate per MW | Total Penalty | Shortfall MW | Weighted Rate per MW | Total Penalty | Shortfall MW | Weighted Rate per MW | Total Penalty | Shortfall MW | Weighted Rate per MW | Total Penalty |
| Limited | 96.4 | $165.35 | $5,836,255 | 48.9 | $166.41 | $2,967,158 | 13.9 | $124.08 | $631,665 | 0.0 | $179.80 | $2,100 |
| Extended Summer | 1.9 | $163.70 | $113,835 | 7.3 | $138.14 | $370,290 | 10.5 | $142.86 | $547,928 | | | |
| Annual | 3.7 | $184.67 | $250,621 | 4.8 | $137.45 | $241,406 | 16.3 | $144.00 | $855,940 | | | |
| Base DR and EE | | | | | | | | | | 16.3 | $186.80 | $1,110,134 |
| Capacity Performance | | | | 2.1 | $160.80 | $124,310 | 0.6 | $181.80 | $40,146 | | | |
| Total | 102.0 | $166.02 | $6,200,711 | 63.1 | $160.72 | $3,703,163 | 41.3 | $137.54 | $2,075,678 | 16.3 | $186.79 | $1,112,234 |

## Emergency Energy Payments

Emergency and pre-emergency demand response dispatched during a load management event by PJM are eligible to receive emergency energy payments if registered under the full program option. The full program option includes an energy payment for load reductions during a pre-emergency or emergency event for demand response events and capacity payments.[74] There were 98.2 percent of nominated MW for the 2017/2018 Delivery Year and 98.8 percent of nominated MW for the 2018/2019 Delivery Year registered under the full program option. There were 1.8 percent of nominated MW for the 2017/2018 Delivery Year and 1.2 percent of nominated MW for the 2018/2019 Delivery Year registered as capacity only option. Demand resources clear the capacity market like all other capacity resources and the dispatch of demand resources should not trigger a scarcity event. The strike price is set by the CSP before the delivery year starts and cannot be changed during the delivery year. The demand resource energy payments are equal to the higher of hourly zonal LMP or a strike price energy offer made by the participant, including a dollar per MWh minimum dispatch price and an associated shutdown cost. Demand resources should not be permitted to offer above $1,000 per MWh without cost justification or to include a shortage penalty in the offer. FERC has stated clearly that demand resources in the capacity market must verify costs above $1,000 per MWh, unless they are capacity only. “We clarify, however, that reforms adopted in this Final Rule, which provide that resources are eligible to submit cost-based incremental energy offers in excess of $1,000/MWh and require that those offers be verified, do not apply to capacity-only demand response resources that do not submit incremental energy offers in energy markets.”[75] PJM interprets the scarcity pricing rules to allow a maximum DR energy price of $1,849 per MWh for the 2017/2018 Delivery Year and the 2018/2019 Delivery Year.[76] [77] Demand resources registered with the full option should be required to verify energy offers in excess of $1,000 per MWh. PJM does not require such verification.[78] The MMU recommends that the maximum offer for demand resources be the same as the maximum offer for generation resources.

Shutdown costs for demand response resources are not adequately defined in Manual 15. PJM’s Cost Development Subcommittee (CDS) approved changes to Manual 15 to eliminate shutdown costs for demand response resources participating in the Synchronized Reserve Market, but not demand resources or economic resources.[79]

Table 6-28 shows the distribution of registrations and associated MW in the emergency full option across ranges of minimum dispatch prices for the 2018/2019 Delivery Year. The majority of participants, 76.8 percent of locations and 53.9 percent of nominated MW, have a minimum dispatch price

74 *Id.*

75 161 FERC ¶ 61,153 (2017).

76 139 FERC ¶ 61,057 (2012).

77 FERC accepted proposed changes to have the maximum strike price for 30 minute demand response to be $1,000/MWh + 1*Shortage penalty - $1.00, for 60 minute demand response to be $1,000/MWh + (Shortage Penalty/2) and for 120 minute demand response to be $1,100/MWh from ER14-822-000.

78 OATT. Attachment K Appendix Section 1.10.1A Day-ahead Energy Market Scheduling (d) (x).

79 “PJM Manual 15: Cost Development Guidelines,” § 8.1, Rev. 30 (Dec. 4, 2018).

between $1,550 and $1,849 per MWh, which is the maximum price allowed for the 2018/2019 Delivery Year, 2.3 percent of locations and 4.0 percent of nominated MW have a dispatch price between $0 and $1,000 per MWh, and 97.7 percent of locations and 96.0 percent of nominated MW have a dispatch price above $1,000 per MWh. The shutdown cost of resources with $1,000 to $1,275 per MWh strike prices had the highest average at $173.97 per location and $130.17 per nominated MW.

**Table 6-28 Distribution of registrations and associated MW in the full option across ranges of minimum dispatch: 2018/2019 Delivery Year**

| Ranges of Strike Prices ($/MWh) | Locations | Percent of Total | Nominated MW (ICAP) | Percent of Total | Shutdown Cost per Location | Shutdown Cost Per Nominated MW (ICAP) |
|---|---|---|---|---|---|---|
| $0-$1,000 | 338 | 2.3% | 350.6 | 4.0% | $69.18 | $55.03 |
| $1,000-$1,275 | 2,666 | 18.4% | 3,355.9 | 37.9% | $173.97 | $130.17 |
| $1,275-$1,550 | 361 | 2.5% | 380.6 | 4.3% | $51.11 | $48.48 |
| $1,550-$1,849 | 11,159 | 76.8% | 4,775.2 | 53.9% | $51.43 | $120.18 |
| Total | 14,524 | 100.0% | 8,862.3 | 100.0% | $74.33 | $121.81 |

Table 6-29 shows the distribution of registrations and associated MW in the emergency full option across ranges of minimum dispatch prices for the 2019/2020 Delivery Year. The majority of participants, 75.3 percent of locations and 56.7 percent of nominated MW, have a minimum dispatch price between $1,550 and $1,849 per MWh, which is the maximum price allowed for the 2019/2020 Delivery Year, 3.6 percent of locations and 3.6 percent of nominated MW have a dispatch price between $0 and $1,000 per MWh, and 96.4 percent of locations and 96.4 percent of nominated MW have a dispatch price above $1,000 per MWh. The shutdown cost of resources with $1,000 to $1,275 per MWh strike prices had the highest average at $181.51 per location and $141.57 per nominated MW.

**Table 6-29 Distribution of registrations and associated MW in the full option across ranges of minimum dispatch: 2019/2020 Delivery Year**

| Ranges of Strike Prices ($/MWh) | Locations | Percent of Total | Nominated MW (ICAP) | Percent of Total | Shutdown Cost per Location | Shutdown Cost Per Nominated MW (ICAP) |
|---|---|---|---|---|---|---|
| $0-$1,000 | 530 | 3.6% | 339.5 | 3.6% | $46.98 | $86.48 |
| $1,000-$1,275 | 2,761 | 18.8% | 3,397.5 | 35.9% | $181.51 | $141.57 |
| $1,275-$1,550 | 350 | 2.4% | 364.9 | 3.9% | $57.49 | $55.14 |
| $1,550-$1,849 | 11,073 | 75.3% | 5,370.6 | 56.7% | $49.77 | $102.62 |
| Total | 14,714 | 100.0% | 9,472.5 | 100.0% | $74.57 | $115.84 |

## Distributed Energy Resources

Distributed Energy Resources (DER) are not well defined, but generally include small scale generation directly connected to the grid, generation connected to distribution level facilities and behind the meter generation.[80] For example, Table 6-24 shows the fuel mix of behind the meter generation participating as emergency demand response in the 2018/2019 Delivery Year. Clear rules for defining DERs and for defining the ways in which DERs will interact with the wholesale power markets do not yet exist, although the development of those rules is under active discussion.[81] [82] DERs should be treated like other resources. Creating preferential treatment for DERs could create an incentive to move resources behind the meter in a manner inconsistent with efficiency and competitive

80 Some energy storage facilities may be DERs. The February 15, 2018, FERC Order No. 841 requires that energy storage resources have access to capacity, energy and ancillary service markets. 162 FERC ¶ 61,127, at P 1 (2018).
81 In PJM, the Distributed Energy Resources Subcommittee (DERSC) is currently discussing these issues. *Distributed Energy Resources Subcommittee*, PJM, <http://www.pjm.com/committees-and-groups/subcommittees/ders.aspx>.
82 See "Notice of Technical Conference," Docket No. RM18-9-000 and AD18-10-000 (February 15, 2018); "Technical Conference Distributed Energy Resources," Docket No. RM18-9-000 and AD18-10-000 (April 10, 2018).

markets. FERC directed that DER aggregation be as geographically broad as technically feasible.[83]

The current demand response rules appropriately restrict demand response from injecting power into the grid and receiving demand response revenue. At the January 30, 2019, Demand Response Subcommittee meeting, PJM without a stakeholder process or FERC approval, decided to allow some economic DR payments when DR injects power into the grid. PJM's test compares the total benefits of running the generator which includes generation payments and assumed retail rate savings against the total cost of the generator. If the total cost of the generator is greater than the benefits, then the resource would receive economic DR payments while injecting. The use of a retail rate in calculating wholesale power market benefits raises significant issues analogous to net metering that require discussion and tariff changes. PJM should not include retail rate benefits in the definition of demand response without approval of FERC.

Aggregation to a single node is technically feasible. Allowing DER aggregation across nodes is not necessary and is not consistent with the nodal market design. Getting the rules correct at the beginning of DER development is essential to the active and effective participation of DER in the wholesale power markets in a manner that enhances rather than undercuts the efficiency and competitiveness of the power markets.

83 162 FERC ¶ 32,718 at P 139 (2016).

# TAB K

This is Exhibit **"K"** referred to in the Revised Affidavit of Brian Rivard sworn before me this 21st day of November, 2019

*A Commissioner for Taking Affidavits*

Lauren Theresa Daniel, a Commissioner, etc.,
Province of Ontario, while a Student-at-Law.
Expires April 8, 2022.

# Consumer Savings, Price, and Emissions Impacts of Increasing Demand Response in the Midcontinent Electricity Market

*Steve Dahlke[a,b] and Matt Prorok[a]*

**ABSTRACT**

This paper estimates consumer savings, $CO_2$ emissions reductions, and price effects from increasing demand response (DR) dispatch in the Midcontinent Independent System Operator (MISO) electricity market. To quantify market effects, we develop a dynamic supply and demand model to explore a range of DR deployment scenarios. The study is motivated by the existence of regulatory and market rule barriers to market-based deployment of DR resources in the MISO region. We show annual consumer savings from increased market-based DR can vary from \$1.3 million to \$17.6 million under typical peak operating conditions, depending on the amount of DR resources available for market dispatch and the frequency of deployment. Consumer savings and other market effects increase exponentially during atypical periods with tight supply and high prices. Additionally, we find that DR deployment often reduces $CO_2$ emissions, but the magnitude of emissions reductions varies depending on the emissions content of marginal generation at the time and location of deployment. The results of this study suggest regulators and other stakeholders should focus policy efforts to reducing regulatory barriers to DR deployment in wholesale markets, particularly in locations that experience high price spikes, to improve market efficiency and achieve cost savings for consumers.

**Keywords:** Demand response, Electricity markets, Demand side management, Load management, Midcontinent ISO

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## 1. INTRODUCTION

A significant challenge associated with the development of wholesale electricity markets is the lack of demand-side participation. In most electricity markets, consumers face static prices that often do not change over the course of days, weeks, and months, while the costs to supply electricity change significantly across these time scales. The result is a mismatch between real-time market conditions and retail prices that causes over-consumption during high-price periods and under-consumption during low-price periods (Schweppe, Caramanis, Tabors, and Bohn, 1988; Faruqui and George, 2002). This inefficiency increases spot price volatility, makes it more difficult for operators to manage physical constraints, and increases vulnerability to the exercise of market power (Bushnell, Hobbs and Wolak, 2009). In the MISO region there is a significant potential for electricity demand response that is largely unmet (Faruqui, Hajos, Hledik, and Newell, 2009). Barriers in the region include state regulatory hesitancy and wholesale market rules designed for large centralized

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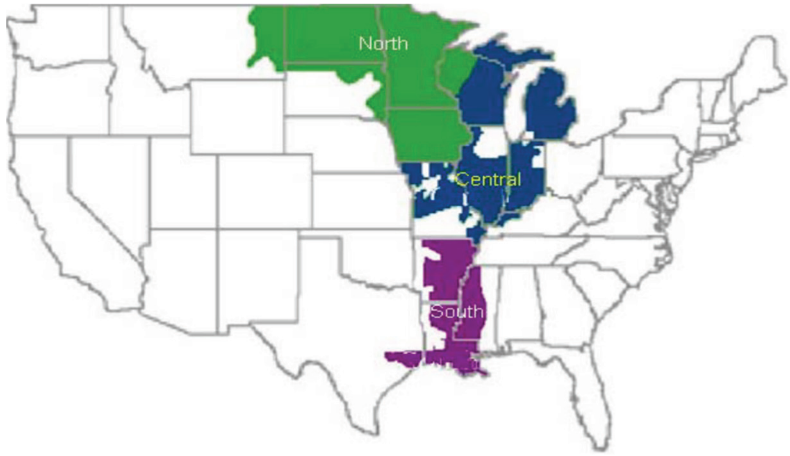
**Figure 1: MISO market and subregions.**




power generation (Cappers, MacDonald, Goldman, and Ma, 2013). These regulatory barriers keep economic demand response resources out of the wholesale energy market, creating an inefficiency that leads to artificially high prices.

This paper quantifies wholesale consumer savings and other impacts of increasing economic demand response (DR) dispatch in the MISO energy market using a bottom-up[1] hourly supply and demand model for the Midcontinent Independent System Operator wholesale electricity market (also referred to as Midcontinent ISO, or MISO; in the remainder of the paper we will use the acronym MISO). The MISO market spans 15 U.S. states and facilitates trade across 65,000 miles of electric transmission and between 200 gigawatts of electricity generation. We model DR dispatch across three different MISO subregions, North, Central, and South, defined in Figure 1 (MISO, 2014).

We use historic data to simulate market effects from dispatching a range of existing DR resources that are currently out of the market. All datasets and code for this analysis, as well as online appendices, are publicly available on the Open Science Framework repository at https://osf.io/6r5cw/. Our study is not the first to show energy market benefits from increased DR (e.g. see Faruqui, Hledik, Newell, and Pfeifenberger, 2007; Walawalkar, Blumsack, Apt, and Fernands, 2007; Braithwait and Eakin, 2002; Aalami, Moghaddam, and Yousefi, 2009). However, as discussed in Cappers et al. (2013), DR in the MISO market is shaped by a unique set of state-jurisdictional regulatory and market rule challenges that do not exist in other competitive wholesale markets, warranting a region-specific study. We make several contributions to the literature. First, we estimate market effects from increased DR dispatch for the MISO market, the largest power system in the United States by geographic scope and one of the largest electricity markets in the world. Second, we fill a gap in the energy literature characterized by a lack of studies on incentive-based DR. Third, we apply microeconomic theory to model the costs and benefits of dispatching incentive-based DR in a wholesale electricity market using a net-benefits criteria, described in section 2.2. Finally, we combine DR data from the U.S. Energy Information Administration (EIA) with ISO market data in

1. "Bottom-up" means we rely on historic generator-level and DR program data to build supply curves, and historic demand data to construct demand curves. Conversely, a "top-down" modeling approach may involve constructing a model using market-wide summary statistics and representative technical and cost assumptions. See Rivers and Jaccard (2005) for further discussion of differences between top-down and bottom-up modeling approaches in the context of energy modeling.

a dynamic supply and demand simulation model. Other novel characteristics of this study include estimating wholesale DR market offers from EIA data, calculating the sensitivity of results to a range of DR energy shifting assumptions, and producing estimates of carbon emissions impacts for various DR deployment scenarios.

The rest of this paper is organized as follows. In section 2 we define and classify DR for the purposes of our analysis, and motivate our research design and modeling strategy. In section 3 we describe the methodology and data used for the analysis. In section 4 we present our results, and in section 5 we conclude with a summary of results and subsequent policy recommendations. Our modeling shows how increasing cost-effective DR dispatch can generate consumer savings net of system costs by lowering prices under typical peak operating conditions. We also show how the market impacts of DR increase exponentially when deployed during critical peak operating conditions.

## 2. MOTIVATION

### 2.1 Background

Demand response in electricity markets encompasses a range of market participant activities, programs, and technologies. DR can be classified into two broad categories, according to definitions adopted by the U.S. Department of Energy, the Federal Energy Regulatory Commission (FERC), and numerous academic articles (U.S. DOE, 2006; U.S. FERC, 2009; Albadi and El-Saadany, 2008). The first category of DR is defined as "changes in electricity usage by end-use customers from their normal consumption patterns in response to changes in price." These types of demand response resources are referred to as price-based programs, and encompass electricity price structures designed to change over time including time-of-use (TOU), critical-peak-pricing (CPP), and real-time-pricing (RTP) programs. The second category is defined as "incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is in jeopardy." These resources are referred to as incentive-based programs and include direct load control (DLC) and interruptible/curtailable (I/C) load programs.

The MISO region of the United States historically has had a higher proportion of DR relative to total load compared to other regions in the United States for several important reasons. First, some states in the region require utilities to invest a percentage or two of revenue from retail sales in DR programs. Second, utilities in the region have historically had favorable resource adequacy rules that allow load management to be counted towards meeting reserve requirements, generating savings or revenues from the DR even if it is never deployed. Third, the customer base in this region has a significant fraction of industrial load that is amenable to interruption (Cappers, Goldman, and Kathan, 2009). EIA reports that utilities in MISO have 4.4 GW of DR (U.S. Energy Information Administration, 2016), while MISO reports they have 5.7 GW of DR resources available (MISO Planning Resource Auction, 2016). This discrepancy is largely due to the fact that EIA's DR survey form covers electric retail utilities, and not large end-use customers that register their DR program directly with MISO.

Despite a large portion of DR in the MISO region, the resources are deployed at a much lower frequency than the rest of the country. For example, in 2015 only 22% of the available DR resources in the MISO market were deployed, compared to 42% in the rest of the country (U.S. EIA, 2016). In California, a particularly active market for DR, 64% of available resources were deployed. During the few occasions when DR resources in the MISO are deployed, they are often done so by individual utilities outside of the MISO market, and show up to the market operator as unexpected load reductions. However, the large majority of DR is available for direct deployment by MISO up to at least 5 times per summer through a product category called a "Load Modifying Resource" (LMR). LMRs do not directly participate in the energy market and are only called on during grid emergencies. However, many LMR resources are "economic" during peak periods in that they have a lower marginal cost of dispatch than the generators in the energy market that get dispatched ahead of them. MISO has an energy DR program available but participation is negligible due to market rule and regulatory barriers.

MISO has historically underutilized the DR assets available to it. Since the launch of MISO's energy markets in 2005, MISO has only deployed its registered DR under the LMR asset classification twice at the time of writing. On April 4th, 2017 during a maximum generation event triggered by unseasonably high temperatures, MISO called on just over 700 MWs of LMRs in the southern portion of its footprint (MISO LMR Performance, 2017). The only other deployment in MISO's history we have record of was in 2006 (Potomac Economics, 2017).

Various market and state regulatory barriers prevent better DR participation in the MISO market. MISO's rules for economic Demand Response Resources require a minimum size threshold of at least 1 megawatt (MW) to participate in the market[2] (MISO Tariff, 2017; MISO BPM, 2016). Additionally, MISO's rules make it difficult to aggregate small DR resources to meet the minimum size threshold.[3] This prevents many demand response resources from entering the market. Other markets that have more active DR participation, including PJM and ISO New England, have corresponding minimum size thresholds of 0.1 MW and do allow aggregation of resources across pricing nodes. The second reason for low DR participation in MISO is state regulatory resistance to giving up control of regulated DR assets in the competitive market. As a result, regulators often will not let utilities enter their DR assets into the wholesale markets, and most states in the MISO region have banned commercial activity by third party DR aggregators (Cappers et al. 2013). More information on regulatory and technical reasons why demand-side management programs have underdelivered in wholesale electricity markets around the world are provided by Wirl (2000) and Rivers and Jaccard (2011).

### 2.2 Modeling DR in wholesale markets

In this section we develop a general microeconomic model that is applied to understand the effects of deploying incentive-based DR in a wholesale electricity market under a net-benefits criterion. First, it is important to clarify that consumers in the wholesale market are often electric utilities or third-party intermediaries purchasing energy on behalf of their customers. In some cases, large users of electricity will bypass the utility and purchase energy directly from the wholesale market. All these entities can provide demand response in the wholesale market.[4] A utility demand response program in the wholesale market is typically an aggregation of the utility's customers who are able to provide reliable energy reductions when it is cost-effective to do so. The details of the financial arrangements between utilities and their retail customers, including incentives offered to DR consumers for participation, as well as what happens with the wholesale revenue earned by the

2. In order for any resource to set prices in the market it must be both eligible to provide specific market services and be included in MISO's Network Model. Demand Response Resources (DRR) – Type II must be at least 1 MW to be included in the Network Model. DRR-Type I do not have this same requirement, but are only modelled as load in the Network Model and thus are not able to set market clearing prices. Instead they may only participate as a price taker.

3. For DR providing energy and reserve services, MISO prevents aggregation across local balancing authority areas, and for DR providing regulation service, MISO presents aggregation across economic pricing nodes.

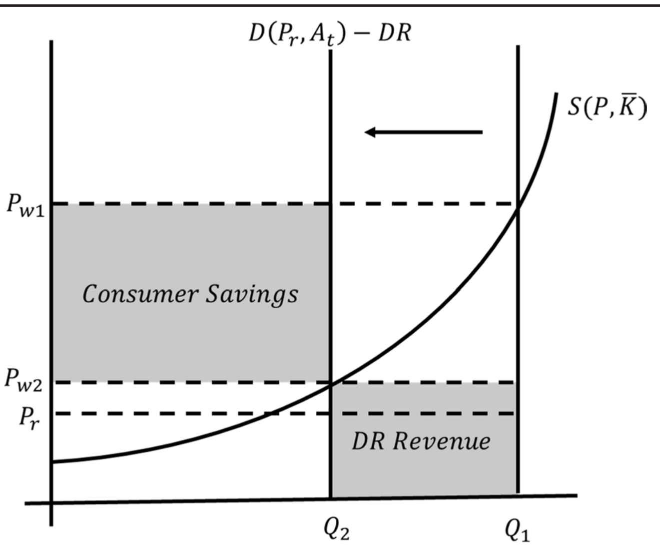
4. A utility may also contract with another entity to aggregate customers and offer DR into the market on their behalf.

utility, are not included in our model. These retail arrangements can vary by utility and customer, they occur downstream of the wholesale model, and are out of scope for this study. In the model we assume a competitive wholesale market so that DR resources offer into the market at the marginal cost of energy reduction. This includes the cost to the consumer of not using the electricity, plus marginal costs associated with administering the energy reduction. In reality, market participants may violate this assumption by acting non-competitively or may be constrained from acting competitively by regulations.

Aggregate wholesale electricity demand is inelastic to the wholesale price and a function of an exogenous fixed retail price $P_r$ and a demand shifting parameter $A_t$, represented by $D(P_r, A_t)$. $A_t$ varies exogenously through time due to external factors such as weather and changing consumer preferences. We assume generators are competitive and offer into the market until price falls below their marginal cost of production. $S_t(P, \bar{K})$ provides the aggregate market supply at price $P$ with total supply capacity $\bar{K}$. The quantity cleared in the market is equal to the amount demanded at the fixed retail price $P_r$, so that $Q=D(P_r,A_t)$. If generators are stacked by their marginal cost so that the lowest-cost generator is deployed first, the wholesale market clearing price is determined by the marginal cost of the last generator required to meet market demand $Q$, so that $Q = S(P_w, \bar{K})$. In the short term, $Q$ is inefficiently high when $P_w > P_r$, and inefficiently low when $P_w < P_r$, generating deadweight loss (DWL).

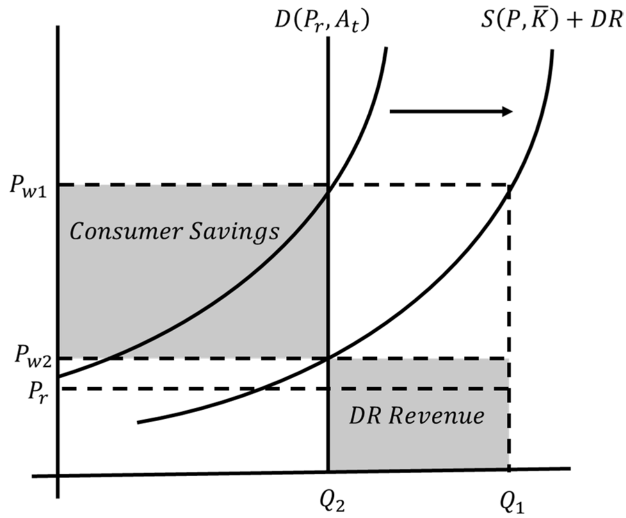
Incentive-based DR programs involve payments to customers in exchange for energy reductions. Current federal regulations in the United States require DR in wholesale markets to be compensated the same as electric generators providing a similar energy service (U.S. Federal Energy Regulatory Commission, 2011). An incentive-based DR deployment in the market can be modeled by a leftward shift in the market demand curve to $D(P_r, A_t) - DR$ as shown in Figure 2. Now the market clearing quantity is $Q_2 = Q_1 - DR$, and the new wholesale price $P_{w2}$ is equal to the marginal cost of the last generator needed to supply $Q_2$. The price reduction generates consumer savings equal to $Q_2 \times (P_{w1} - P_{w2})$. Since regulations require that DR providers be compensated at the wholesale price, there are still $Q_1$ resources receiving payment $P_{w2}$,[5] but only $Q_2$ electricity consumers

**Figure 2: Incentive-based DR deployment modeled as a shift in demand.**




5. This consists of $Q_1 - Q_2$ DR resources and $Q_2$ generation resources receiving $P_{w2}$.

**Figure 3: Incentive-based DR deployment modeled as a shift in supply.**




purchasing at $P_{w2}$. This creates a market revenue shortfall equal to $P_{w2} \times (Q_1 - Q_2)$, the revenue owed to DR providers (labeled "DR Revenue" in Figure 2).

The fact that consumer savings from DR deployment are offset by the revenue owed to DR providers is known as the billing effect. The revenue shortfall is typically socialized as a charge applied proportionately to the remaining wholesale consumers. If DR revenue exceeds consumer savings, costs will outweigh the benefits of DR deployment. FERC regulations require that consumer savings be greater than revenue to DR consumers, so that non-DR consumers still experience a net-benefit from DR deployment. The situation in which consumer savings equals DR revenue is known as the net-benefits threshold, below which DR cannot be deployed (FERC, 2011). Any demand reduction that occurs when the market equilibrium is at an inelastic portion of the supply curve will yield more consumer savings then revenue owed to DR owners and pass the net benefits test. Our analysis is designed to ensure that all DR deployments that occur in the simulations satisfy the net benefits test.

Because incentive DR programs are compensated at the wholesale price like a generator, market operators treat DR like generators in that they are dispatched as part of the supply stack. In this case, DR dispatch can be equivalently modeled as a rightward shift in supply, shown in Figure 3. In this model, DR resources prior to being dispatched are equivalent to negative supply, so the original supply curve is left of the market supply curve presented in Figure 2. $Q_1$ is the quantity that would clear if DR was not included as a supply resource and instead added back to the demand curve. $Q_2$ is the market clearing quantity with DR included. Since in this case DR is scheduled as supply, $D(P_r, A_t)$ does not include the demand reserved as DR capacity. As in the previous case, consumer savings are equivalent to $Q_2 \times (P_{w1} - P_{w2})$, and the revenue owed to DR providers is equal to $P_{w2} \times (Q_1 - Q_2)$.

### 2.3 Why model incentive-based DR?

Most incentive-based DR programs in the U.S. were developed starting in the 1980's due to a significant increase in air-conditioning load, which increased the need for peaking capacity relative to non-peak. Many regulated utilities invested in incentive-based DR as a lower-cost alternative to peaking generators (Lovins, 1985). At the time, metering technology required to implement price-based DR was not available. After significant incentive-based DR investments in the 1980's and 1990's, the FERC assumed jurisdiction via a congressional mandate and began working to remove barriers to DR participation in wholesale markets (Wellinghoff and Morenoff, 2007). Now, advanced metering technology to enable price-based DR is available. However the prevalence of price responsive demand remains small primarily due to an unwillingness by state regulators to expose retail customers to uncertain prices (Bushnell et al., 2009).

Economists disagree on the effectiveness of compensating incentive-based DR at the wholesale price as current regulations require. Some claim that wholesale payments for energy reductions inflate price signals because customers are 'double-compensated' for their reduction, as DR participants benefit both from the savings from not purchasing electricity and the wholesale market payment (Hogan, 2010). Others worry that incentive-based DR will crowd out true price response (Bushnell et al., 2009). Additionally, they point out incentive-based DR consumers may game the market and inflate pre-reduction consumption baselines if proper rules are not implemented (Chao and Depillis, 2013; Chen and Kleit, 2016). Some do note that concerns about improper baselines can be mitigated by properly structured market rules, as outlined by Chao and Depillis (2013).

Proponents of incentive-based DR in wholesale markets point out it is a second-best solution that, in the absence of price-responsive demand, moves market prices closer to the efficient level. Additionally, implementing a price-based DR program includes upfront costs that in many cases exceed the benefits to the customer (Leautier, 2014). In a market with static retail rates, failing to deploy DR resources when the market clearing price exceeds the marginal cost of demand reduction results in a market inefficiency (Kahn, 2010). This is the case in the MISO market, leading to inefficiently high prices and extra costs for consumers. Moreover, there is a gap in the literature with respect to studies on incentive-based DR. A recent literature review analyzed 117 studies on DR modeling, and concluded:

> there is a clear lack of models addressing incentive-based DR programs. This is somewhat astonishing given the fact that, in the U.S., DLC and I/C programs are applied more frequently than TOU or RTP programs. The majority of studies focus on price-based programs (Boßmann and Eser, 2016).

Furthermore, there is currently a large fleet of underutilized incentive-based DR assets in the MISO region that are not comprehensively integrated into the wholesale energy market, described previously in section 2.1. Despite concerns from some economists with respect to incentive-based DR, we analyze effects of increasing participation of incentive-based DR in the MISO market because, 1) there is a much bigger penetration of incentive-based DR currently in existence relative to price-based DR, 2) these resources are underutilized and not comprehensively integrated into wholesale markets, especially in MISO, and 3) there is a lack of studies in the literature focused on incentive-based DR.

## 3. METHODOLOGY

### 3.1 Overview

The purpose of our modeling exercise is to estimate consumer savings, emissions impacts, and price effects from increasing DR dispatch in the MISO energy market. We do this for a range of scenarios that explore differences in DR dispatch amounts, frequencies, energy shifting effects, and energy offer prices. Our modeling approach consists of a dynamic supply and demand model that varies hourly, where the market clearing prices and quantities are determined by the intersection of the two curves. This is similar to the model applied in Buzoianu, Brockwell, and Seppi (2005), except in our case supply curves are constructed bottom-up from historical generator-level offers data obtained from MISO. Demand curves in the model are based off hourly historic MISO demand data and are assumed to be inelastic. We assume inelastic demand because the large majority of electricity customers in the MISO region face retail rates that are fixed in the short-term and do not adjust when wholesale prices change. We use 2015 market and DR data because it is the most recent year in which demand response data is available from the EIA at the time of writing. Additionally, real-time instead of day-ahead MISO market data are used since the real-time market is used as a ‘true-up’ to balance unexpected deviations from day-ahead predictions and scheduling. Furthermore, real-time prices more accurately reflect historic system conditions, and are the final prices used to settle transactions in the energy market. Because our bottom-up supply curves are discontinuous, we use an iterative solver-based approach to calculate the market equilibrium for each hour and market region, programmed in the R statistical computing language. We model supply and demand for every hour of 2015 for the three MISO regions defined in Figure 1: North, Central, and South. This is motivated by recent empirical work finding sub regional variation in price responsiveness within the MISO region (Eryilmaz, Smith, and Homans, 2017). Our analytical approach quantifies market clearing price and quantity effects from dispatching DR and compares them to baseline outcomes that occurred without DR.

The model scenarios dispatch DR based on resource quantities and marginal cost estimates for existing DR resources located in the MISO region that do not participate in the energy market.[6] Since most DR resources in the MISO region are registered through the market under the ‘Load Modifying Resources’ (LMR) category, our model dispatch constraints are based on MISO’s LMR operating agreement (Potomac Economics, 2017). LMR contracts require DR resources to be available for up to 5 deployments during the summer season for a minimum of 4 hours per deployment (MISO Tariff, 2017). Because many DR programs are available for dispatch more than 5 deployments per year and not necessarily limited to summer months[7], we simulate additional scenarios that dispatch DR up to 20 times per year and outside of summer months when it is economic to do so.

Since the number of DR deployments per year is constrained, DR should be deployed on days with both high prices and energy demand in order to maximize value. To determine the highest value days in 2015, we use a similar approach to The Brattle Group (2007) and rank highest value days according to the price-load product for 4-hour dispatch blocks. Specifically, we multiply the average price and demand for each hour in 2015 and calculate 4-hour moving averages. We then select the days that have the highest price-load product average to determine the most valuable days for DR dispatch, eliminating duplicate days. Because we model scenarios that limit DR dispatch to summer months as well as scenarios that model DR dispatch year-round, we compile two lists of 20 highest-value days from 2015, one for the entire year and the other restricted to the summer months. These lists are provided in online appendix 1, publicly available at the link provided in section 1.

### 3.2 Costs

A key input for the supply-demand model is resource-level energy offers, measured in dollars per megawatt-hour ($/MWh). These are the supply offers from which the market operator schedules least cost dispatch. In section 2 we describe that market rule and regulatory barriers

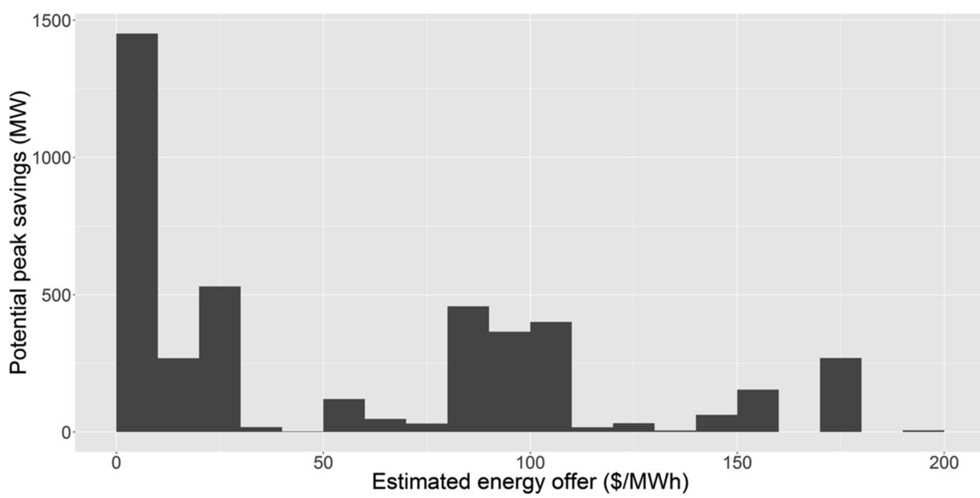
6. Except for the few events described in section 2.1.

7. Cappers et al. (2013) notes that incentive-based DR programs have historically been designed for between 8–20 deployments per year.

currently inhibit a competitive DR market in MISO. In contrast, our modeling effort is designed to explore the effects of a more competitive market. In a competitive market, DR is assumed to offer energy reductions at the marginal cost of deployment. In the absence of marginal cost data, DR energy offers are estimated to be a function of the cost incurred by the underlying electricity customers for service interruption, which varies by customer.[8] To estimate DR energy offers, we use utility-reported data from the EIA on DR customer incentive costs. Customer incentive costs are defined as the total financial value provided to a customer for their program participation, including direct payments, lowered tariff rates, in-kind services, or other benefits (U.S. EIA, 2014). Customers that have a high cost of electricity interruption will demand high incentive payments, and have a lower likelihood of deployment (Albadi and El-Saadany, 2008). The distribution of energy offer estimates is displayed in Figure 4. 3% of MISO DR programs had offer cost estimates above $200/MWh, which are omitted from the figure to eliminate scaling issues. A portion of these high cost DR resources were constrained to be equal to the MISO energy market price cap of $2,000/MWh. As shown in Figure 4, about one third of MISO DR resources have low energy offer estimates between $0/MWh and $10/MWh. The remaining distribution is spread about evenly between $10/MWh and $200/MWh. Further details on the DR energy offer estimation methods are provided in online appendix 2.

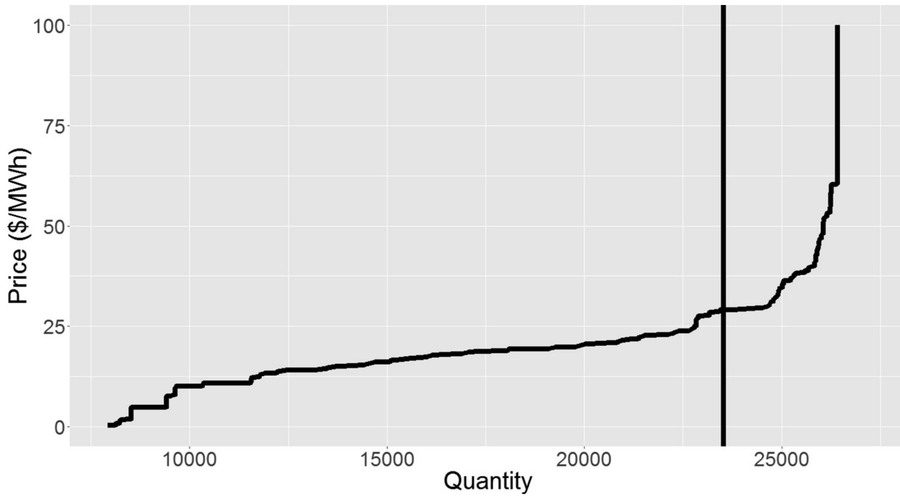
Our energy offer estimates are compared to historic DR offers in the PJM market, which has active energy market DR participation. In 2015, economic demand response resources in the PJM market provided over 121,000 MWhs of supply (McAnany, 2016). Demand response bids during this year range between $0/MWh and $1,850/MWh. This range aligns well with the range of our marginal cost estimates, however the PJM DR offers are higher on average (McAnany, 2016). This could be due to a number of factors, including higher costs of DR deployment in PJM compared to MISO, non-competitive bidding behavior by DR providers, or under-estimated DR program costs provided by utility survey responses to the EIA. Due to higher energy offers from DR observed in PJM, we model sensitivity scenarios in which all energy offers in MISO are increased by 100%.

**Figure 4: DR resource by estimated energy offer, MISO region.**




8. For example, a hospital may have a greater cost of electricity interruption than an office building.

**Figure 5: MISO system supply curve plus demand (vertical line) for the North region on July 12, 2015 at 4pm.**




### 3.3 Baseline model

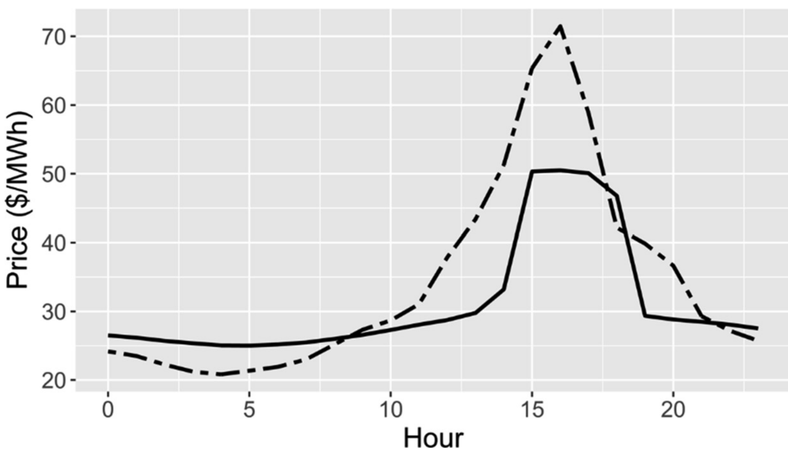
Hourly supply curves were constructed using historic MISO offers data. This data includes hourly price-quantity pairs for every generator offering into the MISO, anonymized to protect confidentiality. From this we construct hourly supply curves by region. We separate the model into MISO's three operations regions: North, Central and South. Inelastic demand is included based on historic load data, and the intersection of supply and demand curves determines the market clearing price and quantity prediction for each hour and region. As an example, Figure 5 plots the supply and demand curves for the North region on July 12, 2015 at 4pm.

Next, DR resources are added to the baseline model, assigning each DR resource to the corresponding region depending on that resource's reported state. The baseline supply-demand model predicts hourly prices based on historic data. The model abstracts from other real-world factors that also determine price, including transmission constraints, net imports, unforced outages, and forecast error. Sometimes these factors cause large price spikes that our model does not predict. To understand how often actual prices deviate from our model's predictions we compare the model-predicted prices to actual historic prices. Plots of the hourly distributions of actual prices by subregion for the highest-value days modeled are provided in online appendix 3.

Figure 6 shows the average predicted prices by hour versus average actual prices for the 20 highest value days in the south region during the summer of 2015. These hourly averages are smoothed[9] and weighted by daily demand. The model consistently under predicts prices during afternoon peak hours. Corresponding plots for the North and Central regions are provided in online appendix 4. Peak periods are when factors exogenous to our model including transmission constraints and forecast error are most pronounced and when we expect the model to under-predict prices. We use historical price data to adjust the baseline model to better reflect the actual price levels throughout the day. The difference between the average actual price and the average predicted price for each region are used as hourly adjustment factors to calibrate the model's predictions.

9. We apply exponential smoothing to the actual hourly price series to minimize noise across hours. Hourly smoothing doesn't materially affect modeling results since DR events are modeled in 4-hour blocks.

**Figure 6: Average hourly prices predicted by model (solid line) versus actual prices (dashed line) during highest value summer days in 2015, south region.**




This adjusts predicted prices upward during hours in which the model systematically under-predicts prices, and downward during hours that systematically over-predict prices.

Most of our modeling results, including changes in consumer savings, emissions, and prices, are calculated as differences between scenarios with and without DR in the supply curve, all else equal. Thus, the adjustments made to absolute price levels will not directly impact these results. The adjustment factors allow for predicted market clearing prices that more closely match historic prices, and simulate levels of economic DR clearing the market based on realistic price levels.

### 3.4 Energy shifting

Aggregate effects on demand from DR dispatch consist of both a reduction and a shift in energy use. Demand shifting involves moving electricity use to off-peak periods, but doesn't involve a net reduction in energy use over time. Smith and Brown (2015) find that on average, 16% of peak energy reduction from DR is shifted to off-peak periods. This value was derived from price-quantity elasticity estimates from a study that empirically measured the effects of a Duke Energy real-time pricing program over 8 years (Taylor, Schwarz, and Cochell, 2005). Modeling in De Jongh, Hobbs, and Bellmans (2012) assumes DR energy shifting ranges from 8% to 16%. Furthermore, FERC's Demand Response Impact and Value Estimation (DRIVE) model provides hourly impact profiles of DR programs. Examining the load shifting parameters in this model for residential programs, commercial/industrial (C/I) interruptible tariffs, and other large C/I programs, yields a weighted average energy shift value of 12.1%. In contrast, the EIA NEMS assumes DR energy shifting of 96%, although this parameter does not appear to be supported by empirical experimental evidence (Smith and Brown, 2015).

Drawing from this literature, our baseline scenario assumes 15% of DR energy reductions are shifted to off-peak hours. We also conduct sensitivity scenarios that assume 1) zero energy shifted to off-peak, and 2) 96% energy shifted to off-peak. We model DR reductions occurring during the last hour of the highest-value four-hour blocks plus the three preceding hours. The load shift is then modeled as an energy increase during the four hours following the DR reduction. In the occasional situations where DR deployment occurs during the late evening (HE 19-23), we model the rebound during the hours preceding the event, assuming customers will anticipate the DR reduction instead of increasing energy use when most people are asleep. Since prices are similar on average before and after DR events, changing whether the energy shifting occurs before or after the DR event does not have a material impact on the aggregate market effects reported as results.

### 3.5 Carbon emissions

We estimate carbon dioxide ($CO_2$) emissions effects for each model scenario. For confidentiality purposes, MISO's generator offers data do not identify individual plants, so neither plant-level emissions nor fuel-type information is available. We approximate the carbon content of the marginal generation for each hour by using MISO's real-time fuel on the margin data (MISO Real-Time Fuel, 2015). The data specifies the fuel of the marginal generator by region for every hour. Specifically, we multiply the hourly change in energy from DR (in MWh) by our estimate of the hourly $CO_2$ emissions content of the marginal generator (in kg $CO_2$/MWh). We use national averages of $CO_2$ emissions rates per MWh by fuel type from the U.S. Department of Energy (U.S. DOE, 2016), provided in Table 1. Since the MISO fuel-type data does not break out natural gas plants by combined cycle or combustion turbine, and since data on dispatch frequency by generator type in MISO is not available, the emissions factor used for natural gas is a simple average of the combined cycle and combustion turbine emissions rates. It is possible that a reduction in DR could cause the marginal fuel type to switch, however we are unable to see when this would happen given limitations in publicly available data. Thus, our results should be treated as approximations of the $CO_2$ emissions effects from DR dispatch.

**Table 1: U.S. average carbon dioxide emission rates by fuel type. Source: US Department of Energy.**

| Fuel type | Emission rate (kg $CO_2$/MWh) |
|---|---|
| Coal | 960.6 |
| Petroleum | 743.4 |
| Natural Gas | 505.9 |

### 3.6 Scenarios

We calculate market savings, price effects, and emissions effects for several scenarios to understand how changes in several variables affect our results. The scenarios include variations on the following parameters:

a) **When to deploy DR.** As discussed in section 3.1, LMR contracts only require DR to be available during the summer months (June 01–August 31), however many DR resources in MISO can be deployed outside of the summer. We model scenarios with DR deployment occurring during the highest value hours in summer months, and another with deployment during the highest value days from the entire year.

b) **Frequency of deployment.** As discussed in section 3.1, MISO's DR contracts only require DR to be deployed up to 5 times per year, but DR programs are often designed to be deployed more than 5 times per year. In general, incentive-based DR programs are designed for 8–20 deployments per year (Cappers et al, 2013). We model scenarios where DR is deployed 5 times per year, 10 times per year, and 20 times per year. Note that deploying a DR resource more often will lower its average energy offer value necessary to recover program lifetime costs, which will lead to reduced energy offers in a competitive market. As a result, increasing the frequency of DR deployment will lower DR offer cost estimates described in online appendix 2. As a result, increasing the frequency of DR dispatch will lower energy offer estimates, and more DR may clear at a given price.

c) **Amount of DR resources.** The DR dataset obtained from the EIA reports 4,355 MW of DR registered in the MISO region. In contrast, MISO's resource auction results for the 2015–16 planning year indicate 5,745 MW of installed DR capacity (MISO Planning Resource Auction, 2016). We model a baseline scenario with the 4,355 MW of DR for which we have detailed cost data, and an expanded scenario with 5,745 MW of DR. When scaling up DR to match the amount reported by MISO, we assign the DR to regions based on their relative regional shares as reported in the EIA data, displayed in Table 2, and assume energy offers for the expanded DR equal to the median values from the detailed EIA cost data. More details on the data cleaning process for this EIA dataset are provided in online appendix 5.

d) **Demand shift.** As discussed in section 3.4, we vary the demand shifting assumption from 0%, 15%, and 96%.

e) **Marginal costs.** As mentioned in section 3.2, we model scenarios in which energy offer estimates are increased by 100%, due to the possibility that DR resources may offer into the market at higher prices than our estimates.

**Table 2: DR resources by region. Source: US Energy Information Administration.**

| Region | DR (MW) | Share |
|---|---|---|
| Central | 2074.0 | 0.48 |
| North | 1791.3 | 0.41 |
| South | 489.9 | 0.11 |
| Total | 4355.2 | 1 |

### 3.7 Scenario summary

In summary, the following list summarizes the five parameters that are varied to produce sensitivity scenarios:

- When to deploy DR
  1. Summer
  2. Year-round
- Frequency of deployment
  1. 5 deployments per year
  2. 10 deployments per year
  3. 20 deployments per year
- Amount of DR resources
  1. Base—4,355 MW
  2. Expanded—5,745 MW
- Rebound effect
  1. Low—0%
  2. Base—15%
  3. High—96%

- Energy offers
  1. Baseline estimates
  2. Baseline estimates increased by 100%

We vary these parameters to produce 30 simulations, the results of which are discussed next.

## 4. RESULTS

### 4.1 Baseline scenario

The parameter levels for the baseline scenario are listed below:

- Summer-only deployment
- 5 deployments per year
- Base-level DR resources (4,355 MW)
- Base-level rebound effect (15%)
- Baseline energy offer estimates

The results by region are provided in Table 3. In these and subsequent results, the dollar level values are rounded to the nearest $1,000 to provide a realistic perspective on the model's precision. The results for the North and Central regions are more indicative of 'typical' peak operating conditions, while the South region results include an extreme price event. For example, the average adjusted predicted price during the peak hours in the baseline scenario for the North and Central regions was $43.57, and the maximum price observed was $62.56. The South region had similar predicted price levels except for one day where prices spiked above $100 for a few hours, at which point a small amount of DR had a large effect on prices and consumer savings. Almost 2,000 MW of DR deployment in the North and Central regions combined is predicted to produce about $1.3 million in consumer savings in the baseline scenario. Conversely, only 45 MW of DR in the south region produced $38 million in consumer savings.

The South region outlier demonstrates how a small amount of DR can generate exponentially higher consumer savings if deployed in a location where the market is clearing in a steep portion of the supply curve. While not typical, extreme price events do happen and contribute to a large share of the value case for DR in wholesale markets. For example, from 2015 through 2017, the years for which historical system price data is readily available online at the time of writing, there were 100 hours during which the average MISO system price exceeded $100/MWh. Of this 12 hours were above $200/MWh, of which 2 hours were above $300/MWh (MISO Real-Time Pricing, 2015).

In addition to consumer savings, the baseline model shows modest $CO_2$ emissions reductions from DR, on the order of 0.3%–0.5% of total electric sector emissions from the MISO region. Because DR must pass the net benefits test before being deployed, the revenue paid to DR providers is less than consumer savings for each region.

**Table 3: Simulation results by region—baseline scenario.**

| Region | Annual consumer savings ($) | Annual $CO_2$ reduction (kg) | DR cleared—hourly average (MW) | Annual DR Revenue ($) | Price effect—hourly average ($/MWh) |
|---|---|---|---|---|---|
| North | 466,000 | 6,754,000 | 789 | 325,000 | –0.54 |
| Central | 836,000 | 9,696,000 | 1,163 | 511,000 | –0.43 |
| South | 37,696,000 | 73,000 | 45 | 15,000 | –32.33 |

## 4.2 Alternative scenarios

As discussed in section 3.6, we explore how changes to the parameter values impact results. The effects of parameter changes are summarized in Table 4. The first row in Table 4 presents the results of the baseline scenario for the North and Central regions combined. Each subsequent row presents average deviations from the baseline for each scenario, totaled across the North and Central regions, holding all other model parameters constant. For example, the values in the second row indicate that increasing from 5 to 10 DR deployments per year increases annual consumer savings by $1,054,907 on average across our simulations. We omit the outlier results from the South region to better represent effects of DR during non-emergency peak operating conditions. Including the South region results would change these results by orders of magnitude.

To derive the values in Table 4, we estimate a regression model using the simulated results across all scenarios for the North and Central regions. The independent variables in the regression are indicator variables corresponding to each of the simulation parameters, corresponding to the rows in Table 4. Regression coefficients on categorical explanatory variables are interpreted as average deviations from the reference category. Thus, each coefficient represents an average change from the baseline DR scenario. Because these coefficients show average deviations in outcomes predicted by various modeled supply-demand equilibria, the underlying data generating process lacks a stochastic element and reporting standard errors is not informative. The coefficients from the regression corresponding to each parameter adjustment are added to the baseline results to produce the non-baseline values in Table 4. The output for all 30 scenarios provides the underlying data for these regressions and are provided in online appendix 6. The detailed results in the appendix show that consumer savings vary across model scenarios between $1.3 million to $17.6 million for the North and Central regions during typical peak operating conditions.[10]

As reported in Table 4, increasing the frequency of deployments per year and expanding the amount of DR resources available for deployment increases annual consumer savings, $CO_2$ reductions, DR cleared, and price reductions relative to the baseline scenario. This is logical, as one would expect an increase in DR deployment frequency or amount to increase the magnitude of market effects relative to the baseline scenario. Changing the demand shifting parameter to zero

**Table 4: Average deviations from baseline results by scenario.**

| Scenario | Annual Savings ($) | Annual $CO_2$ reductions (kg) | DR cleared—hourly average (MW) | Annual DR revenue ($) | Price effect—hourly average ($/MWh) |
|---|---|---|---|---|---|
| Baseline | 1,302,000 | 16,450,000 | 1,952 | 836,000 | –0.49 |
| 10 deployments | +1,055,000 | +10,478,000 | +838 | +321,000 | –0.04 |
| 20 deployments | +3,319,000 | +33,114,000 | +321 | +683,000 | –0.12 |
| Expanded amount (5,745 MW) | +996,000 | +9,346,000 | +562 | +465,000 | –0.22 |
| Zero energy shift | +461,000 | +5,548,000 | 0 | 0 | –0.35 |
| High energy shift (96%) | –2,940,000 | –29,958,000 | 0 | 0 | 0.80 |
| Annual deployments | +1,500,000 | –3,334,000 | –151 | +40,000 | –0.36 |
| High energy offers | –598,000 | –5,767,000 | –202 | –290,000 | –0.14 |

Note: Values summarize the results of 30 simulations. Each column represents results for that variable in the north and central regions. The top row presents the baseline results, summed over the north and central regions. Each subsequent row presents the corresponding scenarios' average deviations from the baseline value.

10. These numbers exclude the simulations with 96% energy shifting as this is not an empirically realistic level.

also increases the savings, $CO_2$ reductions, and the price effect relative to the baseline scenario. This is because in the baseline scenario, the 15% demand shift partially offsets the peak hour effects as consumers purchase more energy in off-peak hours. The 'annual deployments' row indicates that allowing DR to dispatch during non-summer days when more cost savings opportunities are available will increase overall consumer savings, while the negative coefficient on emissions suggests less opportunity for emissions reductions are available during non-summer months. This is because DR deployments during summer months often reduce output from less efficient peaking generators, and DR in non-summer months sometimes shifts peak energy generated from gas to off-peak energy generated from coal. Finally, increasing DR energy offer costs by 100% reduces annual consumer savings by about one-third, decreases emissions savings, lowers the amount of DR cleared, and dampens the negative price effect relative to the baseline scenario. This is to be expected, since this scenario makes DR resources more expensive for the market operator.

Excluding outliers from the South region, the results of our modeling across all our simulations show average price reductions ranging from 3% to 9%. This is consistent with past analyses of the PJM market, which showed that reducing approximately 1% of peak demand in the PJM market would result in a 5%–8% reduction in LMPs (The Brattle Group, 2007; Faruqui, Hledik, Newell, and Pfeifenberger, 2007).

The scenario with a high energy shift produced some interesting results. First, increasing the rebound effect to 96% increased overall $CO_2$ emissions in every region and deployment scenario, suggesting that off-peak generation in MISO has a higher average emissions content than on-peak generation. Secondly, some of our high-rebound simulations produced negative net consumer savings. In other words, deploying demand response resources that pass the net benefits test in the hour they were deployed actually increased overall costs after taking into account the off-peak increase of energy. This occurred because less supply resources are available for dispatch in non-peak hours. The large increase in energy use during off-peak hours increased prices on average by more than prices decreased during peak hours, when more supply is available to meet high levels of demand.

In all the high energy shift scenarios except for those in the South region, aggregate consumer savings from DR were less than the aggregate revenue paid to DR providers. In this situation, the DR is deployed because it passes the net benefits test during the peak hours in which the DR is dispatched, and DR providers earn revenue. However, the large increase in off-peak energy offsets consumer savings, with no corresponding decrease to DR providers' revenue. These results violate the net benefits test in principle, however they still occurred because we programmed the net benefits test in our model to be temporally myopic. By this we mean that the net benefits test did not incorporate decreased consumer welfare in future periods due to energy shifting. This myopic characteristic is also present in the ISO/RTO net benefit test methodologies in tariffs filed with FERC. FERC's final ruling in Order 745 makes no mention of incorporating effects of energy shifting in net benefits testing (U.S. FERC, 2011). Furthermore, most ISO/RTO net benefits tests in practice are characterized by econometric estimates of the monthly average price quantity pair where the supply curve becomes inelastic, with no consideration of how energy shifting from DR reduction may offset consumer savings.[11] As shown by our modeling, a demand reduction that occurs at an inelastic portion of the supply curve can fail the net benefits test if consumer savings are offset by energy shifting to other periods, without a corresponding offset to DR revenue. We identify this myopic characteristic as a policy shortcoming of the net benefits test required by FERC and operational in wholesale electricity markets across the U.S. Despite this theoretical issue identified in our

11. MISO Net Benefits Price Threshold Information, 2017; California ISO, 2018; Southwest Power Pool, 2018; PJM 2018; New York Independent System Operator, 2011.

modeling, we note again that this issue occurred only in our simulations with a 96% energy shift. While 96% is the energy shifting value assumed in EIA's Annual Energy Outlook modeling, it does not appear to be supported by empirical experimental evidence (Smith and Brown, 2015).

### 4.3 Effects not quantified

In addition to what was quantified in this study there are other potential market effects which we do not attempt to quantify in our dynamic supply-demand framework. These include:

- Reduced generation reserve investment.
- Improved operational efficiency of the transmission and distribution systems.
- Integration of intermittent renewable generation.
- Reduced wholesale market price volatility.
- More competitive power markets.
- Insurance against extreme events.
- Improved system reliability.
- Delayed retirements of coal plants by increasing off-peak demand and reducing operational wear and tear induced by using them to follow shifts in load.

It is clear from the body of literature on the topic that the value from deploying DR programs extends across the range of actors and processes within the electricity system. Furthermore, the magnitude of these value streams varies greatly across individual markets and regulatory environments, emphasizing the need for targeted, market-specific analysis to understand the effects of implementing DR within a given market context.

## 5. CONCLUSIONS

This study quantifies consumer savings and other market effects from increasing incentive-based demand response (DR) dispatch in the Midcontinent ISO energy market. It is motivated by the fact that regulatory and market barriers in the Midcontinent region keep cost-effective DR out of the wholesale market, raising electricity prices. We develop a bottom-up, dynamic supply and demand model of the Midcontinent market that shows:

1. DR dispatch can generate consumer savings ranging from \$1.3–17.6 million under typical peak operating conditions.
2. Model results for the South region demonstrate that consumer savings and other market effects can exponentially increase when a small amount of DR is deployed at locations with very high prices.
3. We estimate market effects for a range of scenarios that change DR deployment levels, frequencies, and demand-shifting effects. Emissions reductions are modest but positive for most scenarios, and average price effects range from about -\$0.50 to -\$1.50 per megawatt-hour across most scenarios during typical peak operations.
4. Demand response modeling can be sensitive to energy shifting assumptions. We note that the large energy shifting assumption of 96% utilized in the U.S. Energy Information Administration's National Energy Modeling Systems can produce DR deployments that violate the net benefits test once the increased post-DR consumption is accounted for. The myopic net benefits testing procedures currently used in U.S. power markets do not account for this possibility.

Our supply-demand framework quantifies DR market effects due to supply curve shifts, and does not consider other market effects, including reduced or deferred capital investments, reduced price volatility, and improved system reliability. This study suggests that regulators, market operators, market participants, and other stakeholders should focus policy efforts to reduce regulatory and market rule barriers to DR deployment, particularly in locations that experience high price spikes. This will improve market efficiency and generate cost savings for electricity consumers net of system costs.

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# TAB L

This is Exhibit **"L"** referred to in the Revised Affidavit of Brian Rivard sworn before me this 21st day of November, 2019

*A Commissioner for Taking Affidavits*

Lauren Theresa Daniel, a Commissioner, etc.,
Province of Ontario, while a Student-at-Law.
Expires April 8, 2022.

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# Fixing FERC's Order No. 745

*While the Federal Energy Regulatory Commission's landmark ruling provides strong stimulus for demand response resources in wholesale electricity markets, extensive testing of the Order's net benefits test reveals several significant shortcomings. A couple of improvements can remedy these shortcomings without altering the nature of the Order.*

*Kai Van Horn, Isaac Castillo and George Gross*

## I. Introduction

The Federal Energy Regulatory Commission's Order No. 745 was promulgated on the premise that demand response resources (DRR) participation enhances the competitiveness of wholesale energy markets and that it is FERC's mandate to ''ensure the competitiveness of organized wholesale energy markets''[1] and thus ensure ''just and reasonable wholesale rates.''[2] Prior to the Order, the incentives for DRR participation in the wholesale electricity market varied from market to market and were insufficient to engender consequential DRR participation. FERC deemed the failure of independent system operators (ISOs)/regional transmission organizations (RTOs) to provide DRR incentive payments at the locational marginal price (LMP) as ''unjust and unreasonable''[3] and cited the level of the incentives DRRs received, and the lack of standardized DRR incentives, as significant barriers to DRR participation. The key objectives of FERC Order No. 745 are to remove the identified barriers to DRR participation in electricity markets and to ensure that DRRs are utilized only in instances in which they have the ''capability to

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balance supply and demand''[4] and are a ''cost-effective''[5] alternative to supply-side resources. FERC Order No. 745 is a landmark ruling that provides significant stimulus for *DRR* participation in wholesale electricity markets and has been a major catalyst for the recent growth and development of the demand response industry. The Order aims to achieve its objectives via three main thrusts. The first thrust is to establish standardized incentives, payment at the LMP, for DRRs operating in any ISO/RTO-run electricity market. This thrust addresses the Order's first objective by establishing ''greater uniformity''[6] in the incentives provided to DRRs in ISO/RTO-run markets. The second thrust is to explicitly define a cost-effectiveness criterion, the *threshold price*, to determine the instances under which such incentives are provided, and to prescribe a methodology, the net benefits test (NBT), by which ISO/RTOs calculate the threshold price. The third thrust is to establish a mechanism by which to allocate the costs to the post-curtailment loads to provide the DRR incentive payments, which we term the incentive payment allocation (IPA). In other words, the IPA sets forth an explicit means by which the proportion of the costs of providing DRR incentive payments borne by each post-curtailment load is determined. The second and third thrusts address the second objective of the Order by providing a screen to filter out those hours in which DRRs may not reduce post-curtailment buyer payments and to ensure that FERC's cost causation principle[7] is upheld in the IPA.

While the thrusts of the Order make strides toward achieving its objectives, they have significant limitations, which prevent the full realization of those objectives. The principal limitation is the failure of the NBT to account for the impacts of transmission congestion. Though sufficient information, the LMPs, is currently available to integrate the impacts of transmission congestion on the cost-effectiveness of DRRs on a nodal basis into the NBT, FERC did not address or require the use of such information in the NBT methodology. A secondary limitation is the ambiguity of the IPA mechanism as stated in the Order. A lack of adequate specificity in the IPA provisions has left open the door to IPAs which are not consistent with the second objective of the Order. These limitations result in unintended economic consequences for the non-DRR buyers.

*While the thrusts of the Order make strides toward achieving its objectives, they have significant limitations, which prevent the full realization of those objectives.*

FERC NBT explicitly defines the DRR cost-effectiveness criterion, the so-called threshold price, as ''the point along the supply stack beyond which the overall benefit from the reduced LMP resulting from dispatching demand response resources exceeds the cost of dispatching and paying LMP to those resources.''[8] This threshold price is calculated on a *system-wide* basis making use of averaged historical supplier offers and historical fuel price data. If the LMP at a node exceeds the threshold price in a day-ahead or real-time market interval, all cleared DRR curtailments at the node must be provided incentive payments at the LMP. The explicit definition of a cost-effectiveness criterion benefits DRRs by providing a concrete condition under which they receive incentives at the LMP that reduces the level of uncertainty in the magnitude and frequency of their compensation. The threshold price is intended to benefit the non-DRR buyers by preventing the utilization of DRRs when they do not reduce post-curtailment buyer payments. However, the threshold price benefits to non-DRR buyers are not as certain as those for DRRs, and, while DRRs always receive incentive payments at the LMP when the threshold price is met, non-DRR buyer payments may not be reduced. When implemented, the threshold price is compared on a nodal basis to the LMPs, which explicitly account for the impacts of transmission congestion. The congestion impact information

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mismatch introduced by the direct comparison of the system-wide threshold price with the LMPs leads to cases of omission and commission in the determination of the level of DRR incentive payments that have important ramifications for the non-DRR buyer payments.

In a pre-curtailment network with transmission congestion, the LMPs differ from one node to another. As a result, cases arise in which DRR curtailments occur but do not result in a reduction in post-curtailment buyer payments i.e. cases of commission, and cases arise in which DRR curtailments do not occur that would have resulted in a reduction in post-curtailment buyer payments i.e. cases of omission. Moreover, the LMP impacts of DRRs differ on a nodal basis. In such a system, there may be a subset of nodes whose LMPs are above the threshold price and a subset of nodes whose LMPs are below the threshold price. At nodes where DRR curtailments occur, the post-curtailment LMPs are, in general, less than the pre-curtailment LMPs due to the load reductions brought about by the DRR curtailments. However, the *LMP* impacts of *DRR* curtailments at those nodes where there are no *DRR* curtailments are mixed. *The post-curtailment LMPs at nodes which have no DRR curtailments may be higher or lower than the pre-curtailment LMPs at the same nodes due to the transmission congestion impacts.* Clearly, those nodes which experience *LMP* increases as a result of *DRR* curtailments are made worse off, while those nodes which experience *LMP* reductions share in the benefits of *DRR* curtailments. The existence of cases omission and commission and cases in which loads at certain nodes are made worse off as a result of *DRR* curtailments are the unintended consequences of the failure to integrate transmission congestion impact information into *FERC NBT*. Further unintended consequences arise as a result of the Order's *IPA* definition.

*The IPA definition in the Order is ambiguous and has led to IPAs which have unintended consequences in congested systems.*

According to the *IPA* mechanism in the third thrust of the Order, the *IPA* must be done ''proportionally to all entities that purchase from the relevant energy market in the area(s) where the demand response resource reduces the market price for energy at the time when the demand response resource is committed or dispatched.''[9] This mechanism aims to uphold *FERC*'s cost causation principle and ensure that costs of the incentive payments to *DRR*s are distributed among the buyers in the system so that all buyers benefit from *DRR*s in the form of reduced post-curtailment payments. However, the *IPA* definition in the Order is ambiguous as to the nature of the proportionality of the payment allocation and has led to *IPA*s which have unintended consequences in congested systems. The accepted Order No. 745 compliance filings to date have included load-proportional *IPA*s (*LP-IPA*s)[10] i.e. the allocation of the costs of the *DRR* incentive payments to the non-*DRR* buyers which benefit from *DRR* curtailments is in proportion to a buyer's load's contribution to the total load of those buyers who benefit. While such an *IPA* takes two steps toward achieving the objectives of the Order, it also takes one step away as it divorces the magnitude of the benefits of *DRR* curtailments received by buyers from the proportion of the costs of the incentive payment to the *DRR* for which the buyers are responsible. In a congested system, buyers at a node *i*, at which a *DRR* curtailment occurs, may experience only a modest buyer payment reduction as a result of the curtailment. The buyer payment reductions for buyers at node *i* may be less than the portion of the costs to provide *DRR* incentive payments for which buyers at that node are responsible. The result is that, though the node *i* post-curtailment *LMP* is less than the pre-curtailment *LMP*, the buyers at node *i* may face a *post-IPA LMP* which exceeds the pre-curtailment *LMP*. *Under a load-proportional IPA there is no guarantee that the post-IPA*

  

*LMP will be less than the pre-curtailment LMP*. Clearly, buyers which face a post-*IPA LMP* which exceeds the pre-curtailment *LMP* are worse off as a result of the *DRR* curtailments. Moreover, the accepted *IPA*s have not addressed the *DRR* benefit allocation issues which arises in cases in which the total post-curtailment buyer payments decrease but the buyers at some nodes experience post-curtailment *LMP* increases while buyers at other nodes experience post-curtailment *LMP* decreases. Such cases show a limitation of the Order which is counter to *FERC*'s intent in the second objective, and that can be addressed through the design of an appropriate *IPA*.

In this work, we identify and discuss several limitations of *FERC* Order No. 745 that have unintended economic consequences and provide the results of studies which give insights into the magnitude of the economic impacts of those consequences. We then propose effective modifications to *FERC* Order No 745 that address the limitations we have identified. Our proposed modifications maintain the spirit of the Order and are both simple, requiring few changes to the procedures outlined in the Order, and effective, significantly reducing the number of hours in which *DRR* curtailments are uneconomic. We propose the application of the *NBT* on a nodal basis, a nodal *NBT*, to calculate nodal threshold prices, the calculation of which takes explicit account of the transmission congestion impacts through the use of readily available *LMP* data. The nodal *NBT* brings the explicit representation of the grid and the deliverability of the supply to meet the demand into the prescribed *NBT* process. Such a nodal criterion provides a finer screen for the evaluation of *DRR* cost-effectiveness that reduces the frequency of the occurrence of uneconomic *DRR* outcomes and the cases of omission and commission. Furthermore, we put forth a benefit-proportional *IPA* with side payments which marries the benefits realized by non-*DRR* buyers with the proportion of the costs to provide incentive payments for which they are responsible and includes the additional post-curtailment payments by those buyers made worse of as a result of *DRR* curtailments as a ''cost'' to be allocated under the *IPA*. Our approach provides what the current approaches have so far failed to provide: the explicit assurance that no loads are made worse off by *DRR* curtailments in cases in which the *DRR* curtailments reduce the total post-curtailment buyer payments. This assurance, along with the nodal *NBT*, guarantees to a greater extent that the objectives of the Order will be achieved.

*Our proposed modifications maintain the spirit of the Order, and are both simple and effective.*

The remainder of the article is divided into three sections. In Section II, we provide a detailed discussion of the unintended consequences that result from the limitations of *FERC* Order No. 745 and show the significant impact these consequences have on non-*DRR* buyers. In Section III, we describe our proposed modifications to the Order to address its limitations and show the non-*DRR* payment impact improvements which can be gained by applying our modifications. In Section IV, we summarize the article.

## II. The Unintended Consequences of *FERC* Order No. 745

*FERC* Order No. 745 is one of the most important rulings regarding *DRR* participation in the wholesale electricity markets to date. The incentives mandated by the Order are already beginning to have a major impact on increasing *DRR* participation in some wholesale electricity markets.[11] This increased *DRR* participation is a testament to the effectiveness of the thrusts of the Order at achieving its first objective: to encourage *DRR* participation by removing market barriers to *DRR*s. However, we question the effectiveness of the

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thrusts at achieving the second objective, and whether the impacts of *DRR*s under the Order will be beneficial for all buyers. In this section we discuss in detail the limitations of *FERC* Order No. 745 we have identified, the unintended consequences which arise as a result of those limitations and the economic impacts of those unintended consequences on non-*DRR* buyers.

The second objective of *FERC* Order No. 745 is to ensure that *DRR*s are only used when they are a ''cost-effective'' alternative to generation i.e. the *DRR* curtailments results in reduced post-curtailment buyer payments. As we outlined in the introduction, the second thrust of the Order aims to ensure post-curtailment buyer payments do not increase through the establishment of the *NBT* and its corresponding threshold price. The *NBT* essentially provides a screen through the hours in which *DRR*s may be provided incentives at the *LMP* must pass. The goal of the use of such a screen is to prevent *DRR* curtailments in hours in which they will result in higher post-curtailment buyer payments. However, as we will show, the screen provided by *FERC NBT* is too coarse due to the system-wide nature of the data used to calculate the single system-wide threshold price and the failure to explicitly account for the impacts of transmission congestion. As a result, *FERC NBT* screen dictates that *DRR*s be provided incentive payments in many hours in which the provision of those incentives increases post-curtailment buyer payments for at least a subset of the buyers.

We illustrate several cases in which *DRR* curtailments result in increased buyer payment due to the limitations of the Order with two examples on a 7-bus system. In the first example, we consider a single 10 MW *DRR* at node 3, which represents approximately 1 percent of the total load of the system. Figure 1 shows the pre-curtailment and post-curtailment *LMP*s at the load nodes in the 7-bus system. The system is congested, as indicated by the fact that the pre-curtailment *LMP*s differ at each node. The highest pre-curtailment *LMP* in the system is at node 3 and we assume this price exceeds the threshold price. From Figure 1, we see that the post-curtailment *LMP*s at nodes 2, 3, and 6 are decreased by the *DRR* curtailment—the intended impact. However, changes in the network congestion patterns caused by the *DRR* curtailment result in post-curtailment *LMP* spikes at nodes 5 and 7. These *LMP* spikes overwhelm the *LMP* reductions at nodes 2, 3 and 6 and the overall buyer payment impact of the *DRR* curtailment is an increase in the total post-curtailment buyer payments. This example clearly shows the importance of transmission congestion impacts on the *DRR* curtailment outcomes. The resulting buyer payment increases are an unintended consequence of the *FERC NBT* and we will show that such cases arise frequently in congested systems.

The example in Figure 1 also highlights an issue that arises in transmission-congested networks: the non-*DRR* buyer benefits of *DRR* curtailments are different at each node. When there is no transmission congestion, the benefits of *DRR* curtailments received, or losses borne, by the non-*DRR* buyers are the same on a per-MW basis for each buyer regardless of the buyer's location. However, this is not the case when transmission congestion arises. *In a transmission-constrained system, the per-MW benefits*

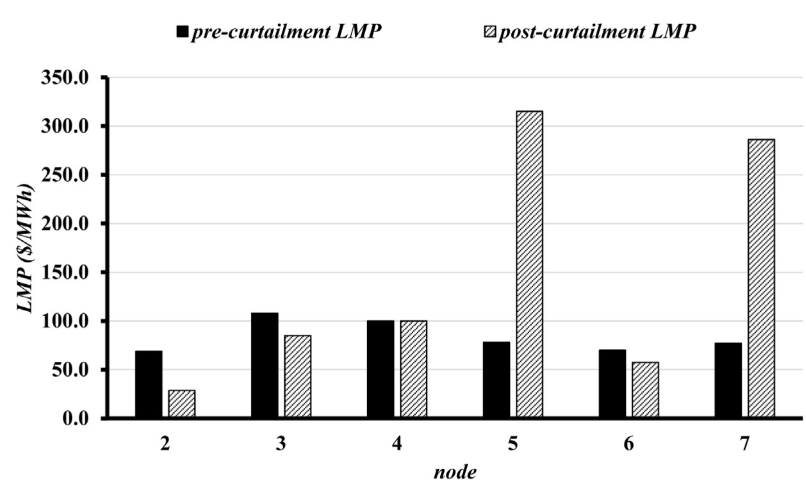


**Figure 1:** 7-Bus System Example 1, 10 MW DRR Curtailment at Node 3, Total Buyer Payment Increase

*(losses) received (borne) by each buyer as a result of DRR curtailments differ on a nodal basis*. In the example, clearly the loads at nodes 5 and 7 have been negatively impacted by the *DRR* curtailment *despite their lack of participation as DRRs* while the loads at nodes 2, 3 and 6 benefit. Such a distribution of the *DRR* benefits and losses represents a second unintended consequence of the limitations of the Order.

A key stipulation of *FERC* Order No. 745 which plays a large role in the ultimate impact of *DRR* curtailments on the non-*DRR* buyer payments is the *IPA* stipulation. The *IPA* framework outlined in the Order requires that the costs of providing incentive payments to the *DRR*s for their curtailments be borne by the buyers who benefit from those curtailments in the form of reduced post-curtailment *LMP*s. However, how those ''costs'' are distributed to the buyers who benefit is not specified. Absent specific details from *FERC* about the proportionality of the allocation, *LP-IPA*s have emerged as the prevailing *IPA* approach. However, such *IPA*s fail to account for the impacts of transmission congestion on the distribution of the *DRR* benefits among the post-curtailment buyers. This shortcoming leads to cases under which the total post-curtailment buyer payments are reduced but, for buyers at some nodes, the post-*IPA* buyer payments increase. We illustrate such a case with a second example using the same 7-bus system as before with a different distribution of the loads to produce a different *LMP* profile. In this example, we introduce a 100 MW *DRR* curtailment at node 3, which represents approximately 10 percent of total load, and allocate the costs of the incentive payments via an *LP-IPA*. The pre- and post-curtailment *LMP*s and the post-*IPA* *LMP*s are shown in **Figure 2**.

We note that buyers at a single node, node 2, suffer a small increase in the post-curtailment *LMP* as a result of the *DRR* curtailment while buyers at the remaining nodes experience post-curtailment *LMP* decreases or no change in the post-curtailment *LMP*. The overall result of the *DRR* curtailment for the non-*DRR* buyers is a decrease in the total post-*IPA* buyer payments. We see in Figure 2 that the post-curtailment *LMP* is reduced for the loads at nodes 3-5 and node 7.[12] However, the *LMP* reductions are not uniform across the nodes and we see that, in particular, the buyers at nodes 3 and 4 experience far higher post-curtailment *LMP* reductions compared to the pre-curtailment *LMP*s than those buyers at nodes 5 and 7. This non-uniform accumulation of the *DRR* benefits on a per-MW basis, combined with the *LP-IPA*, which allocates uniformly to each buyer on a per-MW basis, results in buyers at nodes 5 and 7 paying a share of the *DRR* curtailment incentives which is higher than the benefits they receive from the curtailment. The result is the increased post-*IPA* *LMP*s compared to the pre-curtailment *LMP*s for buyers at nodes 5 and 7 shown in Figure 2. Furthermore, the *IPA* provides no compensation for the ''innocent bystander'' node 2, which has a higher post-curtailment *LMP* as a result of the *DRR* curtailment at node 3. The ultimate outcome in this example, despite the overall reduction in total post-*IPA* buyer payments, is that buyers at half of the load nodes pay higher *LMP*s than they would have without the *DRR* curtailment. The negative impact of the *IPA* in this case showcases another unintended consequence of the Order. This example also illustrates the importance of the

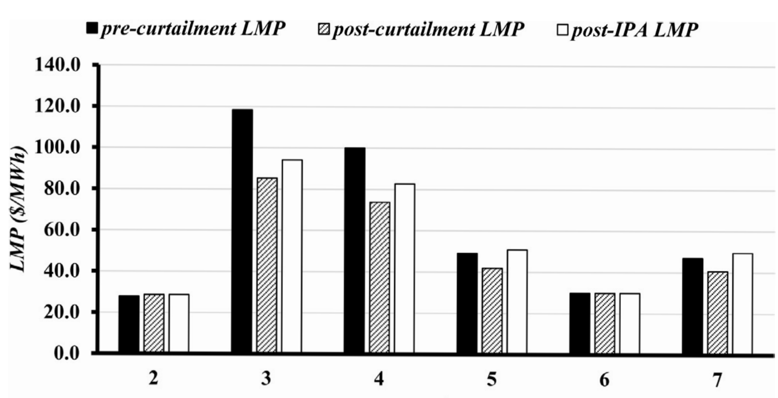


**Figure 2:** 7-Bus System Example 2, 100 MW *DRR* Curtailment at Node 3, Total Buyer Payment Decrease

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**Table 1:** Reference Cases $N_0$ and $M_0$ and *DRR* Cases $N_3$ and $M_3$ System-Wide Metrics.

| Metrics | $N_0$ Annual Metrics | $N_3$ Annual Metrics | $M_0$ Annual Metrics | $M_3$ Annual Metrics |
|---|---|---|---|---|
| Cleared demand (h) | 47,700,000 | 47,300,000 | 53,100,000 | 52,700,000 |
| Buyer payments (M$) | 3,320 | 3,240 | 3,090 | 3,060 |
| Congestion rents (M$) | 295 | 216 | 116 | 85.9 |

nature of the proportionality of the distribution of the costs to provide *DRR* incentive payments in the *IPA* and further highlights the importance of the explicit consideration of transmission congestion to ensure the thrusts of the Order meet its second objective.

The examples given above have highlight several cases in which the failure of *FERC* to account for transmission congestion considerations leads to unintended outcomes that are inconsistent with the second objective of the Order for buyers at some or all nodes in the system. We turn next to the aggregate impact of such cases over a one-year period to shed some light on the magnitude of *FERC* Order No. 745's unintended consequences.

We present a representative selection of results from our extensive simulation studies to facilitate the discussion of the aggregate impact of the unintended consequences of *FERC* Order No. 745.[13] We simulate the day-ahead markets (*DAM*s) with *DRR* penetrations in the range of [1,11]% of system peak load for the year 2010 on the IEEE 118-bus test system using data from *ISO-NE*, the cases from which we label $N_c$, and *MISO*, the cases from which we label $M_c$, where c case *DRR* capacity as a percentage of the system peak load.[14] Furthermore, we assume *DRR* curtailments occur between the hours of 1:00 p.m. and 9:00 p.m., in compliance with *FERC NBT* and that an *LP-IPA* is used. Our reference case for comparison in both the $N_c$ and $M_c$ cases is the study system without *DRR*s, $N_0$ and $M_0$, respectively.

**Table 1** shows the metrics for the one year simulated in the reference cases and in the 3 percent *DRR* cases. We see that *DRR*s are a net benefit to the system reducing the overall buyer payments in the $N_3$ and $M_3$ cases. *DRR* curtailments result in 2.4 percent and 1.9 percent reductions in the total buyer payments from the reference case in the $N_3$ and $M_3$ cases, respectively.

Though the annual buyer payments are reduced in both of the *DRR* cases presented, there are many hours in which *DRR* curtailments do not reduce buyer payments. In **Figure 3**, we present the monthly number of hours in which *DRR* curtailments resulted in post-curtailment buyer payment increases in case $N_3$.

In most months, we see that the number of hours in which *DRR* curtailments result in increased buyer payments remains below 20 indicating the capability of *FERC NBT* to screen out the hours in which providing *DRR* incentive payments at the *LMP* would be detrimental to the non-*DRR* buyers. However, we see several months in which a large number of hours had curtailments which increased the total buyer payments. Surprisingly, one of these months is August when we would expect *DRR* curtailments to be the most

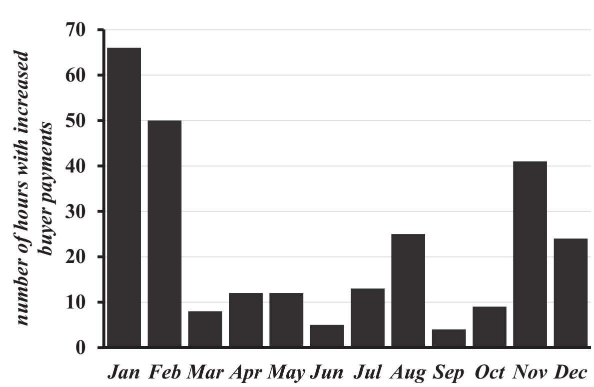


**Figure 3:** Post-Curtailment Buyer Payment Increases Due to *DRR* Curtailments for Case $N_3$

effective due to the higher loads and higher prices most systems experience during the summer. We conclude that *FERC NBT* performs poorly in August due to shifts in the congestion patterns caused by the *DRR* curtailments which increase payments for buyers at many nodes. *FERC NBT* breaks down primarily during the winter months. In January and February, the hardest-hit months, approximately 71 percent and 62 percent of the hours during which *DRR* curtailments occurred, resulted in a total buyer payment increases post-curtailment. For these two months, *FERC NBT* failed to screen out the majority of hours that in the end resulted in higher buyer payments than if the load had been served by generators.

In **Figure 4**, we show the monthly number of hours in which *DRR* curtailments resulted in post-curtailment buyer payment increases in case $M_3$. In this case, we see that the limitations of *FERC NBT* are even more pronounced. In nearly every month the number of hours in which *DRR* curtailments increase the post-curtailment buyer payments exceeds 20 hours.

In fact, in the months of October and November, in every hour in which there are *DRR* curtailments, those *DRR* curtailments result in increased post-curtailment buyer payments. Furthermore, only in the months of June, July, and August does the number of hours in which *DRR* curtailments result in decreased post-curtailment buyer payments exceed the number of hours in which *DRR* curtailments do not. Clearly, *FERC NBT* screen is too coarse (Figures 3 and 4).

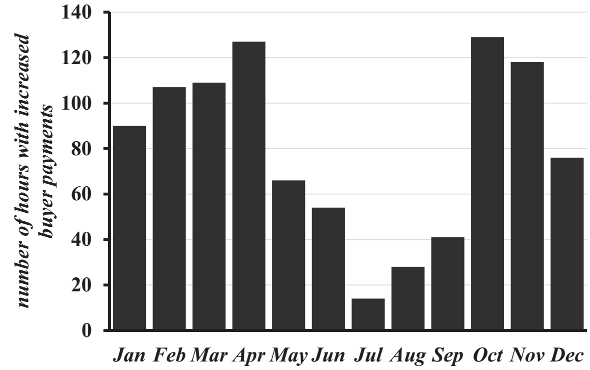


**Figure 4:** Post-Curtailment Buyer Payment Increases Due to DRR Curtailments for Case $M_3$

We also investigated the distribution of *DRR* benefits and losses among the buyers. Indeed, our analysis of the $N_3$ and $M_3$ case studies indicates that *there are nodes in the system that experience higher post-curtailment LMP so often that, at the end of the year, their buyer payments in the case with DRRs are higher than in the case with no DRR participation*. Out of the 99 load nodes in the $N_3$ test system, 19 experienced an increase in the annual buyer payments due to the *DRR* curtailments for case $N_3$. In **Figure 5**, we show buyer-payment related metrics for the 10 nodes that experienced the greatest percentage increase in buyer payments at the end of the year for case $N_3$. For contrast, we also show the nodes that experienced the highest decrease in consumer payments in this case. These nodes have greater demand response

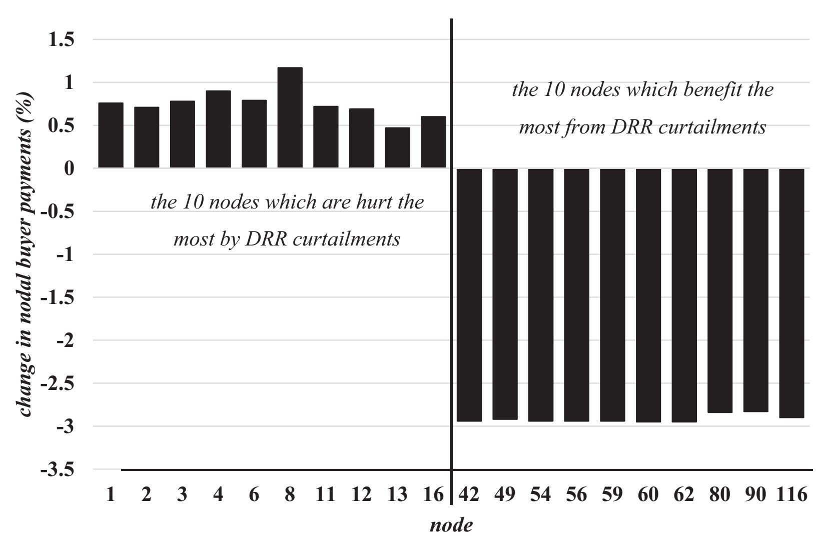


**Figure 5:** The Impact of DRR Curtailments on the Top 10 Nodes Which Benefit and Top 10 Which Experience Losses over the One-Year Period in Case $N_3$

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participation and also experience a decrease in the annual consumer payments of approximately 3 percent compared to case $N_0$. The node that experienced the highest percentage increase in the buyer payments with respect to case $N_0$, is node 8 at 1.17 percent.

The situation in our cases with the *MISO* data is no different. In those cases, there are a total of 29 nodes that experience higher annual buyer payments with *DRR* participation. The emergence in both the *ISO*-NE and *MISO* cases of a set of nodes at which buyers are made worse off by *DRR*s, while *DRR*s benefit buyers overall, highlights the differences in the distribution of the *DRR* benefits that can arise under the stipulations of *FERC* Order 745 in a congested system.

We draw three conclusions from our studies into the aggregate impacts of the unintended consequences resulting from the limitations of *FERC* Order No. 745:

- *FERC NBT* provides an insufficiently fine screen to filter out *DRR* curtailments in hours in which they cause increases in the total post-curtailment buyer payments.
- The distribution of *DRR* benefits and losses among the buyers under the Order is a serious issue and the prevailing *LP-IPA* fails to fully address it.
- The failure of the thrusts of the Order to integrate the transmission congestion impacts is a driving force behind the outcomes we observe.

The cases we have described in which *DRR*s lead to increased post-curtailment buyer payments for some or all buyers occur in a large number of *DRR* curtailment hours under the current stipulations of *FERC* Order No. 745. The number of hours in which *DRR* curtailments are uneconomic highlights the importance of the Order's failure to account for the

network effects and points to the need of a finer screen to capture hours in which *DRR* curtailments are uneconomic. The failure to account for network congestion impacts also raises issues with the *LP-IPA*, and we have shown that the result may be a tacit picking of winners and losers among the buyers through the distribution of the *DRR* benefits and losses. It is clear that the limitations of *FERC* Order No. 745 have a significant impact on the magnitude and the distribution of *DRR* benefits. These unintended consequences work against the thrusts of the Order in achieving its second objective. In the following section, we describe proposed modifications to the Order to integrate transmission congestion impacts into the *NBT* and the *IPA* and show the improvements in the market outcomes that can be achieved by doing so.

## III. The Proposed Modifications to FERC Order No. 745

The thrusts of *FERC* Order No. 745 have come close to hitting their mark of achieving the Order's objectives. However, the unintended consequences limit the effectiveness of the Order at achieving the second objective. In this section we describe modifications to the Order to address the limitations. We propose two modifications which, in essence, integrate the transmission congestion impacts. The modifications preserve the spirit of 745 and make precise adjustments to the *NBT* to provide a finer screen to determine the hours in which *DRR*s are compensated at the *LMP* and to the *IPA* to address the distribution of *DRR* benefits. We first discuss the modifications to *FERC NBT* to reduce the number of hours in which *DRR* curtailments occur but result in increased total buyer payments.

Our proposed *NBT* modifications are based on the clear need to integrate congestion information into *FERC NBT* methodology. The system-wide nature of *FERC NBT* is insufficient to capture the often serious impact of transmission congestion on the market outcomes. To this end, we

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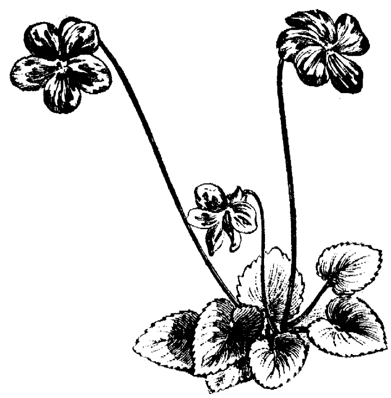
propose the use of a *nodal NBT*. The nodal *NBT* retains many of the same characteristics of the system-wide *FERC NBT* and keeps the basic format of *FERC NBT* unchanged. The key differences between the nodal *NBT* and *FERC NBT* are that the former is applied on a nodal basis and that the former makes use of available *LMP* data, instead of seller offer data, to calculated threshold prices on a nodal basis, which we term the locational threshold prices (*LTP*s). When there is transmission congestion, the markets clear on a nodal basis. Therefore, to apply *FERC NBT* on a nodal basis, we would need to reconstruct the nodal offer curves in every hour. However, it is not straightforward to reconstruct the nodal offer curves and so we use the hourly *LMP*s over a month as a proxy for the nodal seller offer curves in a congested system. For each node we take the hourly *LMP*s and cleared load in the peak hours of a month and construct an ''offer'' curve by arranging the hourly *LMP*s in increasing order and cumulatively summing the cleared load associated with each *LMP*.[15] This *LMP*-based proxy offer curve represents the purchase price at the node, which includes transmission congestion impacts, under a range of load conditions and so captures the transmission congestion impacts under each of those conditions.

This offer curve is then treated within the *NBT* framework of the Order to determine the *LTP*s at each node. The modifications to *FERC NBT* to arrive at the nodal *NBT* give rise to a finer screen by integrating a greater amount of the relevant system information into the *NBT* cost-effectiveness test. As we will show, the nodal *NBT* reduces the number of hours in which *DRR* curtailments occur but result in increased total buyer payments. The integration of congestion information into the *NBT* via the



nodal *NBT* impacts the frequency and location of *DRR* curtailments and thus impacts the distribution of the *DRR* curtailment benefits among the non-*DRR* buyers. However, the nodal *NBT* does not directly address the distribution of *DRR* benefits. To address the benefit distribution issue, we propose a more specific *IPA*.

We propose a benefit-proportional *IPA* with side payments (*BP-IPA* w/ *SP*). Under the *BP-IPA* w/ *SP*, the increased post-curtailment payments experienced by some buyers as a result of *DRR* curtailments are considered a 'cost' of the *DRR* curtailment to be allocated among the beneficiaries of the curtailment and the buyers which were made worse off by the *DRR* curtailment are made whole by a side payment. The costs of providing these side payments, combined with the costs to provide the *DRR* incentive payments are allocated to those buyers which benefit from the curtailment *in proportion to the benefits they receive*. For example, consider a congested three bus system and suppose there are three buyers, A, B and C, each with a 10 MW load at different nodes and one *DRR*. Now suppose a *DRR* curtailment occurs that reduces buyer A's payments by \$60, buyer B's payments by \$40 and increases buyer C's payments by \$20. Suppose the incentive payment to the *DRR* is \$80. The total ''cost'' to the buyers which benefit from the curtailment (buyers A and B) under the *BP-IPA* w/ *SP* is \$80 for the *DRR* incentive payment plus \$20 for the make-whole payment to buyer C, a total of \$100. The total benefit is the sum of the individual benefits of buyers A and B, or \$100. We note the curtailment does not increase total buyer payments since the total ''cost'' is equal to the total benefits. Buyer A received 60 percent of the total benefits of the curtailment and so, under the *BP-IPA* w/ *SP*, is responsible for 60 percent, or \$60, of the ''cost.'' Similarly, Buyer B received 40 percent of the benefits of the curtailment and so is allocated 40 percent or \$40, of the ''cost.'' In this example, the benefits are exactly equal to the ''costs'' for all the buyers and thus no buyer is made worse off by the curtailment. Note that under an

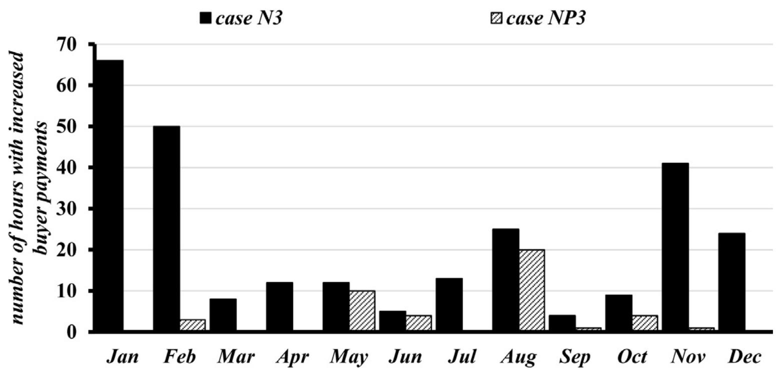



**Figure 6:** Number of Hours in Each Month in Which DRR Curtailments Increase Buyer Payments in Case $N_3$

*LP-IPA* buyer B would suffer an increase in the post-*IPA* buyer payments. This example illustrates an important strength of the *BP-IPA* w/ *SP*: under this *IPA*, we can guarantee that no buyers are made worse off by the *DRR* curtailment provided that the *DRR* curtailment reduces total post-curtailment buyer payments. In the case where the *DRR* curtailment does not reduce the total post-curtailment buyer payments, which are the cases which we address with the nodal *NBT*, we suggest a distribution of the losses such that the final outcome is a load-proportional sharing of the losses i.e. individual buyer's benefits and losses are taken into account and those buyers which are made worse off by the *DRR* curtailment due to congestion patterns are allocated a lesser portion of the costs and vice versa. The *BP-IPA* w/ *SP* reduces the instances where some buyers are made worse off while others benefit from *DRR*s, which arise when *DRR* curtailments occur in congested systems, by redistributing the benefits of the curtailment to compensate those buyers that are made worse off. Such an *IPA* is consistent with *FERC*'s cost-causation principle and enhances the ability of the thrusts of the Order to effectively achieve its second objective.

To show the impacts of the proposed nodal *NBT* and *BP-IPA* w/ *SP* and the reductions in the impacts of the unintended consequences which might be achieved under these proposed modifications we present a set of simulation studies. For all the simulation studies presented in this section, we use the same test system and set-up that was used for the simulation studies presented in Section II. We denote the simulation studies using the nodal *NBT* as: $\text{NP}_c$ for the cases using *ISO-NE* data and $\text{MP}_c$ for the cases using *MISO* data, with $c$ as the demand response capacity. To start, we explore the impacts on the number of curtailment hours which result in buyer payment increases of using the nodal *NBT* in place of *FERC NBT* under which, in many curtailment hours, the payments to the *DRR*s exceed the benefits attained.

In Figure 6, we summarize the monthly number of hours in which the payments to the *DRR*s exceeded the benefits attained for case $\text{NP}_3$ using the nodal *NBT* and show the same for case $N_3$ for comparison. In this case a total of 43 instances resulted in higher *DRR* payments than system benefits, which represents approximately 5.7 percent of the total curtailment hours. Compared to case $N_3$, where 17.8 percent of the curtailment hours resulted in extra payments due to the demand curtailments, the nodal *NBT* screened out more of the hours in which *DRR* curtailments resulted in increased total post-curtailment buyer payments. The percentage of hours with such unintended consequences is reduced for all cases with the nodal *NBT*, compared to *FERC NBT* cases.

We note that, even with the proposed changes to the *NBT*, there are still hours in which the societal costs exceed the benefits of *DRR* participation. This is due to the fact that, while the nodal *NBT* explicitly includes transmission congestion information, it does not account for the impacts of concurrent *DRR* curtailments at multiple nodes on the buyer payments at each node. Consequently, while considerably reduced in number, there still arise cases where the collective impact of the *DRR* curtailments results in an increase in the total buyer payments under the nodal *NBT*.

In Figure 7, we show the monthly number of hours in which the societal costs of *DRR* participation exceed the benefits in the $\text{MP}_3$ and $M_3$ cases. For all

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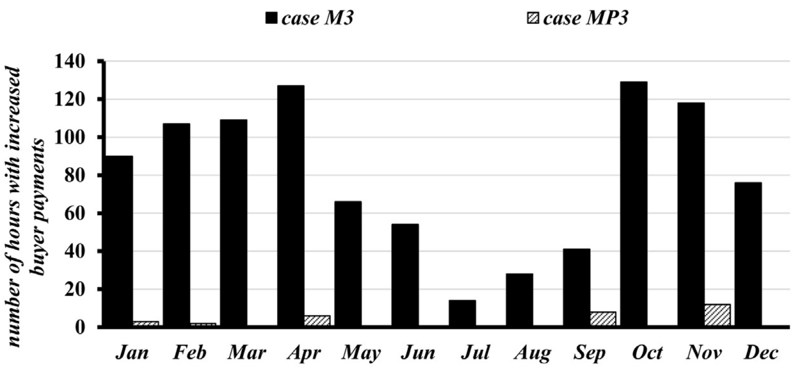


**Figure 7:** Number of Hours in Each Month in Which DRR Curtailments Increase Buyer Payments in Case $M_3$

the cases using the *MISO* data, there was a significant drop in the number of curtailment hours. Some 66 percent of the curtailment hours resulted in higher payments than benefits in case $M_3$. In case MP3, the 31 instances of hours with higher *DRR* payments than benefits represent 20 percent of the total curtailment hours. As in the $NP_3$ case, the application of *LTP*s in the $MP_3$ case, and the finer screen they provide, reduces considerably the number of hours in which *DRR*s increase the total post-curtailment buyer payments.

Next, we discuss the differences between the impacts of *DRR* curtailments on individual nodes under the nodal *NBT LTP*s compared to *FERC NBT* system-wide threshold. Since, under the nodal *NBT*, we use the *LTP*s, there is no longer a set of nodes whose *LMP*s are above the threshold price and a set whose *LMP*s are below, but rather hours in which a node's *LMP* is above the *LTP* and hours in which it is not. We examine the buyer payment impacts under the nodal *NBT* on a node which was previously made worse off as a result of *DRR* curtailments. In Figure 8, we show the pre- and post-curtailment *LMP*s at node 8 during the first week of May 2010 in case study $NP_3$.

Under *FERC NBT*, node 8 had no *DRR* curtailments during this week and experience post-curtailment *LMP* increases in most of the hours in which *DRR* curtailments occurred at other nodes in the system due to the network effects. However, the *LTP* is lower than the peak hour pre-curtailment *LMP*s and so, under the nodal *NBT*, *DRR* curtailments occur at node 8 and result in post-curtailment *LMP* decreases in most hours, an indication that these *DRR* curtailments represented cases of omission which are corrected by the nodal *NBT*. The few hours in which the post-curtailment *LMP*s still increase are due to the impacts of concurrent *DRR* curtailments at other nodes whose impacts have not been captured by the nodal *NBT*. The application of the nodal *NBT* has reversed the fortunes of the buyers at node 8 such that they too enjoy the benefits of *DRR* curtailments rather than becoming an unintended consequence and bear the cost of *DRR* curtailments at other nodes in the system. For cases such as node 8, the *LTP* provides a more appropriate metric than the system-wide threshold price. The former is a better measure of whether *DRR* curtailments at a specific node will bring about greater benefits *to that node* than the costs to provide incentive payments which will be incurred.

We now examine the impacts of the nodal *NBT* on a node which was the beneficiary of *DRR* curtailments under *FERC NBT*. In Figure 9, we show the

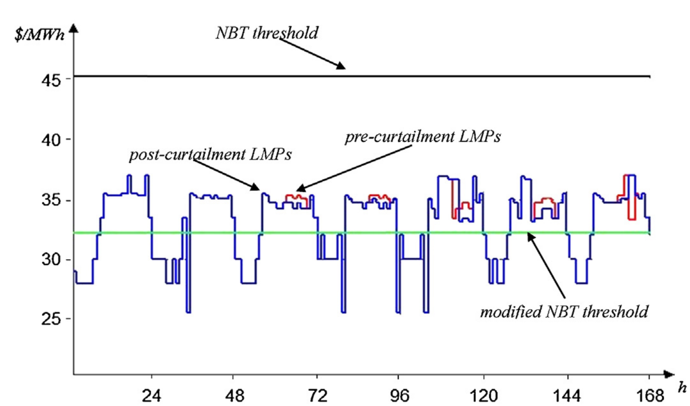


**Figure 8:** Pre- and Post-curtailment LMPs during the Week of May 1–7 at Node 8 in Study Case $NP_3$

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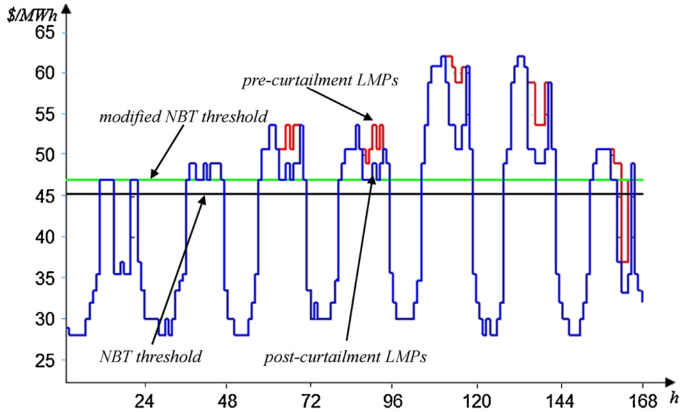


**Figure 9:** Pre- and Post-curtailment LMPs during the Week of May 1–7 at Node 116 in Study Case $NP_3$

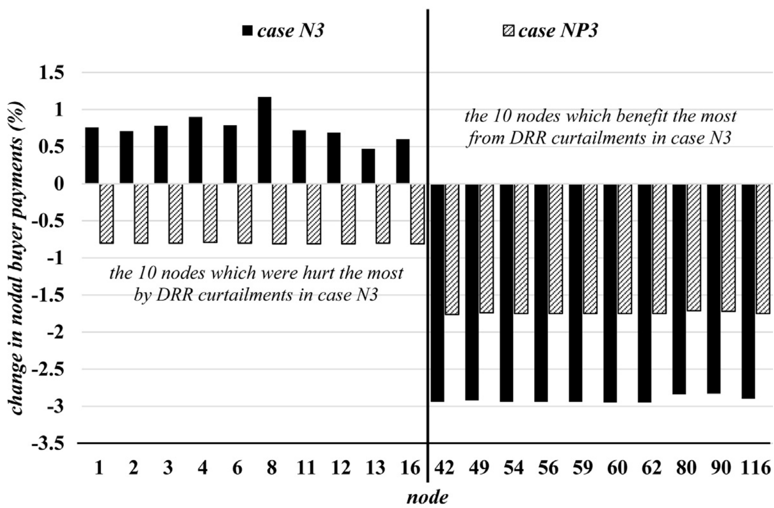


**Figure 10:** The Impact of DRR Curtailments Under the Nodal NBT and BP-IPA with Side Payments on the Top 10 Nodes Which Benefit and Top 10 Nodes Which Experience Losses over the One-Year Period under FERC NBT in Case $N_3$

pre- and post-curtailment *LMP*s during the first week of May at node 116 in study case $NP_3$. We note that the *LTP* is slightly higher than the system-wide threshold.

Nodes such as node 116 experienced persistently higher pre-curtailment *LMP*s, which were higher than the system-wide threshold price, than other nodes in the system and so such nodes benefited more frequently from *DRR* curtailments both due to the frequency of the curtailments at such nodes and the magnitude of the *LMP* reductions those curtailments brought about. The persistently high pre-curtailment *LMP*s explain why the *LTP* is higher than the system-wide threshold at node 116, since the *LTP* is calculated from these higher peak-hour *LMP*s. That the *LTP* is higher than the system-wide threshold price also indicates that, under *FERC NBT*, *DRR* curtailments at node 116 which occurred in cases which the *LMP*s were between system-wide threshold price and the *LTP* would not result in buyer payment reductions at node 116. Such cases would represent a cases of commission which *FERC NBT* screen would fail to filter out and that the *LTP* captures. However, the pre-curtailment *LMP*s at node 116 are above the *LTP*, and consequently well above the system-wide threshold price, and so the curtailments at node 116 are largely unaffected by the introduction of the *LTP* i.e. *FERC NBT* was an effective screen for curtailments at node 116 in the week pictured. However, our observations of node 116 are not the case for all nodes, and the nodal impacts of *DRR* curtailments may not be well represented by *FERC NBT*, as we observed in the case of node 8 and as reported in our studies presented in Section II. The nodal *NBT* provides the finer screen needed to account for the nodal differences in *DRR* value which arise due to transmission congestion and which have a profound impact on conditions under which *DRR* curtailments result in nodal benefits.

Though the nodal *NBT* addresses the cases of omission and commission which arise under *FERC NBT* and reduces the number of hours in which *DRR* curtailments result in buyer payment increases, it does not address the distribution of *DRR* benefits among the buyers in congested systems. We now turn to the impacts of our proposed *IPA* modifications to show the effectiveness of the *BP-IPA* w/ *SP* in addressing the distributional impacts of the *DRR* curtailment benefits in congested systems.

To show the reduction in the number cases in which nodes experience post-*IPA LMP* increases which can be gained by the use of the *BP-IPA* w/ *SP*, we show in **Figure 10** the percentage decrease in buyer payments in case $NP_3$ at the same nodes that were worse off in case $N_3$ using *FERC NBT*, presented in Section II. We see that, due to the side-payments, buyers at no nodes incur higher total payments due to *DRR* curtailments in case $NP_3$. In fact, all those nodes which were made worse off under *FERC NBT* and *IPA* now benefit from the curtailments. The *IPA* methodology we suggested addresses the distribution of *DRR* benefits such that all nodes in the case presented benefit from the *DRR* curtailments.

We also show the percentage decrease in consumer payments in case $NP_3$ at the same nodes that benefited the most from demand curtailments under *FERC NBT* in case $N_3$. All these nodes continue to benefit from demand curtailments but, as expected with *BP-IPA* w/ *SP*, these benefits are reduced due to the inclusion of the side payment to the buyers at nodes that were worse off. Such a redistribution of the *DRR* benefits ensures that *DRR* curtailments are beneficial *for all buyers* and so such curtailments are in line with the second objective of the Order.[16]

In this section we described our proposed *NBT* and *IPA* modifications and showed the improvements which can be realized by applying those modifications. The nodal *NBT* applies the same basic structure in *FERC NBT* but includes relevant system information to integrate the impacts of transmission congestion. These additional considerations reduce considerably the incidence of *DRR* curtailments when they result in total buyer payment increases under the nodal *NBT* compared to *FERC NBT* in our test cases. The *BP-IPA* w/ *SP* follows the thrust of the order to allocate the costs of *DRR* on a proportional basis to those buyers that benefit from the curtailments. Further, the explicit inclusion of side payments and the benefit-proportional allocation ensures that, in cases in which *DRR* curtailments reduce total buyer payments, no load is made worse off. Our results showed that the *BP-IPA* w/ *SP* eliminates instances in which some buyers benefit from *DRR*s while others are made worse off. The combination of the nodal *NBT* and *BP-IPA* w/ side payments provide a more effective approach to ensure that *DRR*s are use only when they are truly a ''cost-effective'' alternative to supply-side resources.

## IV. Concluding Remarks

*FERC* Order No. 745 set out to break down the putative barriers to *DRR*s in *ISO*/*RTO*-run electricity markets to encourage greater *DRR* participation and, to this end, it is proving to be successful. However, the Order's second aim, to implement a set of mechanisms to ensure that *DRR*s are called upon to curtail their load only when they reduce buyer payments, has come up short. The failure of the Order to integrate the impacts of transmission is a significant limitation that has unintended consequences for the total benefits which *DRR*s may bring to the system and for the distribution of those benefits among the buyers in the system. We identify the sources of the unintended consequences and provide modifications to some aspects of the Order to improve the outcomes for non-*DRR* buyers. We show the specific cases that arise from these limitations and that the aggregate impact of those cases can be significant over the course of a year. Our simulation studies show that *DRR* curtailments may actually increase the overall buyer payments for a subset of buyers and that the distribution of the *DRR* benefits presents a major issue.

  http://dx.doi.org/10.1016/j.tej.2013.09.002 

These significant impacts motivate the need for our proposed modifications to the thrust of the Order.

We propose improvements that do not alter the nature of the Order and provide additional considerations to ensure *DRR* curtailments, when provided, are beneficial to non-*DRR* buyers. The modifications we introduce are:

- The nodal *NBT* and the corresponding *LTP*s which reduce the incidence of hours in which *DRR*s increase total buyer payments, and
- The *BP-IPA* w/ *SP* which ensures that, in cases in which *DRR* curtailments do not increase total buyer payments, no buyer is made worse off as a result of the *DRR* curtailments.

By using *LTP*s instead of a system-wide threshold price, we provide a more appropriate signal for the dispatch of *DRR*s. The introduction of the *BP-IPA* w/*SP* addresses the benefit distribution issues. We showed that these modifications considerably reduce the magnitude of the unintended consequences of *FERC* Order No. 745 and more effectively achieve the second objective of the Order.

Our approach provides a means by which to improve of the Order without changing its ''spirit.''■

**Endnotes:**

**1.** *FERC, Final Rule, Order No. 745, Demand Response Compensation in Organized Wholesale Energy Markets*, 18 CFR Part 35, issued Mar. 15, 2011, at 1.

**2.** *Id., FERC, Final Rule, Order No. 745*, at 1.

**3.** *Id., FERC, Final Rule, Order No. 745*, at 39.

**4.** *Id., FERC, Final Rule, Order No. 745*, at 1.

**5.** *FERC* defines a *DRR* to be cost-effective if ''the overall benefit [for buyers] of the reduced *LMP* that results from dispatching demand response resources exceeds the cost of dispatching and paying *LMP* to those resources.''

**6.** *FERC, Final Rule, Order No. 745*, at 15, *supra*.

**7.** *FERC, Order on Rehearing and Clarification, Order No. 745-A, Demand Response Compensation in Organized Wholesale Energy Markets*, 18 CFR Part 35, issued Dec. 15, 2011, at 45.

**8.** *FERC, Final Rule, Order No. 745*, at 62, *supra*.

**9.** *FERC, Final Rule, Order No. 745*, at 77, *supra*.

**10.** See, for example, for *MISO*, *FERC, Order on Compliance Filing*, Docket No. ER11-4337-000, issued Dec. 15, 2011, at 5; for *PJM*, *FERC, Order on Compliance Filing*, Docket No. ER11-4106-000, issued Dec. 15, 2011, at 24; and for *ISO-NE*, *FERC, Order on Compliance Filing*, Docket No. ER11-4337-000, issued Jan. 19, 2012, at 16.

**11.** Significant growth in the quantity of cleared *DRR*s and in the payments to *DRR*s has occurred in PJM's energy markets since it implemented *FERC* Order No. 745 in April 2012. The *PJM DRR* monthly activity reports are available at http://www.pjm.com/markets-and-operations/demand-response/dr-reference-materials.aspx.

**12.** The post curtailment *LMP* at node 6 is unaffected due to the existence of a marginal generator at this node.

**13.** For additional results, see I. Castillo, *Assessment of the Impacts of Demand Curtailments in the Day-Ahead Markets: Issues in and Proposed Modifications of the FERC Order No. 745*, M.S. thesis, Univ. of Illinois at Urbana Champaign, Urbana, IL, 2012, at 36–50.

**14.** The test system data are taken from the Univ. of Washington Dept. of Electrical Engineering Power Systems Test Case Archive at http://www.ee.washington.edu/research/pstca/. Offer and load data for the *MISO* are found at https://www.midwestiso.org/Library/MarketReports/Pages/MarketReports.aspx. Offer and load data for the *ISO-NE* are found at http://www.is-one.com/markets/hrlydata/index.html.

**15.** A detailed treatment of the *LTP* methodology can be found in Castillo, 2012, at 51–58, supra.

**16.** We observe similar improvements in the unintended consequences in case $MP_3$ and so we omit them for the sake of brevity.

  

# TAB M

This is Exhibit **"M"** referred to in the Revised Affidavit of Brian Rivard sworn before me this 21st day of November, 2019

*A Commissioner for Taking Affidavits*

Lauren Theresa Daniel, a Commissioner, etc.,
Province of Ontario, while a Student-at-Law.
Expires April 8, 2022.

# Money for Nothing? Why FERC Order 745 Should have Died

*Xu Chen* and Andrew N. Kleit***

**ABSTRACT**

Customer baseline load (CBL) measurement is designed to represent participants' expected usage in a number of electricity demand response (DR) programs. Our empirical results, however, show that CBLs can be systematically higher than DR participants' estimated load, especially for those experienced in DR activities, likely due to manipulation behaviors. Thus, the integrity of CBL may degrade over time. With an inflated CBL, the impact of DR programs may therefore be highly exaggerated, and consumers can be paid money when they are not actually reducing their demand. In particular, we design a manipulation-indicating variable "seemingly unattractive free-money opportunity" (SUFO) and discover system-wide manipulative behaviors that increase with time and are widely adopted by experienced DR participants. We suggest that policy makers in FERC, RTOs, and states regulatory agencies consider the threat of manipulation when modifying DR market rules following the Supreme Court's recent upholding of FERC Order 745.

**Keywords:** Demand response, Customer baseline load (CBL), Market manipulation, Electricity markets, FERC Order 745

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## 1. INTRODUCTION

Increasing the responsiveness of consumers to price to create a more efficient and reliable system is an important issue in electricity energy supply markets. By exposing consumers to real-time prices, Demand Response (DR) can reduce peak demand and enhance system reliability. FERC Order 745 (FERC 2011b), which required RTOs to compensate DR with locational marginal prices (LMPs), was vacated by U.S. Court of Appeals for the District of Columbia (USCA Case #11-1486, 2014) on the grounds of both that FERC exceeding its jurisdiction and that the DR pricing formula was "arbitrary and capricious." The court order was widely regarded as the end of traditional DR in the wholesale market. After FERC's appeal, the Supreme Court in January 2016 overturned the lower court opinion and ruled that FERC has the authority to regulate DR. FERC, regional transmission organizations (RTOs) and state governments now have the opportunity to implement and to modify DR programs. In DR programs, demand reduction is measured by comparing a customer's actual load with an administratively determined customer baseline load (CBL). The CBL based DR system requires constant administrative interactions from FERC and RTOs. For example, a recent FERC Order directs PJM to increase the granularity of capacity DR performance monitoring (FERC 2014). Though with all the efforts from FERC and RTOs, DR participants may be able to inflate their CBLs and thus profit by creating artificial load reductions. Obtaining a

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precise CBL and eliminating CBL inflation incentives are therefore critical to effective DR implementation in the coming era.

Researchers have determined that energy DR participants have theoretical opportunities to take advantage of the system by manipulating their CBLs (Chao 2011, Chao and DePillis 2013). Any "artificial" DR reduction may jeopardize system reliability, while creating transfers to DR providers from other rate payers. Here we empirically test for the existence of CBL-inflating behaviors.

In section 2, we introduce the definition of DR in current electricity energy markets. We also discuss the contents of FERC's 2011 Order 745 and manipulation methods to which that Order is potentially vulnerable. Section 3 presents our theoretical approach and the concept of a "seemingly unattractive free-money opportunity" (SUFO). Section 4 describes our data, which comes from the pre-Order-745 era. Section 5 discusses the model specification, the econometric approach and empirical results modeling users' CBL. Section 6 shows our models and empirical results for DR reduction, which support the existence of inflated CBLs. We note that this result occurred even before FERC increased the incentives for such behavior through its enactment of Order 745. Section 7 offers conclusions.

## 2. BACKGROUND

FERC (2011a) defines DR as "changes in electric use by demand-side resources from their normal consumption patterns in response to changes in the price of electricity, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized." We focus here on DR in energy, as opposed to capacity, markets, the subject of FERC Order 745. Several recent articles discuss the peak load reduction effect of DR (for example, Faruqui and George (2005), and Faruqui, Hledik et al. (2007)) and the DR compensation method (Bushnell, Hobbs et al. 2009, Walawalkar, Fernands et al. 2010). Few papers, however, examine DR manipulation theories and CBL-inflating strategies (Chao 2011, Chao and DePillis 2013), while several documents describe DR manipulation cases (FERC 2012a, FERC 2012b). No previous research has examined whether inflated CBLs have occurred widely in RTOs.

FERC Order 745 (FERC 2011b) requires all RTOs to compensate demand response resources with locational marginal price (referred to as the "full LMP payment"), regardless of CBL measurement methods or participants' retail contracts. Over the last several years, the appropriate payment for DR resources has been a topic of much controversy (Hogan 2010, Kahn 2010, Walawalkar, Fernands et al. 2010, Chao 2011, Chao and DePillis 2013).

In PJM's energy market, DR resources and generators submit supply offers (or bids, i.e., willingness to supply a certain amount of energy with a certain level of compensation), and PJM dispatches generators and DR resources in economic order (lowest cost first) to meet system demands. Before FERC Order 745's implementation in PJM in April 2012, DR resources in PJM were compensated by locational marginal price (LMP) minus the generation (G) and transmission(T) parts of the retail tariff (referred to as LMP-G-T payment) in energy-market economic dispatches (PJM 2011). After April 2012, PJM paid LMP, i.e., an increase of generation and transmission fee from the original LMP-G-T payment, for demand response resources in energy market. Following the FERC directive, PJM calculated a firm's CBL based on its historical usage. CBL for a weekday is determined as the average of the four highest usages of the five most-recent non-event

1. A non-event day, or non-dispatch day, is a day that a DR participant does not provide DR curtailment in the market, either because it does not submit a bid in the market for that day, or because its bid is not accepted by the RTO in the merit order dispatch process.

(or non-dispatch)[1] weekdays (in the same hour interval) in the previous 45 calendar days (PJM 2011). Other RTOs also have similar historically determined CBLs.

The historically-based CBL determination method may incentivize potential manipulation strategies, which would lead to a "free-money" problem. Chao (Chao 2011) described moral hazards (over-consumption to increase CBL), adverse selection (consumers anticipating long term declining electricity demand being more likely to enroll in DR program) and behind the meter switching (switching usage between two energy sources to generate fake reduction measured from one source) as three potential free-money problems. Chao discusses DR payments and CBL construction, while reaching the topic of eliminating CBL manipulation through proper market rules. The article does not, however, seek to provide empirical evidence for existence of manipulation and little such evidence is provided. Here we attempt to fill this gap.

In addition to the manipulation strategies discussed above, we suggest an "idiosyncratic-demand bidding strategy" may also result in free money to DR providers. In idiosyncratic-demand bidding, a DR participant's bidding behavior depends on its normal usage schedule instead of the price signal, i.e., the participant uses high consumer-specific usage days as CBL determination days and supplies DR resources on low usage days. Idiosyncratic-demand bidding is thus a CBL-inflating strategy and a market manipulation behavior, since it does not match FERC and RTOs' definition of DR: "reduction from normal usage in respond to price signals."

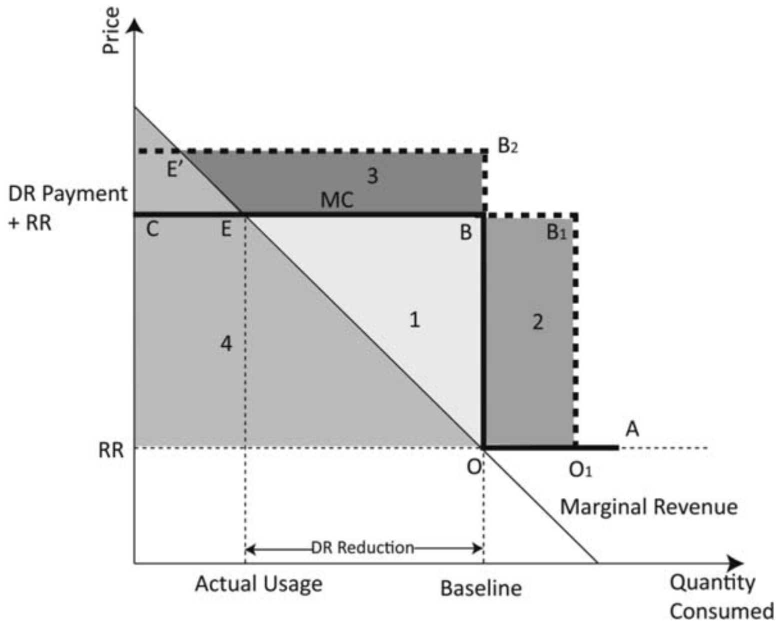
For example, assume a ship factory that produces steel every Monday and Tuesday, consuming 100 MWh per hour. The factory assembles a ship every Wednesday to Friday, consuming 60 MWh per hour. With idiosyncratic-demand bidding, the factory may submit bids for 40MW of DR resources at a low price every Wednesday to Friday, and leave Monday and Tuesday as CBL-determination days. The factory is thus dispatched by the RTO from Wednesday to Friday and has a CBL 40 MW higher than its expected usage. Thus, without reducing usage, the DR participant has a consumption level below the CBL and, as a result, gains DR revenue. The participant is thus paid for an artificial reduction—one that does not actually take place.

In the above idiosyncratic-demand bidding example, the factory clearly violates PJM rules and FERC Orders by claiming a regular consumption pattern as a DR activity. However, if the consumption pattern in DR days changes in a smaller scale from the regular one (for example, a several percent of usage change due to the weather,) it may be difficult to determine whether the DR participant intends to manipulate the market by idiosyncratic-demand bidding. This "free money" that is taken by DR providers who are able to inflate their CBLs is paid by Load Serving Entities and eventually by other rate payers in the RTO.

The New England ISO (ISO NE) has uncovered evidence of idiosyncratic-demand bidding (ISO-NE 2008) in response to its rules on calculating CBL. ISO NE calculated CBL as the average usage of the previous ten non-event days and did not have a limited historical window for CBL-determination days (for example, 45 calendar days as in PJM) in 2007. DR participants in ISO NE could submit bids with a low price on most days and leave several high-usage days in the summer as CBL-determination days. Participants thus created a high CBL that was the average usage of several high-usage summer days and remained almost constant across the year. Further, some DR participants, who had operated on-site generators on a regular basis before participating in DR programs, were found reducing output from their generators during CBL-determination days to achieve a high CBL. FERC has announced an investigation of the above CBL-manipulation events (see, for example, FERC (2012a) and FERC (2012b)), and issued penalties for the fraudulent, or manipulative behaviors (see for example, FERC (2013a) and FERC (2013b)).

In *EPSA v. FERC* 753 F. 3d 216, 225 (2014), the Appeals Court for the District of Columbia struck down Order 745 for two reasons. First, the appeals court concluded that FERC did not have

**Figure 1: Marginal Cost of Consuming Electricity in DR**



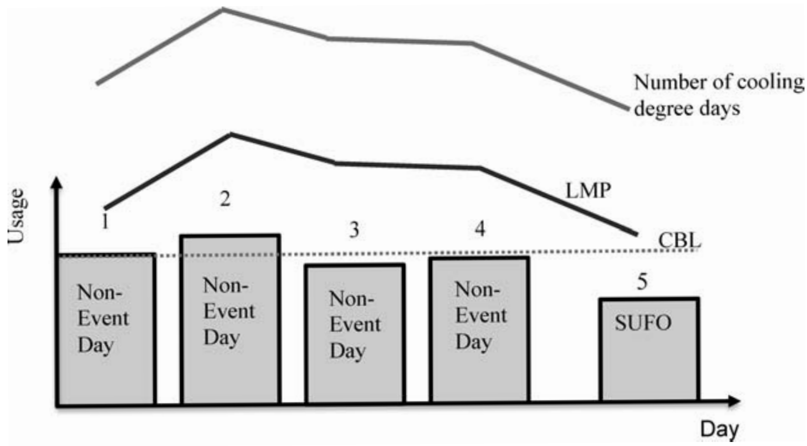

jurisdiction to impose the order. FERC jurisdiction is limited to wholesale markets, and the court viewed DR implement under the order as affecting retail markets. Second, the Court, following the criticism noted above, viewed the LMP payment requirement as "arbitrary and capricious". On appeal, the Supreme Court overturned the Appeals Court in a 6–2 decision (*FERC v. EPSA*, slip. op. 14-840, January 25, 2016). The Supreme Court decision leaves the door open to further rules by FERC, RTOs, and states. We seek to contribute to the debate on these new rules.

## 3. THEORETICAL APPROACH

We consider two manipulative or CBL-inflating strategies: over-consumption and idiosyncratic-demand bidding. Figure 1 presents the decision facing a DR participant with a fixed retail rate. The marginal revenue curve shows the revenue of consuming an additional unit of energy. The marginal cost (MC) curve shows the marginal cost of consuming energy, including the firm's retail rate and DR payment. We consider the following scenarios:

1) When there is no DR, a firm will consume energy at point O, the intersection of the firm's energy demand curve (Marginal Revenue curve) and market energy supply curve (the Retail Rate, or RR.) The firm gains profit equal to area 4.
2) If the firm is dispatched by the RTO to provide DR resources and its CBL correctly predicts future usage, it faces a marginal cost curve as the route CBOA. The marginal cost for consuming more than CBL is still RR. However, the MC for consuming below the CBL becomes the DR payment plus RR. Point E, the intersection of MC and Marginal Revenue, becomes the new equilibrium. With DR payment, the firm thus receives the additional profit represented by area 1. Note that because the firm benefits

**Figure 2: A Condition of SUFO Caused by Temperature Drop**




from the use of electricity, the marginal revenue of consuming power is greater than zero.

3) If a dispatched firm has a CBL higher than the non-DR usage, i.e., the participant has lower demand than expected, the MC curve faced by the firm is route $CB_1$ $O_1A$. The firm remains at point E and gains more profit (area 2) than in condition 2.
4) When the wholesale market has a higher LMP, route $E'B_2OA$ represents the firm's MC, and point E' will be the new equilibrium. Electricity consumption declines and the participant gains more profit (area 3) than it would with a lower LMP.

Given this, a day with a high LMP and an inflated CBL we deem an "attractive free-money opportunity;" while a day with low LMP and an inflated CBL we call a "seemingly unattractive free-money opportunity" (SUFO). A SUFO can be created by a participant's idiosyncratic-demand bidding when the system load of the RTO drops due to, for example, a large change in temperature.

Figure 2 shows an example of a SUFO, with the participant's usage over five days (days 1–5) shown, along with system LMP and the number of cooling degree days. In Figure 2, the number of cooling degree days declines on day 5, so that both the expected usage of DR participants and system load of the RTO decrease. With a lower system load, the RTO generally will have a lower LMP. DR participants thus face a low LMP and low expected use on day 5. If a participant can generate a CBL higher than his expected load on day 5, its apparent curtailment effort on that day may be overstated, and its payments therefore inflated.

Price-responding DR providers make bidding decisions based on LMP. Compared to submitting bids on low-price day 5, participants without manipulation intent may prefer bidding on high-price days 1–4, in response to the high LMP. Days 1–4 thus become DR event days and are excluded in future CBL calculation. However, participants may utilize idiosyncratic-demand bidding to obtain a manipulation-related profit. If they do not submit bids during high LMP days 1–4, the average usage for the 4 most recent non-event days (i.e., days 1–4) become the CBL on low LMP day 5, according to PJM rules. Participants then may take advantage of a free-money opportunity to bid on day 5. Bidding on low LMP days but not high LMP days, an activity that seems economically abnormal, can thus be a manipulation scheme. Thus, without real energy curtailment, participants bidding on SUFO days will earn free money from the RTO.

Participants' ability to inflate their CBLs may also depend on their experiences with DR programs. Taking advantage of a SUFO opportunity may require knowledge of CBL procedures and an ability to predict usage. Participants may learn manipulation-related strategies from previous DR experiences. We thus expect an increase in manipulation-related behaviors as participants become more experienced in DR activities. The integrity of a CBL-based DR policy therefore may degrade over time.

While in the above example SUFO depends on weather, a common condition shared by a group of participants, not all customers facing the same weather have the same SUFO. A participant's SUFO CBL is calculated by usages on its past non-event days, thus its SUFO is based on its non-event days choices before the SUFO day, i.e., a firm's bidding history established by the RTO's acceptance of its bids, as well as its idiosyncratic demand. Even though it is influenced by the same usage shock, a participant has different SUFO condition with another consumer who has a different bidding history. In the modeling process, SUFO thus can be delineated from aggregate shocks (such as changes in weather) for all participants.

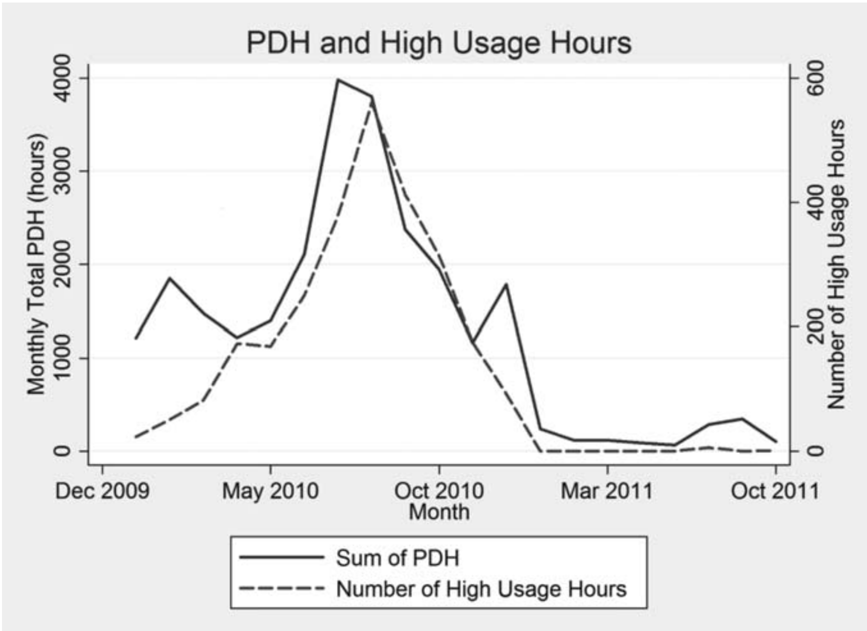
## 4. MODEL SPECIFICATIONS, DATA SUMMARY AND HYPOTHESES

### 4.1 Data Sources and Description

In this section we summarize our data and provide specifications for our statistical model. Our data includes:

1) Hourly locational marginal prices (LMPs) for the PECO zone in the Philadelphia region in PJM, obtained from PJM historical market records, http://www.pjm.com/markets-and-operations/energy/real-time/lmp.aspx.
2) Hourly observations of electricity use, CBL, reduction and transmission fees paid during event hours in the economic DR program for each DR participant in PECO territory, obtained from the PECO Energy Company. While market settlement data is available, other data is not. For example, we know when a participant successfully bid in the market, and that the bidding price is lower than the market clearing price (since the participant is dispatched), but we do not observe its bidding price. Participants in the observation were either charged a fixed rate, or had peak-time pricing contracts. We observe participants' behavior between January 2010 and August 2011 during event hours (hours in which participants' bids are accepted by the RTO in the merit order dispatch process). We do not have data on participants' usage during non-event hours. The observation period is before FERC Order 745, and participants were paid LMP-G-T. Thus, incentives for manipulation were less in the period studied than under FERC Order 745. Our DR data suffers from two types of censoring. First, some DR participants survived in the market in the observation period. Others, however, exited the market during the observation period, so no further observations were available for them. Second, we observe each participant's behaviors on its event hours, but do not have information about its behaviors on non-event hours.
3) Hourly data on temperature and cloudy sky conditions for Philadelphia International Airport, obtained from the National Oceanic and Atmospheric Administration (NOAA). Most DR participants in the PECO zone are located within 20 miles of the airport.

**Figure 3: The Relationship between Peak Usage Hours and DR Dispatch in PECO Territory**




### 4.2 Data Summary

One "participant-dispatch-hour" (PDH) is defined here as a particular participant being dispatched for one hour. Dispatches lasting M hours with N participants dispatched at the same time are considered as M × N PDHs. About 73 percent of PDHs occur between 9:00 and 20:00. Seventy one participants in the PECO area were dispatched in the observation period, for a total of 25,679 PDHs in the 593 days.

Figure 3 shows the relationship between peak usage and dispatch activities. The solid line shows the total of participant-dispatched-hours (PDH) in the given month. The dashed line shows the number of peak usage hours in PECO territory. The monthly total PDHs has a strong correlation (0.645) with the monthly number of peak-usage hours.[2] LMP and PECO loads have a correlation of 0.972.

We use three dependent variables in our regressions. In our first set of regressions, we model CBL (in KWh). We also model Bid Willingness (the possibility that a participant submits a DR bid in the market) and Reduction Ratio (DR percentage reduction once dispatched) as dependent variables. Reduction Ratio is the amount of reduction from the CBL divided by the CBL. Reduction Ratio is available for individual participants only during dispatched hours.

The independent variables we use are as follows:

2. We define a "peak-usage hour" as an hour in which the PECO system usage is higher than the system usage in 90% of all hours. The "number of peak hours" is the total number of such peak-usage hours in a month.

1) Learning, which indicates the number of hours that a participant has been dispatched before the current hour.
2) LMP and transmission fees. These determine the DR payments. Hourly LMP has the same value across participants for each hour. Transmission prices vary across participants.
3) An indicator variable "Weekday," which shows whether a dispatch hour is on a weekday.
4) HUI and CUI are the heating and cooling usage indices, respectively in a particular hour. HUI is defined as max [55.5-temperature (in degrees Fahrenheit), 0] [3] and CUI is defined as max [temperature-55.5, 0].
5) A participant's Past HUI (CUI) is the average of the highest four HUI (CUI) in the particular hour in its most recent 5 comparable non-event days[4] in the last 45 calendar days. This variable varies across participants.
6) HUI (CUI) Seemingly Unattractive Free-Money Opportunity (SUFO) is the difference between past HUI (CUI) and current HUI (CUI), i.e., past HUI (CUI) minus current HUI (CUI). As shown in Figure 2, a decline in HUI (CUI) from past HUI (CUI) may create an opportunity for a SUFO.[5]
7) The Variable HUI (CUI) SUFO $\times$ Learning Experience is the product of the above HUI (CUI) SUFO variables and the ln(Learning Hours).[6]
8) Work-Hour Indicator, which is an indicator variable with value 1 for weekday hours between 8:00 to 18:00, 0 elsewise.
9) Daytime Sky Clear in Heating (Cooling) is a variable with a value of 0 when the temperature is higher (lower) than 55.5°F, or when hours are outside work hours (8:00 to 18:00). For other hours, values are: 0 if more than 7/8 of the sky is covered; 1 if 1/2 to 7/8 covered; 2 if 1/8 to 1/2 covered; and 3 if less than 1/8 covered. Three significant effects may accompany a clear sky condition: a: participants may turn off some of their lights when the sky is clear; b: sunshine may heat the buildings so that there is less need for heat in the winter and more need for air conditioning in the summer; and c: a solar onsite generator to handle demand responses can operate more effectively during the daytime if the sky is clear. Since the sunlight-heating effect reduces usage in winter and increases usage in summer, separate variables are created for heating and cooling conditions.
10) We include a list of variables indicating the participants' business or industry. There are four categories: College, Commercial, Hospital, and Other. The category "Other" acts as the null, and an indicator variable is constructed for each of the other categories.

3. We have fitted PECO load-temperature pairs into a cubic curve; the results imply that the lowest PECO usage occurs at a temperature of 55.5 °F.

4. HUI (CUI) in the past for Saturday (Sunday) is calculated as the average of 2 weekend usages in the most recent 3 non-dispatch Saturdays (Sundays), following PJM's CBL-calculation method.

5. SUFO, i.e., the situation that everyone in the RTO has a lower load, may occur due to drop of HUI (CUI) or weekends and holidays. In PJM, the CBL for weekends and holidays are calculated by the average of past weekends and holidays, which theoretically corrects the potential SUFO problems generated by holidays. However, there was no mechanism to correct the HUI (CUI) SUFO in the observation period. DR participants could require the RTO to conduct a temperature adjustment of CBL, however, they seldom made such a request.

6. The logarithmic form of the Learning Variable is used here to account for a declining marginal value of learning through market participation.

**Table 1: Descriptive Statistics (25,545 Observations)**

| Variable | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|
| Learning Hours | 898.5 | 922 | 0 | 4,028 |
| LMP ($/MWh) | 62.65 | 46.72 | −27.17 | 471.4 |
| Transmission Rate (cent/KWh) | 2.52 | 0.477 | 0.08 | 10.4 |
| Work-Hour Indicator | 0.611 | 0.488 | 0 | 1 |
| Past HUI | 6.65 | 10.96 | 0 | 40 |
| HUI SUFO*Learning Experience | 2.654 | 32.93 | −283.2 | 211.5 |
| Past CUI | 17.5 | 14.2 | 0 | 48 |
| CUI SUFO*Learning Experience | 27.25 | 51.03 | −197.2 | 277.6 |
| Heating Usage Index (HUI) | 6.041 | 9.857 | 0 | 43.5 |
| Cooling Usage Index (CUI) | 13.23 | 12.76 | 0 | 48.5 |
| Daytime Sky Clear in HUI Condition | 0.0904 | 0.287 | 0 | 1 |
| Daytime Sky Clear in CUI Condition | 0.199 | 0.399 | 0 | 1 |
| College Winter Holiday Indicator | 0.0393 | 0.194 | 0 | 1 |
| Average CBL (MW) | 11.79 | 18.46 | 0.34 | 53.86 |
| Percentage SD of CBL | 18.9 | 8.62 | 0.209 | 79 |
| Total Dispatched Hours | 1794 | 1321 | 1 | 4028 |

**Table 2: Number of Participants by Contract and Participant Type**

| | Number of Participants | | |
|---|---|---|---|
| Type | Flat Fixed Rate | Peak Time Pricing | Total |
| College | 13 | 9 | 22 |
| Commercial | 8 | 10 | 18 |
| Hospital | 4 | 10 | 14 |
| Others | 13 | 4 | 17 |
| Total | 38 | 33 | 71 |

11) College Winter Holiday is a binary variable with a value of 1 between December 15th and January 15th for college DR providers, 0 otherwise.
12) Peak Time Pricing is an indicator variable with value 1 for participants engaged in a peak-time-pricing rate structure, and value 0 for those in flat-fixed retail rate plan.
13) Average CBL represents the average of an individual participant's CBL on dispatch hours in the 20-month observation period. Unlike the time-varying hourly CBL, a participant's Average CBL is a constant across time.
14) Percentage SD of CBL represents the percentage standard deviation of CBL for a participant in the 20 months of observations.
15) The variable "Total Dispatched Hours" represents the total number of hours that a participant was dispatched by PJM to provide DR resources across the observation period. A participant's Total Dispatched Hours is a constant across time.

Table 1 shows the descriptive statistics for variables. Table 2 presents the distribution of participants in various categories and rate structures. PECO load does not have a strong correlation with HUI (-0.064), perhaps because natural gas and other non-electric heating sources are widely used in winter in PECO.[7] However, PECO load is highly correlated with CUI (0.55).

7. According to Energy Information Administration, 51.0% of home heating in Pennsylvania were provided by natural gas, 20.7% by electricity, and 19.7% by fuel oil. See http://www.eia.gov/state/data.cfm?sid = PA#Consumption.

### 4.3 Hypotheses

We model the impact of variables on three aspects: a participant's CBL, i.e., whether a factor increase or decrease CBL; DR participation, i.e., whether a factor results in more or less bids that are accepted by PJM; and reduction in DR event hours. For example, the following hypothesis regarding LMP involves the variable LMP's impact on CBL, bid, and reduction. The three aspects of the impact will be tested in three different set of models. The major hypotheses that reveal market manipulations are:

1) H1: Learning experience increases manipulations. With more learning hours, participants may gain a greater understanding of CBL inflation methods and potential free-money opportunities. DR experience may therefore increase manipulative behaviors. Participants may also be more experienced in usage reduction. We expect experience to increase CBL, bidding frequency, and observed reductions.
2) H2: A participant's CBL is impacted by the weather conditions on its previous non-event days. It is clear in theory that CBLs are determined by historically energy use, rather than expected energy use, thus are subjected to manipulations. The paper will test empirically that a high HUI (CUI) in the past may imply a larger CBL.
3) H3: A SUFO decreases bidding willingness for participants without manipulation experience, while increases the observed reduction via an inflated CBL. A high SUFO by definition implies a current HUI (CUI) lower than that in past non-event days HUI (CUI), and further may imply current system usage and LMP lower than those in past non-event CBL-determination days. Since a high SUFO is "seemingly unattractive" due to low system LMP, we expect for SUFOs to decrease participation willingness in modelling of bidding behaviors. In modelling of observed usage reduction, we expect SUFO to have a positive impact, due to CBL inflation.
4) H4: Experienced participants bid on SUFO days to exercise manipulative strategies. As indicated in section 3, the existence of a SUFO and the bidding behaviors that take advantage of the inflated CBL on a SUFO day (low LMP day) may imply idiosyncratic-demand bidding. Participants need experience to exercise SUFO biddings since a SUFO is "seemingly unattractive." The learning variable may indicate participants' experience in understanding the market. In modeling participation willingness and bidding behaviors, if we obtain a negative coefficient for SUFO in testing the third hypothesis, and a positive coefficient for SUFO * Learning in the fourth hypothesis, the coefficients may imply that participants accumulate an understanding of idiosyncratic-demand bidding from their experiences.

There are other hypotheses of interest that may enhance market understanding for demand response behaviors, but are not directly related with market manipulation. They are:

1) Since PJM compensated LMP minus generation and transmission price for DR reduction in the observation period, we expect a greater willingness for participating in DR at higher LMP hours. The electricity grid may have higher load during high LMP hours, and participants are also expected to have loads higher than normal. Since a CBL is likely to under-represents normal usage in high LMP peak hours, the impact on observed reduction level is ambiguous.

2) Since a college may have lower usage during winter holidays, CBL may thus over-represent normal usage during this period. Colleges thus may have more bidding behaviors in the market to take advantage of the CBL, which shows as positive coefficients in modeling bidding willingness.
3) A participant with a larger demand for electricity may use more electricity and thus may gain some advantage in DR bidding, if economies of scale apply. These economies of scale may appear in both the bidding process and the DR reduction implementation.
4) Participants may have higher CBL and greater reduction ability on weekdays and during work hours, compared with weekends and off-work hours.
5) Compared with those in flat-fixed rate, peak-time-pricing participants may pay more attention to price changes and may have a stronger ability to adjust their consumptions. They may thus provide more DR resources than those who have a flat-fixed rate.

## 5. ECONOMETRIC APPROACH AND RESULT FOR CBL

### 5.1 Modeling Consumer Baseline

Modelling CBL tests a part of the first hypothesis (impacts of learning experiences on CBLs) and the second hypothesis. To model CBLs, we will run an OLS regression, a fixed effect OLS regression, and a Heckman model with various explanatory variables. The fixed-effect OLS regression allows each participant to have an unobserved quality (fixed-effect term) that impacts the outcome. A fixed-effect model thus may produce more robust estimators. However, this model cannot provide estimators for variables that a participant has constant values for, such as a firm's business sector. The tests of several hypotheses thus rely only on the OLS model. The OLS and fixed-effect OLS regression models are:

$$CBL = \beta_0 + \beta_1 \times X_{i,t} + \beta_2 \times X_t + \beta_3 \times X_i + \varepsilon_{i,t}, \varepsilon \sim N(0,\sigma) \tag{1}$$

$$CBL = \beta_0 + \beta_1 \times X_{i,t} + \beta_2 \times X_t + \beta_i + \varepsilon_{i,t}, \varepsilon \sim N(0,\sigma) \tag{2}$$

In equations (1) and (2), $X_{i,t}$ includes vectors for individual participant time-varying variables (Learning Hours, Past HUI, Past CUI, and College Winter Holiday Indicator); $X_i$ contains vectors for individual constant variables (Percentage SD, Peak Time Pricing, and participant type); $X_t$ is the group of vectors for time-varying variables (Work-Hour Indicator, and weekend Indicators); and $\varepsilon_{i,t}$ is the normal distributed error term. The fixed-effect model in equation (2) does not include $X_i$, whose variables have the same value across time, and includes a constant fixed-effect vector $\beta_i$ for each participant.

In the observation period, many DR participants exited the market during the first winter.[8] Further, our 20 months observation period covers two summers and only one whole winter. A selection problem may therefore exist because many of our observations come from participants who survive in the market. To account for this possibility we employ a Heckman model.

8. In contrast to early exit, no significant amount of late entry is observed in the dataset. The amount of Demand Response Resources in PJM was therefore declining in the observation period.

In the Heckman two-step model, the first step consists of a Probit regression for the selection function as shown in equation (3) below; the second step is an OLS regression, as shown in equation (4).

$$Quit = \alpha_0 + \alpha_1 \times Z_{i,t} + \alpha_2 \times Z_i + \alpha_3 \times Transmission\ Fee + \alpha_4 \times \text{Total Dispatched Hours} + \varepsilon_{i,t}, \varepsilon \sim N(0,\sigma) \tag{3}$$

$$CBL = \beta_0 + \beta_1 \times Z_{i,t} + \beta_2 \times Z_i + \beta_3 \times Z_t + \beta_4 \times IMR + \varepsilon_{i,t}, \varepsilon \sim N(0,\sigma) \tag{4}$$

In the selection equation, the dependent variable Quit is an indicator with value 1 for a participant after it exited the market and 0 otherwise. Exit behavior serves as the dependent variable in the selection function. $Z_{i,t}$ represents variables “Learning Experience”, “HUI (CUI) in the Past” and indicator “College Winter Holiday”; $Z_i$ consists of variables “Percentage SD of CBL” and other fixed characters for DR participants; $Z_t$ represents variables “Work-Hour Indicator” and “Weekday Indicator.” The Inverse Mill’s Ratio is calculated from the results of the first step and acts as an independent variable in the second step. The variable Transmission Fee is included in the first step but not the second. The variable Transmission Fee can be expected to impact the exit decision, since PJM paid DR resources LMP-G-T and the transmission fee thus impacted a participant’s profit. However, there is no apparent reason why the transmission fee would impact the CBL, the dependent variable in the second step. Transmission fee thus can be the instrument variable in the Heckman model. Similarly, the variable “Total Dispatched Hours” is used in the first step but not the second, and the $Z_t$ variables are used in the second step but not the first.

Since the data includes repeat observations for participants, the error terms may be correlated for observations of the same participant. Thus, clustered errors are used in all regressions.

### 5.2 Results for Factors that Influence the Consumer Baselines

Table 3 shows the OLS, fixed-effect OLS regression and Heckman model results with CBL as the dependent variable.

Three positive and statistically significant coefficients are obtained for the variable Learning Hours. The result supports our hypothesis that with increased experience, participants learn about CBL manipulative and inflating methods. We note that this increase in CBL occurred despite the expectation laid out by Chao (2011) that adverse selection of DR participants would results in declining electricity consumption for the participants in the DR program. The load data shows that the zonal peak load for the PECO territory in PJM increased 1%–2% in the observation period;[9] however, the average CBL increase reached 15%. The abnormal increase in CBL over time is consistent with manipulative and inflation behaviors and is not thus consistent with the minor change in load patterns.

As expected, DR participants have higher CBLs during weekday work hours. Commercial participants have higher CBLs, compared with the default category. Peak time pricing does not show significant impact on CBL. Past CUI obtains a significant positive coefficient in the fixed effects equation. This is consistent with our hypothesis that a high previous high temperature (rep-

9. PECO’s highest load in 2011 was 1.33% higher than the 2010 highest load. The average of the 2 percentile peak load (top 175 hours) in 2011 increased 1.56% from 2010. The average of the 5 percentile peak load, 10 percentile peak load and average load slightly decreased from 2010.

**Table 3: OLS, Fixed-Effect OLS and Heckman Regression Results (dependent variable: CBL in KWh)**

| | OLS: | Fixed-Effect OLS: | Heckman Model |
|---|---|---|---|
| Learning Hours | 9.287*** | 0.893** | 9.272*** |
| | (2.254) | (0.384) | (2.252) |
| Work-Hour Indicator | 830.4 | 1,119** | 825.4 |
| | (1,295) | (530.0) | (1,295) |
| Past HUI | 2.015 | −39.47* | 2.092 |
| | (81.70) | (23.69) | (81.60) |
| Past CUI | 71.04 | 83.47* | 72.38 |
| | (61.42) | (46.81) | (61.75) |
| College Winter Holiday | −8,095 | −3,713 | −7,893 |
| Indicator | (6,297) | (3,276) | (6,241) |
| Saturday | −4,448** | −1,187 | −4,481** |
| | (2,146) | (777.8) | (2,154) |
| Sunday | −4,107** | −1,245 | −4,093** |
| | (1,999) | (817.0) | (2,001) |
| College | 18,093 | | 18,063 |
| | (10,929) | | (10,920) |
| Commercial | 7,424* | | 7,442* |
| | (3,831) | | (3,848) |
| Hospital | −525.3 | | −520.3 |
| | (3,068) | | (3,082) |
| Peak Time Pricing | 7,054 | | 7,021 |
| | (7,983) | | (7,976) |
| Percentage SD of CBL | −12.31 | | −13.58 |
| | (224.2) | | (224.6) |
| IMR | | | −618.8 |
| | | | (504.0) |
| Constant | −11,912 | 5,309*** | −11,824 |
| | (10,675) | (162.4) | (10,662) |
| Observations | 25,059 | 25,545[a] | 25,059 |
| R-squared | 0.461 | 0.976 | 0.461 |

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$
[a] The observation numbers differ across regressions because the fixed-effect model omits several variables that contain missing values.

resented by variable past CUI) may increase the use of energy in cooling in previous non-event days and thus inflate the CBL.

Contrary to expectations, the past HUI variable yields a negative coefficient in the fixed-effect OLS regression. PECO is a summer peaking area and thus we would expect that HUI does not impact the system as much as CUI; sample selection bias also may occur due to the fact that many small participants exited the market during the first winter of our observation period[10]: both may contribute to the unexpected coefficient. In the Heckman model, with the Inverse Mill's Ratio, the regression finds a non-significant positive coefficient for past HUI. These coefficients imply that heating demand may not be an important factor for DR in PECO.

10. Small participants (with low CBLs) remained in the observations in the first winter (HUI period) but not the following summer (CUI period), thus creating a positive correlation between "low CBL" and HUI, i.e., negative correlation between CBL and HUI.

## 6. ECONOMETRIC APPROACH AND EMPIRICAL RESULTS FOR DR REDUCTION

In this section, we present our econometric methods and the results for modelling participation willingness and real-time reduction. Section 6.1 shows the construction of a Tobit regression model, to analyze variables' impacts, the combination of impacts on participation (i.e., bidding choice) and reduction, on the performance of DR. In section 6.2, we further break DR performance into two parts, participation and reduction, and analyze each part separately. Analysis of bidding participation tests the bidding parts of Hypotheses 1, 3, and 4, while analysis of reduction tests the reduction parts of Hypotheses 1 and 3. The section shows the constructions of a Heckman model, a survival model, and a two-part model. Section 6.3 shows the econometric results for all regressions.

### 6.1 Tobit Regression Model

Due to the nature of the censored data, the reduction amount is observable only when a participant is dispatched. We therefore run a Tobit model to account for this censoring. To run a Tobit model we construct a variable "Reduction Index" with the variable "Reduction Ratio" and use it as the dependent variable in the Tobit regression. Reduction Ratio, the percentage of curtailment over CBL, i.e., (CBL - real time usage)/CBL, varies between 0 and 1. Reduction Index is defined following equation (5), which is a method to create a variable ranging $[0, \infty)$ from a variable ranging $[0, 1]$.

$$Reduction\ Index = \frac{Reduction\ Ratio}{1 - Reduction\ Ratio} \tag{5}$$

We then create a latent variable, Reduction $Index_{i,t}*$, which varies between negative and positive infinity, and assume that can be observed as the variable Reduction $Index_{i,t}$ only when it has a value larger than 0. The Tobit model is as follows:

$$Reduction\ Index^*_{i,t} = \beta_0 + \beta_1 \times X_{i,t} + \beta_2 \times X_t + \beta_3 \times X_i + \varepsilon_{i,t}, \tag{6}$$

$$Reduction\ Index_{i,t} = \begin{cases} 0, & Reduction\ Index^*_{i,t} < 0 \\ Reduction\ Index^*_{i,t}, & Reduction\ Index^*_{i,t} \geq 0 \end{cases}$$

### 6.2 Heckman Model and a Two-part Model

To model DR bidding choices and reduction amounts we again utilize a Heckman model and a two-part model (for more information about the two-part model, see, for example, Duan, Manning et al. (1984)). In these models the first step or part analyzes the choice of whether participants provide DR in the market, and the second step or part analyzes the amount of DR resources provided. The fixed cost associated with bidding (for example, labor cost for submitting bids, communication cost between PJM and DR customers, etc.) may be a significant consideration for DR customers. To distinguish between bidding and reduction is thus important for modelling DR. We use the two models for two reasons: both models capture the two-step DR process, separately analyzing bidding choices and reduction; and both models are capable of processing the special-structured data we have. The data observes a participant's bidding choices on all hours, but observes a participant's reduction only when its bidding choice is a "Yes." Under the assumption that a participant constantly adjusts its consumption pattern in accordance to market condition no matter whether it submits a bid, the data would be censored, and Heckman model corrects the censoring bias. Under the assumption that a participant reduces its consumption only when it submits a bid and gets dispatched by the RTO, there is no censoring, and the two-step model is appropriate. Either of the above assumptions may be valid, and we present regression results from both models.

In the Heckman model, the first step Probit regression may capture DR providers' choices and the results can be used to obtain an Inverse Mill's Ratio (IMR). The second step then analyzes the demand reduction once participants decide to provide DR, with IMR as an explanatory variable to adjust for censoring. In the two-part model, the two parts are separated. We employ either Logit regression or survival analysis in the first part, and either OLS or fixed-effect OLS in the second part. No IMR is used in the second part. The two-part model does not adjust for censoring.

The first step of the Heckman model is a Probit regression, as shown in equation (7).

$$Participant\ Choice_{i,t} = \begin{cases} 1, & if\ \beta_0 + \beta_1 \times X_{i,t} + \beta_2 \times X_t + \beta_3 \times X_i + \varepsilon_{i,t} > 0, \varepsilon \sim N(0,\sigma) \\ 0, & otherwise \end{cases} \tag{7}$$

In Probit model equation (7), all variables $X_i$, $X_t$, and $X_{i,t}$ are included. An Inverse Mill's Ratio (IMR) is generated in the first step via the Probit regression. The IMR is then used as an explanatory variable in the second step.

In the second step of Heckman model, we attempt to determine reduction ability after a DR participation decision is made. Since many explanatory variables range between negative and positive infinity, we seek to have a dependent variable that matches the distribution of independent variables, so that the model may produce more accurate results. We use ln(Reduction Index) as our measure of DR reduction ability (or reduction willingness). The two concepts, reduction ability and reduction willingness, both contribute to energy curtailment behavior, and our data does not enable us to distinguish between the two. The variable "Reduction Ability" here and in the following sections models both factors.

The dependent variable "reduction ability," defined as ln(Reduction Index) and shown in equation (8), ranges between negative and positive infinity. The variable "reduction ability" turns out to be $\text{sigmoid}^{-1}$ (Reduction Ratio), where $\text{sigmoid}^{-1}$ is the inversed function of sigmoid function as shown in equation (8), and Reduction Ratio is the amount of DR reduction over CBL (See, for example, Barro (1977) for similar construction of a dependent variable.)

$$Reduction\ Ability = = ln\frac{Reduction\ Ratio}{1 - Reduction\ Ratio} = sigmoid^{-1}(Reduction\ Ratio) \tag{8}$$

We then estimate

$$sigmoid^{-1}(Reduction\ Ratio_{i,t}) = \beta_0 + \beta_1 \times X_{i,t} + \beta_2 \times X_t + \beta_3 \times X_i + \beta_4 \times IMR + \varepsilon_{i,t}, \varepsilon \sim N(0,\sigma) \tag{9}$$

$$sigmoid^{-1}(Reduction\ Ratio_{i,t}) = \beta_0 + \beta_1 \times X_{i,t} + \beta_2 \times X_t + \beta_3 \times IMR + \beta_i + \varepsilon_{i,t}, \varepsilon \sim N(0,\sigma) \tag{10}$$

Equation (9) shows the OLS regression equation, and equation (10) shows the fixed-effect form with a fixed-effect indicator $\beta_i$ and without characteristic variable $X_i$. Impacts from $X_i$ variables that do not vary with time (average CBL, participants' type, etc.) are included in term $\beta_i$ in the fixed effect model. Compared with the first-step Probit regression shown in equation (7), the two regressions in the second step do not contain the two variable HUI (CUI) SUFO $\times$ Learning Experience. These two variables impact the Bid Willingness in the first step but not reduction in the second step, according to the theory presented in Section 3. They thus become the instrumental variables for the Heckman model.

In the two-part model, two regressions can be used in the first part—a multiple failure survival analysis by Cox model or a Logit regression. Both regressions may capture participants' choices about whether to offer into the DR market. We employ the Cox hazard function model, as shown in equation (11). The Cox survival analysis model has fewer underlying assumptions and produces more accurate results. However, the model does not provide coefficients for $X_t$ variables. We use the same set of explanation variables in the Logit, Probit, and hazard model equations.

$$\lambda_{i,t}(X_{i,t}) = \lambda_t \times \exp(\beta_1 \times X_{i,t} + \beta_2 \times X_t) \tag{11}$$

In equation (11), $\lambda$ is the hazard rate; and only individual varying variables $X_i$ and $X_{i,t}$ are covered in the proportional hazards Cox model. The time-varying variables in $X_t$ have the same value across all individuals (such as weather and temperature), and the impacts of $X_t$ variables contribute into the baseline hazard term $\lambda_t$ as a combined effect. The model does not generate coefficients for those $X_t$ variables.

### 6.3 Empirical Results Modeling Demand Response Reduction

The second column in Table 4 shows the results for the Tobit regression on DR reduction as measured by Reduction Index defined in equation (5). Columns three to five show the regression results for the first-stage models (i.e., first step of the Heckman regression and the first part of the two-part model). Table 5 shows the result of the second-stage models (i.e., second step of Heckman model and the second part of the two-part model). Both second-stage models contain either OLS or fixed-effect OLS regression.

In the regression results, the first stage analyzes DR participants' choices whether to bid in the market, and the second stage analyzes the reduction ability or reduction willingness given participants submit bids in the market and are dispatched. The Tobit regression reflects the combination of bidding choice and reduction in consumption.

The learning variable obtains significant positive coefficients in both groups of regressions, consistent with Hypothesis 1. Thus, both willingness to bid in the market and observed usage-reduction ability increase with experience. This implies that learning experience may improve participants' skill in utilizing CBL manipulation strategies. Experience may also enhance participants' ability to reduce energy usage, as indicated by the positive coefficients in the second step.

The effect of locational marginal price is complex. Results shown from the first-stage regressions indicate that high LMP increases willingness to bid in the DR market, consistent with our hypothesis. The negative coefficients in the second-stage regressions indicate that participants have lower reduction ratios during high LMP hours. When a high LMP occurs, the system may have a peak load, and simultaneously participants are likely to have high loads, reducing their ability to decrease their consumption below their CBLs. The positive coefficient from the Tobit regression shows that higher LMPs increases DR performance.

**Table 4: Results for Tobit regression, the First Step of Heckman Model and the First Part of Two-part Model**

| | Tobit | Heckman Step 1: Probit | Two-part Model Part 1: Survival Analysis | Two-Part Model Part 1: Logit |
|---|---|---|---|---|
| Dependent Variable | Reduction Index | Bidding Choice | Bidding Choice | Bidding Choice |
| Learning Hours | 0.00202 | 0.000237** | 0.00107*** | 0.000451* |
| | (0.00123) | (0.000113) | (0.000255) | (0.000237) |
| LMP | 0.0202* | 0.00177*** | | 0.00294*** |
| | (0.0108) | (0.000441) | | (0.000867) |
| Transmission Fee | −3.051 | −0.291 | −0.481 | −0.494 |
| | (1.953) | (0.227) | (0.444) | (0.488) |
| Work-Hour Indicator | 8.581*** | 1.023*** | | 1.999*** |
| | (3.187) | (0.0754) | | (0.141) |
| HUI SUFO | −0.188* | −0.0188* | −0.238*** | −0.0418* |
| | (0.110) | (0.0111) | (0.0384) | (0.0235) |
| HUI SUFO | 0.0142 | 0.00101 | 0.0251*** | 0.00246 |
| *ln(Learning) | (0.0177) | (0.00197) | (0.00502) | (0.00406) |
| CUI SUFO | −0.173** | −0.0205*** | −0.126*** | −0.0376*** |
| | (0.0811) | (0.00681) | (0.0240) | (0.0132) |
| CUI SUFO | 0.0642** | 0.00775*** | 0.0201*** | 0.0150*** |
| *ln(Learning) | (0.0250) | (0.00104) | (0.00304) | (0.00195) |
| Heating Usage Index | 0.0616 | 0.00706 | | 0.0151* |
| (HUI) | (0.0451) | (0.00437) | | (0.00902) |
| Cooling Usage Index | 0.150** | 0.0177*** | | 0.0383*** |
| (CUI) | (0.0725) | (0.00389) | | (0.00832) |
| Daytime Sky Clear | −5.061*** | −0.584*** | | −1.103*** |
| in HUI Condition | (1.866) | (0.0279) | | (0.0492) |
| Daytime Sky Clear | −5.712*** | −0.664*** | | −1.258*** |
| in CUI Condition | (2.148) | (0.0208) | | (0.0355) |
| College Winter | 3.127* | 0.403*** | 0.293 | 0.839*** |
| Holiday Indicator | (1.613) | (0.141) | (0.554) | (0.277) |
| Saturday | −2.995** | −0.329*** | | −0.648*** |
| | (1.422) | (0.101) | | (0.236) |
| Sunday | −2.844** | −0.321*** | | −0.647*** |
| | (1.337) | (0.0896) | | (0.201) |
| College | −1.131 | −0.163 | −0.497 | −0.325 |
| | (2.571) | (0.289) | (0.358) | (0.586) |
| Commercial | 1.199 | 0.0768 | −0.259 | 0.134 |
| | (2.080) | (0.234) | (0.326) | (0.468) |
| Hospital | −3.230 | −0.412 | −1.178** | −0.809 |
| | (2.835) | (0.290) | (0.473) | (0.616) |
| Peak Time Pricing | 1.591 | 0.194 | 0.0755 | 0.379 |
| | (1.830) | (0.200) | (0.316) | (0.400) |
| Average CBL | 0.120 | 0.0188** | 0.000581 | 0.0340** |
| | (0.0835) | (0.00776) | (0.0120) | (0.0164) |
| Percentage SD of | −0.0544 | −0.00328 | −0.0124 | −0.00629 |
| CBL | (0.0753) | (0.00695) | (0.00994) | (0.0144) |
| Constant | −15.11* | −1.542** | | −2.992* |
| | (9.158) | (0.721) | | (1.537) |
| Observations | 347,255 | 345,607 | 347,407 | 347,408 |
| R-squared | 0.0905 | 0.2072 | | 0.2044 |

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

**Table 5: Regression Results for the Second Step of Heckman Model and the Second Part for Two-part Models**

| | Heckman Step 2: OLS | Heckman Step 2: Fixed-Effect OLS | Two-Part Model Part 2: OLS | Two-Part Model Part 2: Fixed-Effect OLS |
|---|---|---|---|---|
| LHS Variables | Reduction Ability | Reduction Ability | Reduction Ability | Reduction Ability |
| Learning Hours | 3.99e-05 | 8.96e-05 | 0.000202*** | 0.000229*** |
| | (8.60e-05) | (6.36e-05) | (6.63e-05) | (6.31e-05) |
| LMP | −0.00177* | −0.00317*** | −0.000556 | −0.00198*** |
| | (0.000960) | (0.000660) | (0.000853) | (0.000680) |
| Transmission Fee | 0.179 | | −0.0116 | |
| | (0.229) | | (0.186) | |
| Work-Hour Indicator | −0.708** | −0.583*** | −0.0594 | −0.00606 |
| | (0.287) | (0.163) | (0.0985) | (0.0606) |
| HUI SUFO | 0.00108 | 0.00241 | −0.00701 | −0.00578 |
| | (0.00942) | (0.00972) | (0.00977) | (0.0106) |
| CUI SUFO | 0.00140 | 0.00895 | 0.0190** | 0.0269*** |
| | (0.0104) | (0.00587) | (0.00732) | (0.00520) |
| Heating Usage Index (HUI) | −0.0280*** | −0.0258*** | −0.0238*** | −0.0211*** |
| | (0.00472) | (0.00361) | (0.00396) | (0.00332) |
| Cooling Usage Index (CUI) | −0.0258*** | −0.0219*** | −0.0145*** | −0.0106** |
| | (0.00597) | (0.00535) | (0.00499) | (0.00503) |
| Daytime Sky Clear in HUI Condition | 0.541*** | 0.531*** | 0.185*** | 0.175*** |
| | (0.145) | (0.115) | (0.0490) | (0.0480) |
| Daytime Sky Clear in CUI Condition | 0.498*** | 0.510*** | 0.0880* | 0.107** |
| | (0.148) | (0.105) | (0.0508) | (0.0455) |
| College Winter Holiday Indicator | 0.108 | 0.0776 | 0.344 | 0.321 |
| | (0.316) | (0.350) | (0.334) | (0.347) |
| Saturday | 0.318* | 0.167* | 0.117 | 0.0492 |
| | (0.189) | (0.0843) | (0.151) | (0.0873) |
| Sunday | 0.494** | 0.331*** | 0.287* | 0.208* |
| | (0.201) | (0.104) | (0.167) | (0.108) |
| College | −0.135 | | −0.239 | |
| | (0.314) | | (0.324) | |
| Commercial | −0.396 | | −0.355 | |
| | (0.384) | | (0.373) | |
| Hospital | −0.621** | | −0.879*** | |
| | (0.302) | | (0.307) | |
| Peak Time Pricing | 0.00959 | | 0.140 | |
| | (0.254) | | (0.237) | |
| Average CBL | −0.0291*** | | −0.0178*** | |
| | (0.00583) | | (0.00314) | |
| Percentage SD of CBL | −0.00607 | | −0.00740 | |
| | (0.0123) | | (0.0124) | |
| IMR (Dispatch) | −0.821** | −0.819*** | | |
| | (0.334) | (0.224) | | |
| Constant | 0.106 | −0.279 | −1.528*** | −2.227*** |
| | (0.900) | (0.496) | (0.498) | (0.100) |
| Observations | 23,440 | 23,440 | 23,484 | 23,933 |
| R-squared | 0.169 | 0.126 | 0.166 | 0.119 |

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The positive coefficients in the first stage for "Work-Hour Indicator" show that participants are more likely to bid in the market during work hours. However, negative coefficients in the second stage imply that participants have lower reduction ability during work hours. The positive coefficient from the Tobit regression implies that the overall reduction ratio is higher during work hours.

The variables “CUI SUFO” and the interaction term with ln(Learning) are the key explanatory variables with respect to manipulation. A high SUFO implies a day with inflated CBL and lower LMP than past non-dispatch days, and is created by a participant’s previous bidding pattern. In the absence of CBL experience, participants may not have sufficient incentive to bid during relatively low LMP hours, even though SUFO may be created accidently. However, experienced DR participants may understand the calculation of CBL and potential idiosyncratic-demand bidding. They may utilize bidding strategies to create SUFO and then take advantage of the current high CBL and bid in the market.

The variable “CUI SUFO” obtains negative coefficients in the first stage and positive coefficients in the second stage, consistent with Hypothesis 3. The interaction term achieves positive coefficients for the first step, consistent with Hypothesis 4. These results imply that inexperienced participants are less willing to bid in the market when SUFO is high. The positive coefficients in the second stage, indicating high observed reduction, support our expectation that inflated CBLs may exist on SUFO days.

In the first-stage models, the positive coefficients for the interaction terms indicate that participants are more likely to utilize idiosyncratic-demand bidding as they become experienced. A higher CUI SUFO initially has a negative effect on DR bidding, but this becomes a positive factor after around 500 learning hours,[11] implying that participants come to know how a past high temperature may inflate their CBL. The number of learning hours varies between 0 and 4,000 in the one and a half years observation period. Our data indicates that an event day on average has 12 DR hours, thus the 500 hours experience may be accumulated in 40 event days, perhaps during a three-month period.

The variables HUI SUFO and the cross-term with ln(Learning) achieve similar results in the Tobit and the first-stage regressions. The coefficients imply the same bidding pattern as with CUI SUFO on these variables. However, the regressions in the second part of the two-part model provide insignificant coefficients. Since PECO is a summer peaking area, HUI SUFO in winter may not represent an important manipulation opportunity

The HUI and CUI coefficients show the same pattern as the coefficients for LMP. The positive coefficients in the first-stage models imply more willingness to bid on high HUI and CUI hours. The negative coefficients from the second-stage models imply a lower observed reduction. High HUI and CUI increase expected usage, and thus CBL may underrepresent the expected load during high HUI and CUI hours.

The first-stage coefficients for Sky Clear Conditions in Heating or Cooling Period are negative, implying that participants are less likely to reduce usage on a clear day. When sunshine is expected, DR suppliers may believe that the heating, ventilation and air conditioning (HVAC) systems will be in more demand than on a cloudy day. The positive coefficients on the sunshine variable in the second stage indicate greater energy reduction ability on sunny days. However, the negative coefficient in the Tobit regression shows an overall lower level of DR on sunny days, representing a combination of low Bid Willingness and high reduction ability.

The negative coefficients for weekend variables in the first-stage regressions imply a lack of willingness of firms to engage in DR on those days. Results in the second-stage regressions indicate high reduction ability on weekends, as expected. The overall reduction for DR on the weekends is lower than on weekdays, as shown by the negative Tobit regression coefficient. Re-

11. The number of hours for HUI SUFO to become a positive factor is: e ^ (- coefficient (SUFO) / coefficient (SUFO*ln(learning))) which equals 528 hours.

gression results for the variable "College Winter Holiday" indicate a higher bidding willingness in the first stage regressions, as expected. Results show that participants with peak time pricing contracts do not significantly differ with other participants in their Bid Willingness and reduction ability.

The explanatory variable "Average CBL" obtains positive coefficients in the first-stage regressions, and negative coefficients in the second stage regressions. According to the first-step regressions, firms using larger amounts of electricity have a greater probability of bidding in the market. This advantage may stem from economies of scale. The negative coefficients in the second stage indicate that firms using more electricity have lower relative reduction ability once dispatched.

## 7. CONCLUSION

Demand response (DR) may potentially play an important role in the electricity systems by reducing peak load and preventing social welfare loss. However, the historical-based customer baseline load (CBL) determination method can induce manipulation strategies, reduce social welfare, increase the burden of rate payers, and at the same time jeopardize system reliability. Vulnerable CBLs that can be manipulated may lead to DR programs that are far from effective.

Regressions based on the PECO data further suggest that participants are utilizing manipulation strategies. The existence of manipulated CBLs is indicated as CBLs dramatically increase with learning experience. In addition, there is substantial evidence that firms engage in DR during Seemingly Unattractive Free-money Opportunities (SUFO) when their CBLs potentially over-represent expected usages. In particular, participants create and use more SUFO days to earn extra profit as their experiences accumulate.

FERC Order 745 envisions that DR participants will provide energy during peak hours, generating a large amount of social welfare and deferring costly infrastructure constructions. However, the incentives for manipulation shown here may well have been undermining DR programs. Indeed, because our data comes from the pre-Order 745 era, the adverse effects of CBL-based DR associated with Order 745's DR payment may be greater than those shown here. (See Lu and Li (2013) for a statistical method to test it.)

In paying for perceived demand reductions, rather than allowing consumers simply to consume until their marginal benefit equals the price of electricity, FERC has created a system ripe for manipulation. Keeping the system in place required a regime of constant FERC vigilance – as was shown in the cases of several manipulation investigations (see, for example, FERC (2013c) and a recent FERC Order directing PJM to increase the granularity of capacity DR performance monitoring (FERC 2014)), or else the system would devolve into a large "free-money" machine with increasing burdens on customers unable to participate in such programs.

With the Supreme Court's upholding of FERC Order 745, the future of DR payment levels, as well as the measurement of DR, can be further studied. To achieve a more robust CBL may require the DR customers to submit to RTOs more detailed, or even real-time, meter reading data on both event days and non-event days. With all the costs in obtaining detailed data, RTOs in the CBL verification process may face important weaknesses in their market monitoring stemming from the information disadvantages with respect to DR participants regarding participants' operations. Perhaps regulatory agencies concerned with promoting demand management should shift their attention toward marginal cost pricing, as well as demand response in the ancillary and reserve market, which has recently shown itself to be successful. (See PJM (2014).)

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# TAB N

This is Exhibit **"N"** referred to in the Revised Affidavit of Brian Rivard sworn before me this 21st day of November, 2019

*A Commissioner for Taking Affidavits*

Lauren Theresa Daniel, a Commissioner, etc.,
Province of Ontario, while a Student-at-Law.
Expires April 8, 2022.

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ORIGINAL ARTICLE

# On the optimal design of demand response policies

**David P. Brown**[1] · **David E. M. Sappington**[2]

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**Abstract** We characterize the optimal regulatory policy to promote efficient demand response (DR) in the electricity sector. DR arises when consumers reduce their purchases of electricity below historic levels at times when the utility's marginal cost of supplying electricity is relatively high. The US Federal Energy Regulatory Commission (FERC) advocates compensation for DR that reflects the utility's marginal cost. We show that the optimal policy often provides less generous compensation, and demonstrate that implementation of the FERC's policy can reduce welfare well below the level secured by the optimal DR policy.

**Keywords** Electricity pricing · Demand response · Regulation

**JEL Classification** L51 · L94

## 1 Introduction

The cost of supplying electricity can vary substantially from day to day and even from hour to hour. This is the case because generating units with relatively high operating costs often must be called upon to produce electricity during times of peak demand. In contrast to the ever-changing cost of supplying electricity, the retail price of electricity typically varies little, if at all, for long periods of time. Such time-invariant

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pricing reflects historic difficulty in measuring the precise time at which electricity is consumed and ongoing consumer resistance to time-sensitive pricing now that smart meters render such pricing feasible.

To help overcome the inefficiencies that arise when the retail price of electricity diverges substantially from the marginal cost of supplying electricity (Borenstein and Holland 2005; Joskow and Tirole 2007), US regulators have, at the urging of Congress, implemented demand response (DR) policies.[1,2] In essence, DR policies compensate electricity customers for reducing their purchases of electricity below historic norms during periods of peak electricity demand. Of central concern in the design of DR policies is the compensation that is provided to consumers who reduce their electricity consumption.

The Federal Energy Regulatory Commission (FERC)'s Order 745 concludes that compensation for reduced electricity consumption should reflect the utility's marginal cost of supplying electricity.[3] Although such marginal-cost compensation may seem natural, it has garnered intense criticism.[4] Specifically, critics of Order 745 argue that marginal-cost compensation will induce excessive DR. Hogan (2009, 2010) and Chao (2011), for instance, suggest that the unit compensation for DR should be reduced below the utility's marginal cost of supplying electricity ($c$) by the prevailing unit retail price of electricity ($r$).[5] Under this compensation policy, a consumer is effectively first required to purchase electricity from the utility at price $r$ before being permitted to re-sell the electricity to the utility at price $c$ (Borlick et al. 2012).

Although these arguments seem compelling, they typically have not been accompanied by fully-specified formal analyses. We provide such an analysis and employ it to characterize the optimal regulatory policy in several relevant settings. Our formal analysis accounts for the realistic possibility that some consumers who provide DR may offset some or all of their reduced purchase of electricity from the utility with electricity they produce on-site. For example, some industrial customers may produce electricity with combined heat and power (CHP) units powered by natural gas and some residential consumers may produce electricity using rooftop solar panels.

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[1] §1252(f) of the Energy Policy Act of 2005 (Pub. L. No. 109-58, 119 STAT. 966 (2005)) states that "It is the policy of the United States that time-based pricing and other forms of demand response, whereby electricity customers are provided with electricity price signals and the ability to benefit by responding to them, shall be encouraged."

[2] The U.S. Department of Energy (2006) defines DR to encompass "Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized."

[3] Order 745 states that a "demand response resource must be compensated for the service it provides to the energy market at the market price for energy, referred to as the locational marginal price (LMP)" (Federal Energy Regulatory Commission 2011, ¶2).

[4] The FERC's authority to implement this compensation policy also has been challenged. The US Court of Appeals for the District of Columbia (2014) vacated FERC Order 745 in May 2014. However, in January 2016, the Supreme Court overturned the decision of the Appeals Court, thereby reinstating Order 745 (US Supreme Court 2016).

[5] Bushnell et al. (2009), Borlick (2010), and Borlick et al. (2012), among others, offer corresponding conclusions.

Our analysis provides substantial support for the critics of the FERC's policy. Indeed, the optimal compensation for DR in the streamlined basic model that we analyze is precisely the compensation that the critics recommend. More generally, though, the optimal compensation can differ from both the level specified in FERC Order 745 and from the level that critics have advocated.

Chao (2011) suggests that a DR policy will play no useful role when retail prices can adjust rapidly to reflect the prevailing marginal cost of supplying electricity.[6] Our formal analysis of this issue again provides considerable support for this conclusion, but identifies conditions under which an optimally-designed DR policy can enhance welfare even when smart meters and real-time pricing allow retail prices to reflect prevailing marginal costs. The incremental value of a DR policy in this setting arises because the prevailing retail price affects consumption by all consumers whereas the prevailing compensation for DR only affects the actions of consumers who provide DR. The ability to differentially affect the behavior of a subset of consumers can be valuable when consumers employ different technologies for on-site electricity production and such production entails social losses from environmental externalities.

In addition to characterizing the optimal DR policy, we investigate the welfare gains that an optimally designed policy can secure. We also examine the welfare losses that can arise when the FERC's marginal-cost compensation policy is implemented in place of the optimal policy. We find that the welfare gains from an optimal policy can be substantial under arguably plausible conditions, as can the losses from the FERC's policy.

We develop and explain these findings as follows. Section 2 reviews the key elements of our model. Section 3 characterizes the optimal regulatory policy in the streamlined basic setting where: (1) the retail price of electricity does not vary with the realized state of demand for electricity, (2) consumers cannot influence the baseline level of electricity consumption that determines whether they are providing DR, (3) society values symmetrically the welfare of all consumers, including those who can readily replace DR with on-site generation of electricity and those who lack this capability, and (4) electricity production entails no social losses from externalities. Section 4 identifies the changes to the optimal policy that arise when each of these restrictions is relaxed. Section 5 illustrates the welfare gains that an optimally designed DR policy can secure and the welfare losses that arise when the FERC's marginal-cost compensation policy is implemented in place of the optimal policy. Section 6 concludes and discusses directions for further research. The Appendix outlines the proofs of all formal conclusions. An online Technical Appendix (Brown and Sappington 2016) provides additional details.

## 2 Model elements

A regulated utility produces and delivers electricity to consumers. The utility's cost of producing and delivering $X$ units of electricity is $C(X)$, which is an increasing,

[6] Chen et al. (2010) and Li et al. (2011) document the optimality of setting the price of electricity equal to its instantaneous marginal cost of production and propose an iterative algorithm to achieve the optimal outcome in the presence of limited information.

convex function.[7] This cost structure reflects the utility's need to employ progressively less efficient generating units as the demand for electricity increases above the utility's baseload capacity.[8]

Consumer $i \in \{1, \ldots, N\}$ derives value $V_i(x_i, \theta)$ from consuming $x_i$ units of electricity in state $\theta$. $V_i(\cdot)$ is a strictly increasing, strictly concave function of $x_i$ in each state. Furthermore, each consumer's total and marginal valuation of electricity increases with the state (so $\frac{\partial V_i(\cdot)}{\partial \theta} > 0$ and $\frac{\partial^2 V_i(\cdot)}{\partial \theta \partial x_i} > 0$ for all $x_i > 0$). The state might reflect the extent of temperature and sunshine extremes, for example. Particularly high (low) temperatures and associated intense (limited) sunshine typically increase the marginal value of electricity that is employed to power air conditioning (heating) units. The state $\theta$ is the realization of a random variable that has strictly positive support on the interval $[\underline{\theta}, \overline{\theta}]$, with density function $g(\theta)$ and distribution function $G(\theta)$.

Every consumer can purchase electricity from the regulated supplier. Some consumers also can produce their own electricity using either a dispatchable on-site generation technology (e.g., CHP units powered by natural gas) or a non-dispatchable technology (e.g., solar panels).[9] We take as given each consumer's investment in one of these technologies and analyze the consumer's on-site production (and consumption) of electricity.[10] Consumer $i$'s cost of producing $x_i^o$ units of electricity in state $\theta$ is $C_i(x_i^o, \theta)$. This function is strictly increasing and strictly convex in $x_i^o$ in each state under the dispatchable technology. In contrast, $C_i(x_i^o, \theta) = 0$ for all $x_i^o \leq \overline{x}_i(\theta)$ and $C_i(x_i^o, \theta) = \infty$ for all $x_i^o > \overline{x}_i(\theta)$ under the non-dispatchable technology. Thus, $\overline{x}_i(\theta)$ is the maximum amount of electricity that consumer $i$ can produce at no additional cost (beyond the cost of his initial capacity investment) in state $\theta$. This maximum output might represent the amount of electricity produced by the consumer's solar panels, for example, which varies with the intensity of the prevailing sunshine.[11]

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[7] Formally, $C'(X) > 0$ and $C''(X) \geq 0$ for all $X > 0$.

[8] In practice, a utility's production costs may increase discontinuously at output levels where less efficient auxiliary generating units are brought on line. We assume $C(\cdot)$ is continuously differentiable for analytic tractability. This assumption does not alter our primary qualitative conclusions. Our model also can be viewed as one in which the utility is a distribution company that purchases electricity from competitive suppliers at increasing marginal cost.

[9] A consumer's choice of on-site production technology might be affected by such factors as his status as a commercial or residential customer, his projected consumption of electricity, the characteristics of his commercial/residential property (including the available space or the rooftop slope and exposure to the sun), and local zoning ordinances, for example. These considerations and others may lead some consumers to refrain from any investment in on-site production capabilities. For expositional ease, we abstract from the possibility that a consumer might invest in multiple distinct production technologies.

[10] Each consumer is assumed to consume all of the electricity he generates on-site, thereby abstracting from the possibility that a consumer might supply electricity to other consumers or sell electricity to the regulated utility.

[11] DNV GL (2014) reports that solar capacity represents the major component of distributed generation (DG) capacity in eight of the ten US states with the most DG capacity. CHP units powered by natural gas account for the majority of DG capacity in Connecticut and New York.

Each consumer pays a fixed charge ($R$) for the right to purchase electricity from the utility. $x_i^u$ is the amount of electricity that consumer $i$ purchases from the utility. The amounts of electricity a consumer purchases and produces are assumed to be unaffected by $R$. In contrast, consumer $i$'s choices of $x_i^u$ and $x_i^o$ are affected by the unit price ($r$) of electricity purchased from the utility and by the prevailing compensation for DR. Consequently, the regulator can set $R$ to ensure the utility's financial solvency while setting $r$ to determine the amount of electricity that consumers purchase from the utility.[12]

Consumer $i$'s DR, $x_i^d$, is the extent to which the consumer reduces the amount of electricity he purchases from the utility below a baseline level, $\underline{x}_i$. Formally, $x_i^d \equiv \max\{0, \underline{x}_i - x_i^u\}$.[13] In practice, $\underline{x}_i$ often reflects the average amount of electricity consumer $i$ has purchased from the utility historically (KEMA 2011). To focus on the pricing issues of central interest, we assume initially that consumer $i$ perceives $\underline{x}_i$ to be an exogenous parameter, e.g., a baseline level established by the regulator over which the consumer has no control.[14]

$m(\theta)$ denotes the payment a consumer receives from the utility for each unit of DR he provides in state $\theta$. Because this compensation for DR can vary with the state, it can be set at a relatively high level when $\theta$ is high, for example, to encourage consumers to reduce the amount of electricity they purchase from the utility when the utility's marginal cost of producing electricity is relatively high. Thus, $m(\cdot)$ can assume a role that peak load retail prices might play if they were feasible.[15]

The regulator chooses her policy instruments $\{r, R, m(\theta)\}$ to maximize expected social welfare while ensuring non-negative expected profit for the utility. Social welfare in our basic model is simply aggregate consumer welfare,[16] which is the difference between: (i) the sum of the value that all consumers derive from their electricity consumption and the compensation they receive for the DR they provide, and (ii) the sum of consumers' payments to the utility and the costs consumers incur in producing electricity themselves. Formally, when consumer $i$ produces $x_i^o(\cdot, \theta)$ units of elec-

[12] Section 4.1 considers the setting where the regulator is not permitted to set a fixed charge ($R$), perhaps because of concerns about the financial burden that a substantial fixed charge can impose on individuals with limited wealth who consume little electricity. Section 4.5 considers the setting where the unit retail price of electricity ($r$) can vary with the realized state.

[13] In principle, a consumer might be penalized for purchasing more than the established baseline level of electricity, in which case $x_i^d$ might be negative. We follow industry practice in abstracting from this possibility.

[14] We thereby abstract initially from the possibility that, as in Chao (2009, 2011) and Chao and DePillis (2012), a consumer's choice of $x_i^u$ in one period might affect the value of $\underline{x}_i$ that is established in future periods. Section 4.3 considers the possibility that consumers might be able to influence their baseline consumption levels.

[15] The analysis in Sect. 4.5 admits state-specific retail prices, $r(\theta)$, that can function like peak load prices. In practice, peak load prices often are designed to generate sufficient revenue to cover the utility's capacity costs (e.g., Crew et al. 1995). The fixed retail charge ($R$) can play this role in our model. Section 4.1 considers the optimal design of $r$ and $m(\theta)$ when fixed retail charges are not feasible.

[16] The utility's profit is zero under the optimal regulatory policy in all of the settings we analyze. Section 4.4 considers a setting where social welfare includes the losses from environmental externalities associated with electricity production.

tricity and purchases $x_i^u(\cdot,\ \theta)$ units of electricity from the utility in state $\theta$, aggregate expected consumer welfare is[17]:

$$E\{U(\cdot)\} = \sum_{i=1}^{N} \int_{\underline{\theta}}^{\overline{\theta}} \Big[ V_i \left( x_i^u(\cdot,\ \theta) + x_i^o(\cdot,\ \theta),\ \theta \right) - r x_i^u(\cdot,\ \theta) \\ + m(\theta) x_i^d(\cdot,\ \theta) - C_i \left( x_i^o(\cdot,\ \theta),\ \theta \right) \Big] dG(\theta) - NR. \tag{1}$$

The utility's expected profit is the difference between its expected revenues and its expected costs (which include payments to consumers for the DR they provide). Formally:

$$E\{\pi\} = NR + \sum_{i=1}^{N} \int_{\underline{\theta}}^{\overline{\theta}} \left[ r x_i^u(\cdot) - m(\theta) x_i^d(\cdot) \right] dG(\theta) - \int_{\underline{\theta}}^{\overline{\theta}} C\left( X^u(\cdot,\ \theta) \right) dG(\theta), \tag{2}$$

where $X^u(\cdot,\ \theta) \equiv \sum_{i=1}^{N} x_i^u(\cdot,\ \theta)$. The regulator's formal problem, denoted [RP], is to choose $r,\ R$, and $m(\theta)$ to:

$$\text{Maximize } E\{U(\cdot)\} \text{ subject to } E\{\pi\} \geq 0, \tag{3}$$

where given $r,\ R$, and $m(\theta)$, consumer $i$ chooses $x_i^u(\cdot,\ \theta)$ and $x_i^o(\cdot,\ \theta)$ to:

$$\text{Maximize } \ V_i \left( x_i^u(\cdot,\ \theta) + x_i^o(\cdot,\ \theta),\ \theta \right) - R - r x_i^u(\cdot,\ \theta) + m(\theta) x_i^d(\cdot,\ \theta) \\ - C_i \left( x_i^o(\cdot,\ \theta),\ \theta \right). \tag{4}$$

$\Omega_i^D$ ($\Omega_i^{-D}$) denotes the set of $\theta \in [\underline{\theta},\ \overline{\theta}]$ realizations for which consumer $i$ provides (does not provide) DR at the solution to [RP].[18] To focus on the settings of primary interest, much of the ensuing analysis considers settings where the optimal regulatory policy induces some DR.[19]

The timing in the model is the following. First, the baseline level of electricity consumption ($\underline{x}_i$) for each consumer is specified exogenously. Second, the regulator sets $r,\ R$, and $m(\theta)$. Third, the state ($\theta$) is realized. Fourth, each consumer determines how much electricity to produce on-site and how much to purchase from the utility. Fifth, the utility supplies all of the electricity that consumers demand, receives the associated revenue, and delivers the required payments to consumers for the DR they provide.

[17] The "$\cdot$" here denotes factors other than $\theta$ that affect consumers' electricity production and consumption. These factors can include $r$ and $m(\theta)$.

[18] Formally, $\Omega_i^D$ ($\Omega_i^{-D}$) is the set of $\theta \in [\underline{\theta},\ \overline{\theta}]$ for which $\frac{\partial V_i(x_i^u + x_i^o,\ \theta)}{\partial x_i^u}|_{x_i^u = \underline{x}_i} < (\geq) r + m(\theta)$ at the solution to [RP].

[19] Formally, unless otherwise noted, we assume $\Omega_i^D \neq \{\varnothing\}$ for some $i \in \{1, \ldots, N\}$. For expositional simplicity, we also assume that $x_i^u(\cdot,\ \theta) > 0$ for all $\theta \in [\underline{\theta},\ \overline{\theta}]$, for $i = 1, \ldots, N$.

## 3 The optimal demand response policy in the basic setting

Before characterizing the optimal regulatory policy in the basic setting described in Sect. 2, we examine how the unit compensation for DR, $m(\theta)$, affects a consumer's actions. Lemma 1 reports that when a consumer is initially purchasing some electricity from the utility, producing some electricity himself using a dispatchable technology, and providing some DR, the consumer will reduce his purchase from the utility and increase his own production of electricity as $m(\theta)$ increases. Furthermore, due to the increasing marginal cost of on-site generation, the consumer will increase his production of electricity by less than he curtails his purchases from the utility. Consequently, an increase in $m(\theta)$ induces a reduction in the sum of the consumer's purchase and production of electricity. In contrast, the consumer will always produce the maximum amount of electricity that his on-site non-dispatchable technology permits, so his electricity production and consumption in each state are not affected by the prevailing compensation for DR.

**Lemma 1** *Suppose* $x_i^u(\cdot,\theta) > 0$, $x_i^o(\cdot,\theta) > 0$, *and* $x_i^d(\cdot,\theta) > 0$. *Then* $\frac{dx_i^u(\cdot,\theta)}{dm(\theta)} \le 0$, $\frac{dx_i^o(\cdot,\theta)}{dm(\theta)} \ge 0$, *and* $\frac{d(x_i^u(\cdot,\theta)+x_i^o(\cdot,\theta))}{dm(\theta)} \le 0$. *These weak inequalities hold as strict inequalities (equalities) when consumer i employs the dispatchable (non-dispatchable) on-site production technology.*

Proposition 1 now characterizes the optimal regulatory policy in the basic setting.

**Proposition 1** *At the solution to* [*RP*]:

$$m(\theta) = C'\left(X^u(\cdot,\theta)\right) - r; \tag{5}$$

$$\sum_{i=1}^{N} \int_{\Omega_i^{-D}} \left[r - C'\left(X^u(\cdot,\theta)\right)\right] \frac{\partial x_i^u(\cdot,\theta)}{\partial r} dG(\theta) = 0; \text{ and} \tag{6}$$

$$R = \frac{1}{N}\left[\int_{\underline{\theta}}^{\overline{\theta}} C\left(X^u(\cdot,\theta)\right) dG(\theta) + \sum_{i=1}^{N} \int_{\underline{\theta}}^{\overline{\theta}} \left\{m(\theta)x_i^d(\cdot,\theta) - r x_i^u(\cdot,\theta)\right\} dG(\theta)\right]. \tag{7}$$

Equation (7) states that, due to the regulator's concern with maximizing consumer welfare, the utility is afforded only the minimum expected profit required to ensure the utility's operation (i.e., $E\{\pi(\theta)\} = 0$). Equation (6) indicates that the optimal unit retail price of electricity ($r$) equates to zero a weighted average of deviations between $r$ and the utility's marginal cost of production. In standard Ramsey fashion, the weights reflect the sensitivity of consumer demand to variations in $r$.[20]

Equation (5) states that the optimal unit compensation for DR in state $\theta$ is the difference between the utility's marginal cost of production in this state and the retail

[20] Ramsey (1927) and Baumol and Bradford (1970) characterize Ramsey prices. Joskow and Tirole (2007) identify conditions under which optimal retail prices for electricity reflect Ramsey principles.

price of electricity. This conclusion reflects the fact that in order to induce the welfare-maximizing level of DR from each consumer in every state, the effective unit price that each consumer faces for purchasing electricity from the utility should reflect the utility's marginal cost of supplying electricity in each state. The effective price a consumer faces is the sum of the nominal retail price of electricity ($r$) and the unit compensation for DR ($m$) the consumer foregoes when he decides to purchase the marginal unit of electricity from the utility rather than increase his DR. Therefore, the optimal policy equates $r + m(\theta)$ and $C'(\cdot)$ by setting $m(\theta) = C'(X^u(\cdot, \theta)) - r$.[21]

Proposition 1 supports the critics of the FERC's marginal-cost compensation policy. As the critics note, the FERC's policy effectively awards to consumers the full social value of a commodity (i.e., reduced electricity consumption) without first requiring them to pay anything for the commodity (since they are not required to purchase electricity at the prevailing retail price before effectively selling it to the utility). Therefore, the FERC's policy induces more than the welfare-maximizing level of DR, ceteris paribus.

Before proceeding to consider alternative settings, we note that even the optimal regulatory policy does not ensure efficient (i.e., welfare-maximizing) consumption and DR by all consumers in every state. Such (conditional) efficacy (given the induced purchases of electricity from the utility by other consumers) requires $\frac{\partial V_i(x_i^u + x_i^o, \theta)}{\partial x_i^u} = C'(X^u(\cdot, \theta))$ for all $\theta \in [\underline{\theta}, \overline{\theta}]$, for $i = 1, \ldots, N$. Corollary 1 reports that efficiency is not ensured even in the simple setting where the utility is the sole producer of electricity.

**Corollary 1** *The consumption and DR actions of each consumer who provides DR are efficient at the solution to* [*RP*]. *The corresponding actions of consumers who do not provide DR generally are not efficient.*

Corollary 1 reflects the fact that the regulator chooses $m(\theta)$ to ensure that each consumer who provides DR delivers the efficient level of DR in each state. However, because the unit retail price does not vary with the state, the regulator typically cannot induce consumers who do not provide DR to purchase the efficient level of electricity from the utility in each state.

## 4 Extensions

We now examine how the optimal regulatory policy changes when fixed retail charges for electricity are not feasible, when distributional concerns arise, when consumers can influence their baseline consumption levels, when electricity production generates social losses from environmental externalities, and when retail prices can vary with the realized state.

[21] The deviation of $m(\theta)$ from marginal cost here does not reflect the deviation of price from marginal cost that commonly arises under peak load pricing to ensure revenue that matches operating costs (e.g., Crew et al. 1995). The regulator can choose the fixed charge ($R$) to ensure the utility's financial solvency in the basic setting analyzed here.

### 4.1 Fixed retail charges are not feasible

We begin by characterizing the optimal compensation for DR when fixed retail charges are not feasible (so $R$ is constrained to be 0 in [RP]). In practice, fixed retail charges for electricity are quite small in many jurisdictions,[22] perhaps because fixed charges might disproportionately burden consumers with limited wealth. Let [RP-N$R$] denote the regulator's problem in this setting and let $\lambda_r$ denote the Lagrange multiplier associated with the utility's profitability constraint ($E\{\pi\} \geq 0$) in this problem.

**Proposition 2** *At the solution to* [*RP-NR*], *given the optimal unit retail price* $r$:

$$m(\theta) = C'\left(X^u\right) - r - \left[\frac{\lambda_r - 1}{\lambda_r}\right] \frac{\sum_{i=1}^{N} x_i^d(\cdot)}{\left|\sum_{i=1}^{N} \frac{\partial x_i^u(\cdot)}{\partial m(\theta)}\right|}. \tag{8}$$

It is readily shown that $\lambda_r > 1$ when the utility's average cost (including payments for DR) exceeds its marginal cost at the solution to [RP-N$R$]. Propositions 1 and 2 imply that in this case, an inability to impose fixed retail charges reduces the optimal compensation for DR, ceteris paribus. The reduced compensation reduces the amount by which $r$ must be increased above marginal cost to ensure the utility's financial solvency.

### 4.2 Distributional concerns

Now return to the setting where the regulator can set $r$, $R$, and $m(\theta)$, and consider the possibility that the regulator might value differently the welfare of consumers who can provide DR and those who cannot. For example, implementation costs may limit participation in a DR program to large commercial and industrial consumers, and the regulator may be particularly concerned with the welfare of small residential consumers.[23] Let $\widetilde{\alpha}$ denote the weight the regulator assigns to the welfare of the $\widetilde{N}$ consumers who can provide DR, and let $\widetilde{x}^d(\cdot)$ and $\widetilde{x}^o(\cdot)$, respectively, denote DR and electricity production by these consumers. In addition, let $\widehat{\alpha}$ denote the weight the regulator assigns to the welfare of the $\widehat{N}$ consumers who cannot provide DR (where $\widetilde{N} + \widehat{N} = N$). [RP-d] will denote the regulator's problem in this setting with distributional concerns.[24] Proposition 3 characterizes the optimal unit compensation for DR in this setting.

[22] To illustrate, two of the three major electric utilities in California (Pacific Electric and Gas and San Diego Gas and Electric) impose no fixed retail charge. The third utility (Southern California Edison) imposes a monthly fixed charge of only \$0.99 (Borenstein 2014).

[23] Borlick (2011) notes that the marginal-cost compensation for DR advised by the FERC requires consumers who do not provide DR to subsidize those who do.

[24] The regulator seeks to maximize the relevant weighted average of the expected welfare of the two types of consumers while ensuring non-negative profit for the regulated utility. The proof of Proposition 3 includes a formal statement of [RP-d].

**Proposition 3** *At the solution to* [*RP-d*], *given the optimal unit retail price* $r$:

$$m(\theta) = C'\left(X^u(\cdot,\,\theta)\right) - r - \frac{\widehat{N}[\widehat{\alpha} - \widetilde{\alpha}]\sum_{i=1}^{N} x_i^d(\cdot,\,\theta)}{[\widetilde{\alpha}\widetilde{N} + \widehat{\alpha}\widehat{N}]\sum_{i=1}^{N}\left|\frac{\partial x_i^u(\cdot,\theta)}{\partial m(\theta)}\right|}. \tag{9}$$

Proposition 3 provides the intuitive conclusion that, ceteris paribus, the regulator will reduce the compensation for DR when she values relatively highly the welfare of consumers who cannot provide DR (i.e., when $\widehat{\alpha} > \widetilde{\alpha}$). Although the reduced compensation induces less than the (unweighted) surplus-maximizing level of DR, it permits reductions in the charges ($r$ and $R$) imposed on consumers who do not provide DR. Equation (9) indicates that, ceteris paribus, the reduction in $m(\theta)$ tends to be more pronounced as: (i) $\widehat{\alpha}$ increases, so the regulator values more highly the welfare of consumers who cannot provide DR, (ii) $\widehat{N}$ increases, so there are more consumers who cannot provide DR, (iii) $\sum_{i=1}^{N} x_i^d(\cdot)$ increases, so the magnitude of the equilibrium DR increases, and (iv) $\sum_{i=1}^{N}\left|\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}\right|$ declines, so a reduction in $m(\theta)$ causes a smaller increase in the demand for electricity from the utility (and an associated smaller increase in the utility's marginal cost of production).

### 4.3 Endogenous baseline consumption levels

Now consider the possibility that consumer $i$ might undertake action $a_i$ at personal cost $D_i(a_i)$ to increase his baseline consumption level, $\underline{x}_i$. For example, as Chao (2011) and Chao and DePillis (2012) posit, a consumer might purchase more than the level of electricity that maximizes his contemporary welfare in early periods, recognizing that doing so will increase his baseline consumption level in later periods. We assume $\underline{x}_i$ is an increasing, concave function of $a_i$ and $D_i(\cdot)$ is a strictly increasing, strictly convex function for all $i = 1, \ldots, N$.[25]

The regulator first specifies $\{R,\ r,\ m(\theta)\}$ and the rule that will be employed to establish baseline consumption levels. Consumers then choose their actions to influence their baseline consumption levels. Finally, consumers determine how much electricity they will purchase from the utility and how much electricity they will produce themselves. The regulator seeks to maximize aggregate expected consumer welfare while ensuring non-negative expected profit for the utility.[26]

Let [RP-a] denote the regulator's formal problem in this setting.[27] Also let $\delta_{i\theta} = 1$ if $\theta \in \Omega_i^{Da}$ and $\delta_{i\theta} = 0$ otherwise, where $\Omega_i^{Da}$ is the set of $\theta \in [\underline{\theta},\ \overline{\theta}]$ for which consumer $i$ provides DR at the solution to [RP-a]. For expositional ease, Proposition 4 characterizes the optimal compensation for DR in this setting for the case where $\Omega_i^{Da} \neq \{\varnothing\}$ for each $i = 1, \ldots, N$.

25 We further assume that, for all $i = 1, \ldots, N$, consumer $i$'s expected welfare is a strictly concave function of $a_i$ and consumer $i$ chooses $a_i > 0$.

26 Consumer $i$'s welfare now includes both the personal cost of action $a_i$ and the impact of this action on $\underline{x}_i$.

27 The proof of Proposition 4 includes a formal statement of [RP-a].

**Proposition 4** *At the solution to* [*RP-a*], *given the optimal unit retail price* $r$:

$$m(\theta) = \frac{C'(X^u) - r}{\left[\sum_{i=1}^{N}\left\{\left|\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}\right| + \delta_{i\theta}\frac{\partial \underline{x}_i}{\partial a_i}\frac{\partial a_i}{\partial m(\theta)}\right\}\right] / \sum_{i=1}^{N}\left|\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}\right|}. \tag{10}$$

It is readily shown that an increase in $m(\theta)$ induces consumers who provide DR to devote more effort to increasing their baseline consumption levels (so $\frac{\partial a_i}{\partial m(\theta)} > 0$ for all $i = 1, \ldots, N$) at the solution to [RP-a].[28] Therefore, the denominator of the fraction in Eq. (10) exceeds 1. Consequently, Propositions 1 and 4 indicate that, ceteris paribus, the optimal compensation for DR is scaled down systematically when consumers can influence their baseline consumption levels. The reduction in $m(\theta)$ limits incentives to artificially inflate baseline consumption, but leads to distortions where they otherwise would not arise, as Corollary 2 reports.

**Corollary 2** *Even the consumption and DR actions of consumers who provide DR generally are not efficient at the solution to* [*RP-a*].

### 4.4 Externalities

We now allow for the possibility that electricity production can entail social losses from environmental externalities and the regulator might seek to limit these losses through her policy instruments $\{r(\theta),\ R,\ m(\theta)\}$. Let $e_i$ denote the social loss associated with each unit of electricity that consumer $i$ produces on-site.[29] The unit loss can vary across consumers because different consumers may employ different technologies to generate electricity. For instance, $e_i$ may be zero when consumer $i$ is a residential customer who employs rooftop solar panels to generate electricity. In contrast, $e_i$ may be strictly positive when consumer $i$ is a commercial enterprise that employs a CHP unit powered by natural gas to generate electricity. $e(X)$ will denote the total social loss from externalities that arises when the utility produces $X$ units of electricity.[30]

The regulator seeks to maximize expected social welfare, which is the difference between expected aggregate consumer welfare and the expected social loss from externalities. This expected loss is:

$$E\{L(\cdot)\} = \int_{\underline{\theta}}^{\overline{\theta}} \left[\sum_{i=1}^{N} e_i x_i^o(\cdot,\ \theta) + e\left(X^u(\cdot,\ \theta)\right)\right] dG(\theta). \tag{11}$$

[28] See the proof of Proposition 4.

[29] This linear structure for the losses from externalities due to electricity production by consumers is adopted for analytic and expositional simplicity. The key qualitative conclusions drawn below persist under nonlinear structures.

[30] $e(X)$ is an increasing function. For simplicity, we abstract from the possibility that the social loss from externalities due to production by the utility might vary with the amount of electricity that consumers produce.

**Proposition 5** *Equation* (7) *holds at the solution to* [*RP-e*]. *In addition*:

$$m(\theta) = C'\left(X^u\right) - r + e'\left(X^u\right) - \frac{\sum_{i=1}^{N} e_i \frac{\partial x_i^o(\cdot)}{\partial m(\theta)}}{\sum_{i=1}^{N} \left|\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}\right|}; \text{ and} \tag{12}$$

$$\sum_{i=1}^{N} \int_{\Omega_i^{-D}} \left\{ \left[r - \left(C'\left(X^u\right) + e'\left(X^u\right)\right)\right] \frac{\partial x_i^u(\cdot)}{\partial r} - e_i \frac{\partial x_i^o(\cdot)}{\partial r} \right\} dG(\theta) = 0. \tag{13}$$

Equation (13) indicates that the retail price of electricity is optimally set to ensure that an expected weighted average of deviations of price from the utility's marginal cost of production (including relevant externality costs) is zero, after adjusting for losses from externalities associated with on-site production of electricity by consumers. The weights on the deviations again are the relevant price-sensitivities of consumer demand for electricity.

Equation (12) reports that when externalities are present, the optimal unit compensation for DR is increased above $C'(X^u) - r$ by the extent to which reduced production by the utility reduces social losses from externalities. In the case where consumers do not produce electricity on-site or where such production does not generate externalities, $m(\theta)$ is optimally increased by $e'(X^u)$, the rate at which social losses from externalities decline as the utility's production of electricity declines.[31] More generally, this increase in $m(\theta)$ is reduced by the extent to which reduced production by the utility increases social losses from externalities due to increased electricity production by consumers on-site. This adjustment becomes more pronounced as $e_i$ increases and as consumers become more likely to replace the electricity they do not purchase from the utility with electricity they produce themselves (i.e., as $\frac{\partial x_i^o(\cdot)}{\partial m(\theta)}$ increases relative to $\left|\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}\right|$).[32]

Self-interested consumers do not consider the social losses from on-site production when deciding how much electricity to produce. Consequently, because the regulator is not endowed with the ability to levy consumer-specific taxes on electricity (and externality) production, the regulator cannot induce consumers to undertake efficient

31 As noted above, the utility can be viewed as a distribution company that purchases electricity from competitive suppliers. If government policies (e.g., emissions taxes) compel electricity suppliers to internalize the social losses from environmental externalities, then the utility's marginal cost of procuring electricity will reflect both the physical marginal cost of generating electricity and the associated marginal social losses from externalities. (Fabra and Reguant 2014 find that a large fraction of emissions costs are passed on to consumers in the form of higher retail prices for electricity.) The optimal unit compensation for DR in this setting would reflect the difference between the utility's marginal cost of procuring electricity and the prevailing unit retail price of electricity.

32 Recall from Lemma 1 that $\frac{\partial x_i^o(\cdot)}{\partial m(\theta)} < \left|\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}\right|$ for all $i = 1, \ldots, N$. Therefore, $e'(X^u) - \frac{\sum_{i=1}^{N} e_i \frac{\partial x_i^o(\cdot)}{\partial m(\theta)}}{\left|\sum_{i=1}^{N} \frac{\partial x_i^u(\cdot)}{\partial m(\theta)}\right|} > 0$ when $e'(X^u) = e_i = \underline{e}$, a constant, for all $i = 1, \ldots, N$. Consequently, Eq. (5) implies that $m(\cdot)$ is optimally increased above $C'(\cdot) - r$ when the marginal social loss from externalities is constant and identical for all sources of electricity production. The increase in $m(\theta)$ serves to reduce social losses from externalities because the increase in the amount of electricity consumers produce on-site as their DR increases is less than the amount of their DR.

on-site production of electricity. The efficient level of on-site production by consumer $i$ in state $\theta$ (given his induced purchase of electricity from the utility) is given by $\frac{\partial V_i(x_i^u + x_i^o, \theta)}{\partial x_i^o} = C_i'(x_i^o) + e_i$.[33]

**Corollary 3** *Suppose $x_i^o > 0$ for some consumer $i \in \{1, \ldots, N\}$ at the solution to [RP-e] identified in Proposition 5. Then the level of on-site production by consumer i at the identified solution is efficient if and only if $e_i = 0$.*

### 4.5 State-specific pricing

In settings where smart meters are deployed ubiquitously, a regulator may be able to set a state-specific unit retail price, $r(\theta)$, in addition to $R$ and $m(\theta)$. Let [RP-s] denote the regulator's formal problem in such a setting where she seeks to maximize aggregate expected welfare (which accounts for losses from externalities) while ensuring non-negative expected profit for the utility.[34] Proposition 6 identifies conditions under which a DR policy admits no strict welfare gains in this setting.

**Proposition 6** *At the solution to [RP-s], $r(\theta) = C'(X^u(\cdot, \theta)) + e'(X^u(\cdot, \theta))$ and $m(\theta) = 0$ for all $\theta \in [\underline{\theta}, \overline{\theta}]$ if: (i) no consumer produces electricity (so $x_i^o = 0$ for all $i = 1, \ldots, N$); (ii) consumer production of electricity entails no externalities (so $e_i = 0$ for $i = 1, \ldots, N$); or (iii) all consumers provide DR in all states (so $x_i^d(\cdot) > 0$ for all $i = 1, \ldots, N$ and for all $\theta \in [\underline{\theta}, \overline{\theta}]$).*

Proposition 6 indicates that when the regulator sets the optimal state-specific retail prices for electricity, a DR policy will not enhance welfare if consumers do not produce electricity on-site or if such production entails no externalities. Under these conditions, the regulator can maximize surplus by setting the retail price of electricity equal to its social marginal cost of production in each state.[35] Consequently, non-zero compensation for DR would only reduce expected welfare by causing the effective price a consumer pays for electricity purchased from the utility to diverge from the utility's social marginal cost of production.[36]

The same is true when all consumers provide DR in every state. In this case, an increase in $r(\theta)$ has the same impact as an increase in $m(\theta)$ on each consumer's electricity purchase and production decisions. Consequently, a DR policy offers no strict welfare gains when the regulator sets the optimal state-specific retail prices for electricity.

In contrast, identical changes in $r(\theta)$ and $m(\theta)$ do not affect symmetrically the actions of all consumers who produce electricity on-site when only some of them

33 For simplicity, we assume here that $\frac{\partial V_i(x_i^u, \theta)}{\partial x_i^o} > C_i'(0) + e_i$ for all $x_i^u \geq 0$, for $i = 1, \ldots, N$.

34 The proof of Proposition 6 provides a formal statement of [RP-s].

35 This conclusion reflects the maintained assumption that the regulator can set a fixed charge ($R$) that does not affect electricity consumption.

36 Chao (2011, p. 79) observes that "In the special case where the [retail price of electricity] equals the wholesale price, the optimal demand response payment would be zero. Therefore, for consumers on dynamic retail pricing, there is no longer any reason to pay then for demand reduction."

provide DR. Therefore, as Corollary 4 indicates, the regulator optimally increases $m(\theta)$ above 0 in states where, relative to corresponding effects on the demand for electricity from the utility, an increase in $r(\theta)$ increases losses from externalities due to increased electricity production by consumers more rapidly than does an increase in $m(\theta)$. The increase in $m(\theta)$ permits a less pronounced increase in electricity (and externality) production by consumers than would an increase in $r(\theta)$.

**Corollary 4** *Suppose $x_i^o(\cdot) > 0$ for some consumers and $x_i^d(\cdot) > 0$ for some, but not all, consumers at the solution to [RP]. Then:*

$$m(\theta) \gtreqless 0 \text{ as } \frac{\sum_{i=1}^{N} e_i \frac{\partial x_i^o(\cdot)}{\partial r(\theta)}}{\sum_{i=1}^{N} \left| \frac{\partial x_i^u(\cdot)}{\partial r(\theta)} \right|} \gtreqless \frac{\sum_{i=1}^{N} e_i \frac{\partial x_i^o(\cdot)}{\partial m(\theta)}}{\sum_{i=1}^{N} \left| \frac{\partial x_i^u(\cdot)}{\partial m(\theta)} \right|} \text{ at the solution to [RP].} \tag{14}$$

As is the case in other settings, the regulator's inability to impose consumer-specific taxes on on-site electricity (and externality) production in the present setting often precludes her from inducing efficient on-site electricity production, as Corollary 5 reports.

**Corollary 5** *Suppose $x_i^o > 0$ for some consumer $i \in \{1, \ldots, N\}$ at the solution to [RP-s] identified in Proposition 6. Then the level of on-site production by consumer i at the identified solution is efficient if and only if $e_i = 0$.*

Corollary 5 implies that when consumers produce electricity and generate social losses from externalities in doing so, the optimal regulatory policy generally does not induce efficient levels of on-site production even when the regulator can set state-specific retail prices.[37]

## 5 Welfare gains and losses

We now illustrate the welfare gains that can arise when an optimally designed DR policy is implemented. We also illustrate the welfare losses that can arise when compensation for DR is instead set equal to the utility's marginal cost of producing electricity. To do so, we consider the following *benchmark setting* in which the utility is the only producer of electricity and production entails no losses from externalities. The utility's cost of producing $X$ units of electricity is $C(X) = F + aX + bX^2$, where $a$, $b$, and $F$ are nonnegative constants.

There are $N_H$ identical "$H$ consumers" and $N_L$ identical "$L$ consumers." The former (e.g., commercial and industrial consumers) value electricity more highly than do the latter (e.g., residential consumers). Each $i$ ($\in \{L, H\}$) consumer derives value $V_i(x_i, \theta) = v_i \left[ \frac{\theta (x_i)^{1+\alpha_i} - \overline{V}_i}{1+\alpha_i} \right]$ from $x_i$ units of electricity in state $\theta$, where $\overline{V}_i \geq 0$ is a constant. $v_L$ is normalized to 1 and $v_H$ is set equal to 1.88, reflecting the estimated relative values of lost load for residential and non-residential electricity consumers

[37] As is evident from the proof of Proposition 6, the optimal policy also typically does not induce efficient levels of consumption and DR in the presence of nontrivial externalities from on-site production.

(London Economics Internatiional LLC 2013). We set $\frac{1}{\alpha_L} = -0.15$ and $\frac{1}{\alpha_H} = -0.20$, reflecting common estimates of the short-run price elasticity demand for electricity for residential and non-residential customers, respectively.[38]

The demand parameter $\theta$ reflects the extent to which the daily high temperature ($\overline{T}$) exceeds an upper threshold (78°F) and the daily low temperature ($\underline{T}$) falls below a lower threshold (65°F) in our sample. Thus, higher values of $\theta$ typically will be associated with increased demand for electricity for cooling and heating.[39] Formally, $\theta = 1 + \max\{0, \overline{T} - 78\} + \max\{0, 65 - \underline{T}\}$. Our sample consists of the daily temperature realizations in 2013 in all states in the PJM Interconnection region (NOAA 2014).[40] (Brown and Sappington 2016 present the results of corresponding analyses that reflect conditions in the California and ISO New England regions.)[41] $\theta \in [0, 70]$ in this sample, and maximum likelihood estimation reveals that the distribution of $\theta$ is well-approximated by a gamma distribution with scale parameter 3.064 and shape parameter 8.021.[42]

$\underline{x}_i$ is the amount of electricity an $i \in \{L, H\}$ consumer would purchase in this benchmark setting under the optimal regulatory policy in the absence of any DR program.[43] $N_L + N_H$ is set to ensure that expected demand is equal to the average hourly load in the PJM Interconnection region in 2013.[44] $\frac{N_L}{N_L+N_H}$ is set equal to 0.879, the fraction of US electricity customers classified as residential customers in the PJM Interconnection region in 2012 (Energy Information Administration 2014a).

The utility's fixed cost of production ($F$) is taken to be \$39, 252, 470. This number reflects the 46 % of revenue collected annually from ratepayers in the PJM Interconnection region that is estimated to be employed to cover the fixed costs of installing generation capacity and maintaining and upgrading the region's transmis-

[38] See, for example, King and Chatterjee (2003), Espey and Espey (2004), Narayan and Smyth (2005), Taylor et al. (2005), Wade (2005), Bernstein and James Griffin (2006), and Paul et al. (2009). It is readily verified that consumer $i$'s price elasticity of demand for electricity in this setting is $\frac{1}{\alpha_i}$.

[39] This formulation reflects a common approach to capturing changes in building energy use due to ambient temperature variation (e.g., Eto 1988).

[40] PJM Interconnection is the "regional transmission organization (RTO) that coordinates the movement of wholesale electricity 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" (www.pjm.com/about-pjm/who-we-are.aspx).

[41] ISO New England is "the independent, not-for-profit corporation responsible for keeping electricity flowing across the six New England states and ensuring that the region has reliable, competitively priced wholesale electricity" (www.iso-ne.com/about). We investigate potential outcomes in the California, ISO New England, and PJM Interconnection regions because Bushnell (2007) provides estimates of the cost parameters $a$ and $b$ in these three regions. We focus on outcomes in the PJM Interconnection region here for brevity and because this region is the largest and the most populous of the three regions.

[42] The data reveal that the distribution of $\theta$ is also approximated reasonably well by a generalized extreme value (GEV) distribution with parameters $(\mu, \sigma, \xi) = (18.460, 10.928, -0.029)$. The key qualitative conclusions reported below are unchanged when this GEV distribution is employed instead of the identified gamma distribution.

[43] The optimal regulatory policy in the absence of a DR policy is characterized in Brown and Sappington (2016).

[44] This average hourly load, 90,314 MW, is total annual consumption (791,152,262 MWh) in the PJM Interconnection region in 2013 divided by 8760, the number of hours in a year (Pennsylvania New Jersey Maryland 2014).

**Table 1** Outcomes in the benchmark setting

| | No DR policy | Optimal DR policy | FERC DR policy |
|---|---|---|---|
| $r$ | 83.19 | 75.20 | 78.10 |
| $R$ | 299.96 | 323.36 | 307.57 |
| $E\{m(\theta)\}$ | 0 | 21.29 | 86.28 |
| $E\{C^P(\cdot)\}$ | 8.49 | 6.99 | 5.13 |
| $E\{W\}$ | 29.16 | 34.23 | 30.27 |

sion and distribution network.[45] The remaining cost parameters are set at $a = 0.0$ and $b = 0.00045$, the parameter values that Bushnell (2007) estimates for this region.

Table 1 reports outcomes in this benchmark setting: (i) in the absence of any DR policy (so $m(\theta) = 0$ for all $\theta$), (ii) under the optimal marginal-cost compensation ("FERC") policy (where $m(\theta) = C'(\cdot)$ for all $\theta$), and (iii) under the optimal DR policy (i.e., at the solution to [RP]). The first row of data in Table 1 reports the unit price of electricity ($r$) in dollars per MWh.[46] The second row reports the fixed charge ($R$) in dollars per year.[47] The third row presents the expected DR compensation payment ($E\{m(\theta)\}$) in dollars per MWh.[48] The fourth row reports expected peak-load production costs ($E\{C^P(\cdot)\}$), which are the utility's expected costs (in millions of dollars) in states in which strictly positive DR arises.[49] The last row presents the level of aggregate expected consumer welfare ($E\{W\}$) in millions of dollars.[50]

Table 1 reports that the optimal DR policy in the benchmark setting increases welfare by 17.4 % above the corresponding level achieved in the absence of any DR policy.[51] The welfare gain reflects in part the 17.6 % reduction in expected peak-load production costs the optimal DR policy secures.[52] The cost reductions, in turn, permit a lower unit price for electricity. Consumers also benefit from the compensation they receive for their DR, which nearly offsets the increase in the fixed charge.

The optimal DR policy increases expected welfare by 13.1 % above the level secured under the optimal FERC policy. This welfare increase arises even though the optimal

[45] ISO-NE (2006) and Thomas et al. (2014) estimate that variable energy production costs constitute between 48 and 60 % (an average of 54 %) of ratepayer revenue. Revenue is calculated as the product of the average retail rate for electricity and the total load in the PJM Interconnection region in 2013 (Pennsylvania New Jersey Maryland 2014).

[46] Thus, $r = 83.19$ denotes a price of approximately \$0.083 per kWh.

[47] Thus, $R = 299.96$ represents a monthly fixed charge of approximately \$25.

[48] $E\{m(\theta)\} = \int_{\theta_m}^{\overline{\theta}} m(\theta) dG(\theta)$, where $\theta_m = 42.5$ is the smallest realization of $\theta$ for which DR is provided both at the solution to [RP] and under the optimal FERC policy in the benchmark setting. The qualitative conclusions drawn below are robust to alternative plausible definitions of peak-load production costs.

[49] Formally, $E\{C^P(\theta)\} = \int_{\theta_m}^{\overline{\theta}} C(\cdot) dG(\theta)$.

[50] $E\{W\} = \sum_{i=1}^{N} \int_{\underline{\theta}}^{\overline{\theta}} [V_i(x_i^u(\cdot, \theta), \theta) - r x_i^u(\cdot, \theta) + m(\theta) x_i^d(\cdot, \theta)] dG(\theta) - NR$, reflecting Eq. (1).

[51] Larger percentage increases in expected welfare arise in the settings analyzed in Brown and Sappington (2016).

[52] Reported percentage changes may not reflect the entries in Table 1 exactly because these entries are rounded.

**Table 2** Expected welfare as $b$ changes

| $b$ | No DR policy | Optimal DR policy | FERC DR policy |
|---|---|---|---|
| 0.000585 | 3.10 | 3.89 | 3.50 |
| 0.000540 | 14.29 | 17.71 | 15.78 |
| 0.000495 | 14.88 | 18.22 | 16.20 |
| 0.000450 | 29.16 | 34.23 | 30.27 |
| 0.000405 | 29.90 | 34.78 | 30.42 |
| 0.000360 | 31.64 | 36.52 | 31.16 |
| 0.000315 | 40.25 | 45.84 | 39.35 |

FERC policy reduces expected peak-load production costs by 26.6 % below the corresponding costs under the optimal DR policy. The optimal FERC policy reduces electricity consumption excessively, causing the value that consumers derive from consuming electricity to decline by more than the corresponding reduction in production costs.

The welfare gains secured under an optimal DR policy typically increase as the convexity of the utility's cost function increases. The enhanced gains arise because the expected cost savings from curtailing peak-load consumption become more pronounced as the utility's marginal cost increases more rapidly with output. To illustrate this more general conclusion, Table 2 reports the levels of expected welfare that arise as $b$ increases and decreases by 10, 20, and 30 % above and below its value (0.00045). In the benchmark setting, holding all other parameter values constant. The table reveals, for example, that when $b$ increases by 20 % (from 0.00045 to 0.00054), the increase in expected welfare secured under the optimal DR policy (relative to the welfare secured in the absence of any DR policy) increases from 17.4 to 23.9 %.[53] In contrast, a 20 % reduction in $b$ (from 0.00045 to 0.00036) reduces this gain in expected welfare from 17.4 to 15.4 %.

When the utility's marginal cost of production increases sufficiently slowly with output, even an optimally designed FERC policy can reduce welfare below the level achieved in the absence of any DR policy.[54] This conclusion is illustrated in the last two rows of data in Table 2. These data indicate that when $b$ declines by 20 or 30 %

[53] Systematic increases in the marginal cost of production (i.e., increases in $a$) also enhance the welfare gains generated by an optimal DR policy. To illustrate, suppose $a$ increases from 0 to 20, while all other parameters are held constant at their levels in the benchmark setting. (The average value of $a$ in the settings considered in Brown and Sappington 2016 is approximately 23.) The increase in expected welfare that the optimal DR policy generates in this case (relative to no DR policy) rises to 33.6 % (from the 17.4 % generated in the benchmark setting). Bushnell's (2007) estimate of $a = 0$ in the PJM region reflects in part substantial supply by nuclear generators. Some of these generators are scheduled for retirement in the near future, which will tend to increase $a$. However, increased supply of energy from renewable sources may reduce $a$.

[54] A value of $b$ substantially below Bushnell's (2007) estimate might arise, for example, from pronounced reductions in the price of natural gas, which often is employed to power peak-load production units. The US experienced sharp reductions in the price of natural gas between 2007 and 2009 (www.infomine.com/investment/metal-prices/natural-gas/all/). The ongoing replacement of (low cost) coal generation by natural gas generation in the PJM region can introduce a countervailing effect on $b$.

below its level in the benchmark setting, the excessive demand reduction the FERC policy induces reduces the value that consumers derive from consuming electricity by more than it reduces peak-load production costs.

## 6 Conclusions

FERC Order 745 specifies compensation for DR that reflects the utility's marginal cost of supplying electricity. Critics of Order 745 contend that when the retail price of electricity does not vary with industry conditions, compensation for DR should reflect the difference between the utility's marginal cost of supplying electricity and the prevailing retail price of electricity. The critics also suggest that no compensation for DR is appropriate when real-time pricing ensures that the retail price of electricity reflects the utility's marginal cost of production.

Our formal analysis lends considerable support to the critics' views, but with some qualifications. We found that the optimal regulatory policy reflects the critics' views under streamlined, but arguably plausible, conditions. The optimal policy varies from the policy recommended by the critics in the presence of such factors as limits on feasible fixed charges for electricity, distributional concerns, endogenous baseline consumption levels, and externalities associated with electricity production. The marginal-cost compensation for DR that the FERC advocates generally is not the optimal policy in any of the settings we analyzed.

We also showed that the optimal DR policy can secure significant increases in expected welfare under arguably plausible conditions. The FERC's DR policy often generates a significantly smaller increase in welfare, and can even reduce welfare below the level that arises in the absence of any DR policy. Therefore, the expressed concerns about the FERC's policy would seem to merit serious consideration.

Our illustrations of the performance of the optimal DR policy and the FERC's policy did not account explicitly for losses from externalities associated with electricity production. A full accounting for these losses could alter the relative performance of the FERC's DR policy. Observe from Proposition 5 that, ceteris paribus, the difference between the marginal compensation under the FERC's policy and the corresponding optimal compensation declines as the marginal social loss from externalities associated with electricity production by the utility increases, after adjusting for relevant social losses from externalities associated with increased electricity production by consumers. Accurate estimation of social losses from externalities requires detailed knowledge of the particular technologies being employed to generate electricity at all relevant output levels. Such estimation and development of the associated implications for the relative performance of different DR policies await further research.

In closing, we note four additional extensions of our analysis that merit further research. First, rather than taking the baseline levels of electricity purchases ($\underline{x}_i$) as given, the optimal structuring of these baselines should be analyzed.[55] In practice,

[55] The regulator might also be permitted to specify the terms under which consumers must "buy" their assigned baselines (e.g., in a day-ahead market) before they are eligible to sell demand reduction (e.g., in a real-time spot market) (Bushnell et al. 2009).

regulators likely will want to implement rules for establishing baseline levels that limit strategic manipulation by consumers (Chao 2011).[56] Second, consumer investment in on-site production capacity should be endogenized in order to examine the impact of DR (and other) policies on DG capabilities. Investment in centralized generating capacity might also be analyzed explicitly. More generous compensation for DR may be optimal if the ensuing demand for electricity supplied by the utility both permits a substantial reduction in centralized generating capacity and reduces the utility's short-run supply costs.

Third, additional policy instruments warrant consideration. The optimal design of a DR policy is best viewed as an element of a broader exercise that includes, for example, the optimal design of DG, energy conservation, and renewable energy portfolio policies. The key qualitative conclusions drawn above seem likely to persist in the context of this more general analysis, but the details of the analysis remain to be determined.

Fourth, the optimal DR policy should be characterized in settings where the retail price of electricity partially reflects the utility's marginal cost of production, e.g., in the presence of time-of-day pricing. Our findings in the settings with a fixed retail price and fully state-specific retail pricing (recall Propositions 1, 5 and 6) suggest that the optimal compensation for DR will continue to reflect differences between the utility's marginal cost of production and the prevailing retail price of electricity.[57]

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## Appendix[58]

*Proof of Lemma 1* (4) implies that when $x_i^d > 0$, the value of $x_i^u > 0$ and the value of $x_i^o > 0$ produced using the dispatchable on-site technology are characterized by:

$$\frac{\partial V_i(\cdot)}{\partial x_i^u} = r + m(\theta) = C_i'(\cdot) \Rightarrow \frac{\partial^2 V_i(\cdot)}{\partial (x_i^u + x_i^o)^2} \frac{d(x_i^u + x_i^o)}{dm(\theta)} = 1 = C_i'(\cdot) \frac{dx_i^o}{dm(\theta)}.$$

Therefore, $\frac{d(x_i^u + x_i^o)}{dm(\theta)} < 0$ and $\frac{dx_i^o}{dm(\theta)} > 0$, and so $\frac{dx_i^u}{dm(\theta)} < 0$ when consumer $i$ employs the dispatchable technology.

Consumer $i$ produces $\overline{x}_i(\theta)$ units of electricity when he employs the non-dispatchable technology. Therefore, $x_i^o$ and $x_i^u$ are not affected by $m(\theta)$. □

56 Our key qualitative conclusions hold for any specified (exogenous) values of $\underline{x}_i$, and so will hold for the optimal (endogenous) such levels.

57 Future research might also characterize the optimal DR policy in settings with richer intertemporal structures. In practice, consumers may secure additional benefit from a DR program as their stochastic demand for electricity naturally falls below the established baseline level at various times, or as they intentionally substitute electricity consumption in other periods for consumption foregone while supplying DR (e.g., Graff Zivin et al. 2014).

58 This Appendix presents the key elements of the proofs of the formal conclusions in the text. Brown and Sappington (2016) provide more detailed proofs.

*Proof of Proposition* 1 The conclusions follow immediately from Proposition 5. □

*Proof of Corollary* 1 First suppose $x_i^u < \underline{x}_i$ for some $i \in \{1, \ldots, N\}$. Then (4) and (5) imply that at the solution to [RP] identified in Proposition 1, $x_i^u$ is determined by $\frac{\partial V_i(x_i^u + x_i^0, \theta)}{\partial x_i^u} = r + m(\theta) = C'(X^u(\cdot, \theta))$. Therefore, given the consumption decisions of other consumers, the consumption and DR actions of consumer $i$ are efficient.

Now suppose $x_i^u(\cdot) > \underline{x}_i$. Then (4) and (6) imply that at the solution to [RP] identified in Proposition 1, $x_i^u$ is determined by:

$$\frac{\partial V_i(x_i^u + x_i^0, \theta)}{\partial x_i^u} = r = \frac{\sum_{i=1}^N \int_{\Omega_i^{-D}} C'(X^u(\cdot, \theta)) \frac{\partial x_i^u(\cdot)}{\partial r} dG(\theta)}{\sum_{i=1}^N \int_{\Omega_i^{-D}} \frac{\partial x_i^u(\cdot)}{\partial r} dG(\theta)}.$$

Therefore, given the actions of other consumers, the actions of consumer $i$ are efficient if and only if, for all $\theta \in [\underline{\theta}, \overline{\theta}]$:

$$\sum_{i=1}^N \int_{\Omega_i^{-D}} C'\left(X^u(\cdot, \theta)\right) \frac{\partial x_i^u(\cdot)}{\partial r} dG(\theta) = \left[\sum_{i=1}^N \int_{\Omega_i^{-D}} \frac{\partial x_i^u(\cdot)}{\partial r} dG(\theta)\right] C'\left(X^u(\cdot, \theta)\right).$$

This equality typically will not hold because $x_i^u(\cdot, \theta)$, and thus $X^u(\cdot, \theta)$, vary with $\theta$. □

*Proof of Proposition* 2 The proof parallels the proof of Proposition 5. □

*Proof of Proposition* 3 Letting " $\widetilde{\cdot}$ " (" $\widehat{\cdot}$ ") denote variables for consumers who can (cannot) provide DR, expected weighted consumer welfare in this setting is:

$$\begin{aligned} E\left\{U^\alpha(\cdot)\right\} = \widetilde{\alpha} \Bigg\{ \sum_{i=1}^{\widetilde{N}} \int_{\underline{\theta}}^{\overline{\theta}} \Big[ & V_i\left(\widetilde{x}_i^u(r, m(\theta), \theta) + \widetilde{x}_i^o(\cdot), \theta\right) - r\widetilde{x}_i^u(\cdot) \\ & + m(\theta)\widetilde{x}_i^d(\cdot) - C_i\left(\widetilde{x}_i^o(\cdot), \theta\right)\Big] dG(\theta) - \widetilde{N}R \Bigg\} \\ & + \widehat{\alpha} \left\{ \sum_{i=1}^{\widehat{N}} \int_{\underline{\theta}}^{\overline{\theta}} \left[V_i\left(\widehat{x}_i^u(r, \theta) - r\widehat{x}_i^u(\cdot)\right)\right] dG(\theta) - \widehat{N}R \right\}. \end{aligned} \quad (15)$$

The utility's expected profit is:

$$\begin{aligned} E\left\{\pi^\alpha\right\} = R[\widetilde{N} + \widehat{N}] + \sum_{i=1}^{\widetilde{N}} \int_{\underline{\theta}}^{\overline{\theta}} \left[r\widetilde{x}_i^u(r, m(\theta), \theta) - m(\theta)\widetilde{x}_i^d(\cdot)\right] dG(\theta) \\ + \sum_{i=1}^{\widehat{N}} \int_{\underline{\theta}}^{\overline{\theta}} r\widehat{x}_i^u(r, \theta) dG(\theta) - \int_{\underline{\theta}}^{\overline{\theta}} C\left(\sum_{i=1}^{\widetilde{N}} \widetilde{x}_i^u(\cdot) + \sum_{i=1}^{\widehat{N}} \widehat{x}_i^u(\cdot)\right) dG(\theta). \end{aligned} \quad (16)$$

The regulator's problem, [RP-d], is to choose $\{R,\ r,\ m(\theta)\}$ to maximize $E\{U^{\alpha}(\cdot)\}$ while securing non-negative expected profit for the utility. Let $\lambda_{\alpha} \geq 0$ denote the Lagrange multiplier associated with the utility's participation constraint ($E\{\pi^{\alpha}\} \geq 0$). Then the Lagrangian function associated with [RP-d] is:

$$\pounds_{\alpha} = E\left\{U^{\alpha}(\cdot)\right\} + \lambda_{\alpha} E\left\{\pi^{\alpha}\right\}. \tag{17}$$

Because the value of $R$ does not affect consumption decisions, differentiating (17) with respect to $R$, using (15) and (16), provides $\lambda_{\alpha} = \frac{\widetilde{\alpha}\widetilde{N}+\widehat{\alpha}\widehat{N}}{\widetilde{N}+\widehat{N}}$.

Because $\frac{\partial \widehat{x}_i^u(\cdot)}{\partial m(\theta)} = 0$ for all $i = 1, \ldots, \widehat{N}$, pointwise optimization of (17) with respect to $m(\theta)$, using (15), (16), Leibnitz' rule, and the continuity of consumer welfare and profit (see the proof of Proposition 5) reveals that:

$$r + m(\theta) - C'(\cdot) = \frac{\widehat{N}[\widehat{\alpha} - \widetilde{\alpha}] \sum_{i=1}^{\widetilde{N}} \widetilde{x}_i^d(\cdot)}{[\widetilde{\alpha}\widetilde{N} + \widehat{\alpha}\widehat{N}] \sum_{i=1}^{\widetilde{N}} \frac{\partial \widetilde{x}_i^u(\cdot)}{\partial m(\theta)}}. \tag{18}$$

(9) follows immediately from (18) because $\frac{\partial \widetilde{x}_i^u(\cdot)}{\partial m(\theta)} < 0$ when $\widetilde{x}_i^d(\cdot) > 0$ and $\frac{\partial \widetilde{x}_i^u(\cdot)}{\partial m(\theta)} \leq 0$ when $\widetilde{x}_i^d(\cdot) = 0$. □

*Proof of Proposition 4* Aggregate consumer welfare in this setting is:

$$E\left\{U^{a}(\cdot)\right\} = \int_{\underline{\theta}}^{\overline{\theta}} \sum_{i=1}^{N} w_i(\theta) dG(\theta) - NR - D(a_i). \tag{19}$$

Because $\sum_{i=1}^{N} w_i(\theta)$ is continuous in $\theta$ for all $\theta$ (see the proof of Proposition 5), (19) and Leibnitz' rule imply that $a_i$ is determined by:

$$H_i(a_i,\ r,\ m(\theta),\ \theta) \equiv \int_{\underline{\theta}}^{\widetilde{\theta}_i} m(\theta) \frac{\partial \underline{x}_i}{\partial a_i} dG(\theta) - D_i'(a_i) = 0. \tag{20}$$

By assumption:

$$\frac{\partial H_i(\cdot)}{\partial a_i} = \frac{d\widetilde{\theta}_i(\cdot)}{da_i} m\left(\widetilde{\theta}_i\right) \frac{\partial \underline{x}_i}{\partial a_i} g\left(\widetilde{\theta}_i\right) + \int_{\underline{\theta}}^{\widetilde{\theta}_i} m(\theta) \frac{\partial^2 \underline{x}_i}{\partial (a_i)^2} dG(\theta) - D_i''(a_i) < 0. \tag{21}$$

(20) implies:

$$\frac{\partial H_i(\cdot)}{\partial m(\theta)} = \begin{cases} \frac{\partial \underline{x}_i}{\partial a_i} g(\theta) > 0 & \text{if } \ \theta \in \Omega_i^D, \\ 0 & \text{otherwise.} \end{cases} \tag{22}$$

(20), (21), and (22) imply:

$$\frac{\partial a_i}{\partial m(\theta)} = -\frac{\partial H_i / \partial m(\theta)}{\partial H_i / \partial a_i} \geq 0. \tag{23}$$

The regulator's problem, [RP-a], is to choose $\{R, r, m(\theta)\}$ to maximize $E\{U^a(\cdot)\}$ while securing non-negative expected profit for the utility. Let $\lambda_a \geq 0$ denote the Lagrange multiplier associated with the utility's participation constraint ($E\{\pi^a\} \geq 0$). Then the Lagrangian function associated with [RP] is:

$$£_a = E\left\{U^a(\cdot)\right\} + \lambda_a E\left\{\pi^a\right\}. \tag{24}$$

Let $\frac{dx_i^j(\cdot)}{dm(\theta)} = \frac{\partial x_i^j(\cdot)}{\partial m(\theta)} + \frac{\partial x_i^j(\cdot)}{\partial a_i}\frac{\partial a_i}{\partial m(\theta)}$ for $j \in \{u, d, o\}$. For the reasons identified in the proof of Proposition 5, expected consumer welfare and the firm's expected profit are both continuous functions of $\theta$. Consequently, Leibnitz' rule implies that pointwise optimization of (24) with respect to $m(\theta)$ provides:

$$\begin{aligned}&[1-\lambda_a]\sum_{i=1}^{N} x_i^d(r, m(\theta), \theta)g(\theta) - e'\left(X^u\right)\sum_{i=1}^{N}\frac{dx_i^u(\cdot)}{dm(\theta)}g(\theta) - \sum_{i=1}^{N} e_i \frac{dx_i^o}{dm(\theta)}g(\theta)\\ &-\lambda_a C'\left(X^u\right)\sum_{i=1}^{N}\frac{dx_i^u(\cdot)}{dm(\theta)}g(\theta) + \lambda_a \sum_{i=1}^{N}\left[r\frac{dx_i^u(\cdot)}{dm(\theta)} - m(\theta)\frac{dx_i^d(\cdot)}{dm(\theta)}\right]g(\theta) = 0.\end{aligned} \tag{25}$$

Because the value of $R$ does not affect consumption decisions, differentiating (24) with respect to $R$ provides $-N + \lambda_a N = 0 \Rightarrow \lambda_a = 1$. Therefore, (25) can be written as:

$$\left[r - C'\left(X^u\right)\right]\sum_{i=1}^{N}\frac{dx_i^u(\cdot)}{dm(\theta)} = m(\theta)\sum_{i=1}^{N}\frac{dx_i^d(\cdot)}{dm(\theta)}. \tag{26}$$

$\frac{\partial x_i^d(\cdot)}{\partial m(\theta)} = -\frac{\partial x_i^u(\cdot)}{\partial m(\theta)} > 0$ because $\frac{\partial x_i^u(\cdot)}{\partial m(\theta)} = 0$ if $x_i^u(\cdot) > \underline{x}_i$. Also, (4) implies that $x_i^u(\cdot)$ does not vary with $\underline{x}_i$, given $r$ and $m(\theta)$. Therefore:

$$\frac{dx_i^u(\cdot)}{dm(\theta)} = \frac{\partial x_i^u(\cdot)}{\partial m(\theta)} \quad \text{and} \quad \frac{\partial x_i^d(\cdot)}{\partial a_i} = \begin{cases}\frac{\partial \underline{x}_i}{\partial a_i} & \text{if } \; x_i^u(\cdot) \leq \underline{x}_i,\\ 0 & \text{if } \; x_i^u(\cdot) > \underline{x}_i,\end{cases} \tag{27}$$

$$\Rightarrow \frac{dx_i^d(\cdot)}{dm(\theta)} = \left|\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}\right| + \delta_{i\theta}\frac{\partial \underline{x}_i}{\partial a_i}\frac{\partial a_i}{\partial m(\theta)} > 0. \tag{28}$$

(10) follows from (26), (27), and (28). □

*Proof of Corollary* 2 Equation (4) Implies that $x_i^u < \underline{x}_i$ at the solution to [RP-a] identified in Proposition 4 is determined by:

$$\frac{\partial V_i(x_i^u + x_i^o, \theta)}{\partial x_i^u} = r + m(\theta) = \frac{C'(X^u(\cdot, \theta))\sum_{i=1}^{N}\left|\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}\right| + r\sum_{i=1}^{N}\delta_{i\theta}\frac{\partial \underline{x}_i}{\partial a_i}\frac{\partial a_i}{\partial m(\theta)}}{\sum_{i=1}^{N}\left\{\left|\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}\right| + \delta_{i\theta}\frac{\partial \underline{x}_i}{\partial a_i}\frac{\partial a_i}{\partial m(\theta)}\right\}}.$$

Therefore, given the actions of other consumers, consumer $i$'s actions are efficient only if:

$$\frac{C'(X^u(\cdot,\,\theta))\sum_{i=1}^N\left|\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}\right| + r\sum_{i=1}^N \delta_{i\theta}\frac{\partial \underline{x}_i}{\partial a_i}\frac{\partial a_i}{\partial m(\theta)}}{\sum_{i=1}^N\left\{\left|\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}\right| + \delta_{i\theta}\frac{\partial \underline{x}_i}{\partial a_i}\frac{\partial a_i}{\partial m(\theta)}\right\}} = C'\left(X^u(\cdot,\,\theta)\right)$$

$$\Leftrightarrow \left[r - C'\left(X^u(\cdot,\,\theta)\right)\right]\left[\frac{\sum_{i=1}^N \delta_{i\theta}\frac{\partial \underline{x}_i}{\partial a_i}\frac{\partial a_i}{\partial m(\theta)}}{\sum_{i=1}^N\left\{\left|\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}\right| + \delta_{i\theta}\frac{\partial \underline{x}_i}{\partial a_i}\frac{\partial a_i}{\partial m(\theta)}\right\}}\right] = 0. \quad (29)$$

(28) implies that (29) holds if and only if $r = C'(X^u(\cdot,\,\theta))$ for each $\theta \in [\underline{\theta},\,\overline{\theta}]$. These inequalities typically will not all hold because $x_i^u(\cdot,\,\theta)$, and thus $X^u(\cdot,\,\theta)$, vary with $\theta$. □

*Proof of Proposition 5* Let $\lambda \geq 0$ denote the Lagrange multiplier associated with the utility's participation constraint ($E\{\pi\} \geq 0$). Then the Lagrangian function associated with [RP-e] is:

$$£ = E\{U(\cdot)\} - E\{L(\cdot)\} + \lambda E\{\pi\}. \quad (30)$$

Pointwise optimization of (30) with respect to $m(\theta)$, using (1), (2), (11), and the envelope theorem provides:

$$[1-\lambda]\sum_{i=1}^N x_i^d(r,\,m(\theta),\,\theta)g(\theta) - e'\left(X^u\right)\sum_{i=1}^N\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}g(\theta) - \sum_{i=1}^N e_i\frac{\partial x_i^o}{\partial m(\theta)}g(\theta)$$
$$-\lambda C'\left(X^u\right)\sum_{i=1}^N\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}g(\theta) + \lambda\sum_{i=1}^N\left[r\frac{\partial x_i^u(\cdot)}{\partial m(\theta)} - m(\theta)\frac{\partial x_i^d(\cdot)}{\partial m(\theta)}\right]g(\theta) = 0. \quad (31)$$

Because the value of $R$ does not affect consumption decisions, differentiating (30) with respect to $R$ provides $-N + \lambda N = 0 \Rightarrow \lambda = 1$. Therefore, (7) holds. Also, $\frac{\partial x_i^d(\cdot)}{\partial m(\theta)} = -\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}$ because $\frac{\partial x_i^u(\cdot)}{\partial m(\theta)} = 0$ if $x_i^u(\cdot) > \underline{x}_i$. Therefore, (31) can be written as:

$$\left[r + m(\theta) - e'\left(X^u\right) - C'\left(X^u\right)\right]\sum_{i=1}^N\frac{\partial x_i^u(\cdot)}{\partial m(\theta)} - \sum_{i=1}^N e_i\frac{\partial x_i^o}{\partial m(\theta)} = 0. \quad (32)$$

$\sum_{i=1}^N\frac{\partial x_i^u(\cdot)}{\partial m(\theta)} < 0$ because $\frac{\partial x_i^u(\cdot)}{\partial m(\theta)} < 0$ when $x_i^d(\cdot) > 0$ and $\frac{\partial x_i^u(\cdot)}{\partial m(\theta)} \leq 0$ when $x_i^d(\cdot) = 0$. Therefore, (12) follows from (32).

Let $\Omega_i^=$ denote the set of $\theta \in [\underline{\theta},\,\overline{\theta}]$ for which $\frac{\partial V_i(x_i^u + x_i^o,\,\theta)}{\partial x_i^u}|_{x_i^u = \underline{x}_i} = r + m(\theta)$ at the solution to [RP-e]. Observe that:

$$V_i\left(x_i^u(r,\,m(\theta),\,\theta) + x_i^o(\cdot),\,\theta\right) - rx_i^u(r,\,m(\theta),\,\theta) + m(\theta)\left[\underline{x}_i - x_i^u(r,\,m(\theta),\,\theta)\right]$$
$$= V_i\left(x_i^u(r,\,\theta) + x_i^o(\cdot),\,\theta\right) - rx_i^u(r,\,\theta) \quad \text{for all}\,\theta \in \Omega_i^=. \quad (33)$$

Further observe that (1) can be written as:

$$E\{U(\cdot)\} = \int_{\underline{\theta}}^{\overline{\theta}} \sum_{i=1}^{N} w_i(\theta) dG(\theta) - NR \quad \text{where } w_i(\theta) \equiv \begin{cases} w_i^D(\theta) & \text{if } \theta \in \Omega_i^D, \\ w_i^{-D}(\theta) & \text{if } \theta \in \Omega_i^{-D}, \end{cases}$$

$$w_i^D(\theta) \equiv V_i\left(x_i^u(r,\, m(\theta),\, \theta) + x_i^o(\cdot),\, \theta\right) - r x_i^u(r,\, m(\theta),\, \theta)$$
$$+ m(\theta)\left[\underline{x}_i - x_i^u(r,\, m(\theta),\, \theta)\right] - C_i\left(x_i^o(\cdot),\, \theta\right), \quad \text{and}$$
$$w_i^{-D}(\theta) \equiv V_i\left(x_i^u(r,\, \theta) + x_i^o(\cdot),\, \theta\right) - r x_i^u(r,\, \theta) - C_i\left(x_i^o(\cdot),\, \theta\right). \tag{34}$$

Equation (33) Implies that for any $\widehat{\theta} \in \Omega_i^{=}$, $\lim_{\theta \to \widehat{\theta}^-} \sum_{i=1}^N w_i^D(\theta) = \lim_{\theta \to \widehat{\theta}^+} \sum_{i=1}^N w_i^{-D}(\theta)$ and $\lim_{\theta \to \widehat{\theta}^-} \sum_{i=1}^N w_i^{-D}(\theta) = \lim_{\theta \to \widehat{\theta}^+} \sum_{i=1}^N w_i^D(\theta)$. Consequently, $\sum_{i=1}^N w_i(\theta)$ is continuous in $\theta$ for all $\theta$. Corresponding arguments reveal that $\sum_{i=1}^N \widetilde{\pi}_i(\theta)$ is continuous in $\theta$ for all $\theta$. The established continuity and Leibnitz' rule ensure that differentiation of (30) with respect to $r$ provides:

$$\sum_{i=1}^{N} \int_{\Omega_i^D} \left\{ \left[r + m(\theta) - C'\left(X^u\right) - e'\left(X^u\right)\right] \frac{\partial x_i^u(\cdot)}{\partial r} - e_i \frac{\partial x_i^o(\cdot)}{\partial r} \right\} dG(\theta)$$
$$+ \sum_{i=1}^{N} \int_{\Omega_i^{-D}} \left\{ \left[r - C'\left(X^u\right) - e'\left(X^u\right)\right] \frac{\partial x_i^u(\cdot)}{\partial r} - e_i \frac{\partial x_i^o(\cdot)}{\partial r} \right\} dG(\theta) = 0. \tag{35}$$

From (4), for $i = 1, \ldots, N$, $\frac{\partial x_i^u(\cdot)}{\partial r} = \frac{\partial x_i^u(\cdot)}{\partial m(\theta)}$ for all $\theta \in \Omega_i^D$. Therefore, (32) and (35) imply:

$$r \sum_{i=1}^{N} \int_{\Omega_i^{-D}} \frac{\partial x_i^u(\cdot)}{\partial r} dG(\theta) = \sum_{i=1}^{N} \int_{\Omega_i^{-D}} \left\{ \left[C'\left(X^u\right) + e'\left(X^u\right)\right] \frac{\partial x_i^u(\cdot)}{\partial r} + e_i \frac{\partial x_i^o(\cdot)}{\partial r} \right\} dG(\theta). \tag{36}$$

(13) follows directly from (36). □

*Proof of Corollary 3* (4) Implies that $\frac{\partial V_i(x_i^u + x_i^o,\, \theta)}{\partial x_i^o} = C_i'(x_i^o,\, \theta)$ at the solution to [RP-e]. Therefore, $\frac{\partial V_i(x_i^u + x_i^o,\, \theta)}{\partial x_i^o} = C_i'(x_i^o,\, \theta) + e_i$ if and only if $e_i = 0$. □

*Proof of Proposition 6* Expected social losses from externalities are:

$$E\left\{L^s(\cdot)\right\} = \int_{\underline{\theta}}^{\overline{\theta}} \left[ \sum_{i=1}^{N} e_i x_i^o(\cdot) + e\left( \sum_{i=1}^{N} x_i^u(\cdot) \right) \right] dG(\theta). \tag{37}$$

Let $\lambda_s \geq 0$ denote the Lagrange multiplier associated the utility's participation constraint ($E\{\pi^s\} \geq 0$). It is readily verified $\lambda_s = 1$ at the solution to the regulator's problem in this setting. Pointwise optimization of the relevant Lagrangian function with respect to $m(\theta)$ provides:

$$[1-\lambda_s]\sum_{i=1}^{N} x_i^d(r(\theta),\, m(\theta),\, \theta)g(\theta) - e'\left(X^u\right)\sum_{i=1}^{N}\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}g(\theta) - \sum_{i=1}^{N} e_i\frac{\partial x_i^o}{\partial m(\theta)}g(\theta)$$
$$-\lambda_s C'\left(X^u\right)\sum_{i=1}^{N}\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}g(\theta) + \lambda_s\sum_{i=1}^{N}\left[r(\theta)\frac{\partial x_i^u(\cdot)}{\partial m(\theta)} - m(\theta)\frac{\partial x_i^d(\cdot)}{\partial m(\theta)}\right]g(\theta) = 0. \tag{38}$$

Because $\lambda_s = 1$, (38) can be written as:

$$m(\theta) = C'(\cdot) - r(\theta) + e'(\cdot) + \frac{\sum_{i=1}^{N} e_i\frac{\partial x_i^o(\cdot)}{\partial m(\theta)}}{\sum_{i=1}^{N}\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}}. \tag{39}$$

Corresponding pointwise optimization with respect to $r(\theta)$ provides:

$$r(\theta) = C'(\cdot) + e'(\cdot) + m(\theta)\left[\frac{\sum_{i=1}^{N}\frac{\partial x_i^d(\cdot)}{\partial x_i^u(\cdot)}\frac{\partial x_i^u(\cdot)}{\partial r(\theta)}}{\sum_{i=1}^{N}\frac{\partial x_i^u(\cdot)}{\partial r(\theta)}}\right] + \frac{\sum_{i=1}^{N} e_i\frac{\partial x_i^o}{\partial r(\theta)}}{\sum_{i=1}^{N}\frac{\partial x_i^u(\cdot)}{\partial r(\theta)}}. \tag{40}$$

Using (40), (39) can be written as:

$$m(\theta) = \left[\frac{\sum_{i=1}^{N}\frac{\partial x_i^u(\cdot)}{\partial r(\theta)}}{\sum_{i=1}^{N}\left[1+\frac{\partial x_i^d(\cdot)}{\partial x_i^u(\theta)}\right]\frac{\partial x_i^u(\cdot)}{\partial r(\theta)}}\right]\left[\frac{\sum_{i=1}^{N} e_i\frac{\partial x_i^o(\cdot)}{\partial m(\theta)}}{\sum_{i=1}^{N}\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}} - \frac{\sum_{i=1}^{N} e_i\frac{\partial x_i^o(\cdot)}{\partial r(\theta)}}{\sum_{i=1}^{N}\frac{\partial x_i^u(\cdot)}{\partial r(\theta)}}\right]. \tag{41}$$

Using (41), (40) can be written as:

$$r(\theta) = C'\left(X^u\right) + e'\left(X^u\right) + \frac{\sum_{i=1}^{N} e_i\frac{\partial x_i^o(\cdot)}{\partial r(\theta)}}{\sum_{i=1}^{N}\left[1+\frac{\partial x_i^d(\cdot)}{\partial x_i^u(\theta)}\right]\frac{\partial x_i^u(\cdot)}{\partial r(\theta)}}$$
$$+\left[\frac{\sum_{i=1}^{N}\frac{\partial x_i^d(\cdot)}{\partial x_i^u(\cdot)}\frac{\partial x_i^u(\cdot)}{\partial r(\theta)}}{\sum_{i=1}^{N}\left[1+\frac{\partial x_i^d(\cdot)}{\partial x_i^u(\cdot)}\right]\frac{\partial x_i^u(\cdot)}{\partial r(\theta)}}\right]\frac{\sum_{i=1}^{N} e_i\frac{\partial x_i^o(\cdot)}{\partial m(\theta)}}{\sum_{i=1}^{N}\frac{\partial x_i^u(\cdot)}{\partial m(\theta)}}. \tag{42}$$

Conclusions (i) and (ii) of the proposition follow directly from (41) and (42) because $e_i\frac{\partial x_i^o(\cdot)}{\partial m(\theta)} = e_i\frac{\partial x_i^o(\cdot)}{\partial r(\theta)} = 0$ when consumers do not produce electricity or when their production entails no externalities. Conclusion (iii) of the proposition follows from

(41) and (42) because $\frac{\partial x_i^d(\cdot)}{\partial x_i^u(\cdot)} = -1$, $\frac{\partial x_i^u(\cdot)}{\partial m(\theta)} = \frac{\partial x_i^u(\cdot)}{\partial r(\theta)}$, and $\frac{\partial x_i^o(\cdot)}{\partial m(\theta)} = \frac{\partial x_i^o(\cdot)}{\partial r(\theta)}$ when $x_i^d(\cdot) > 0$ for all $\theta \in [\underline{\theta}, \overline{\theta}]$ and for all $i = 1, \ldots, N$. □

*Proof of Corollary 4* (14) follows immediately from (41) because $\frac{\partial x_i^u(\cdot)}{\partial r(\theta)} < 0$, $\frac{\partial x_i^u(\cdot)}{\partial m(\theta)} \leq 0$, and $\frac{\partial x_i^d(\cdot)}{\partial x_i^u(\cdot)} \in \{0, -1\}$. □

*Proof of Corollary 5* The proof parallels the proof of Corollary 3. □

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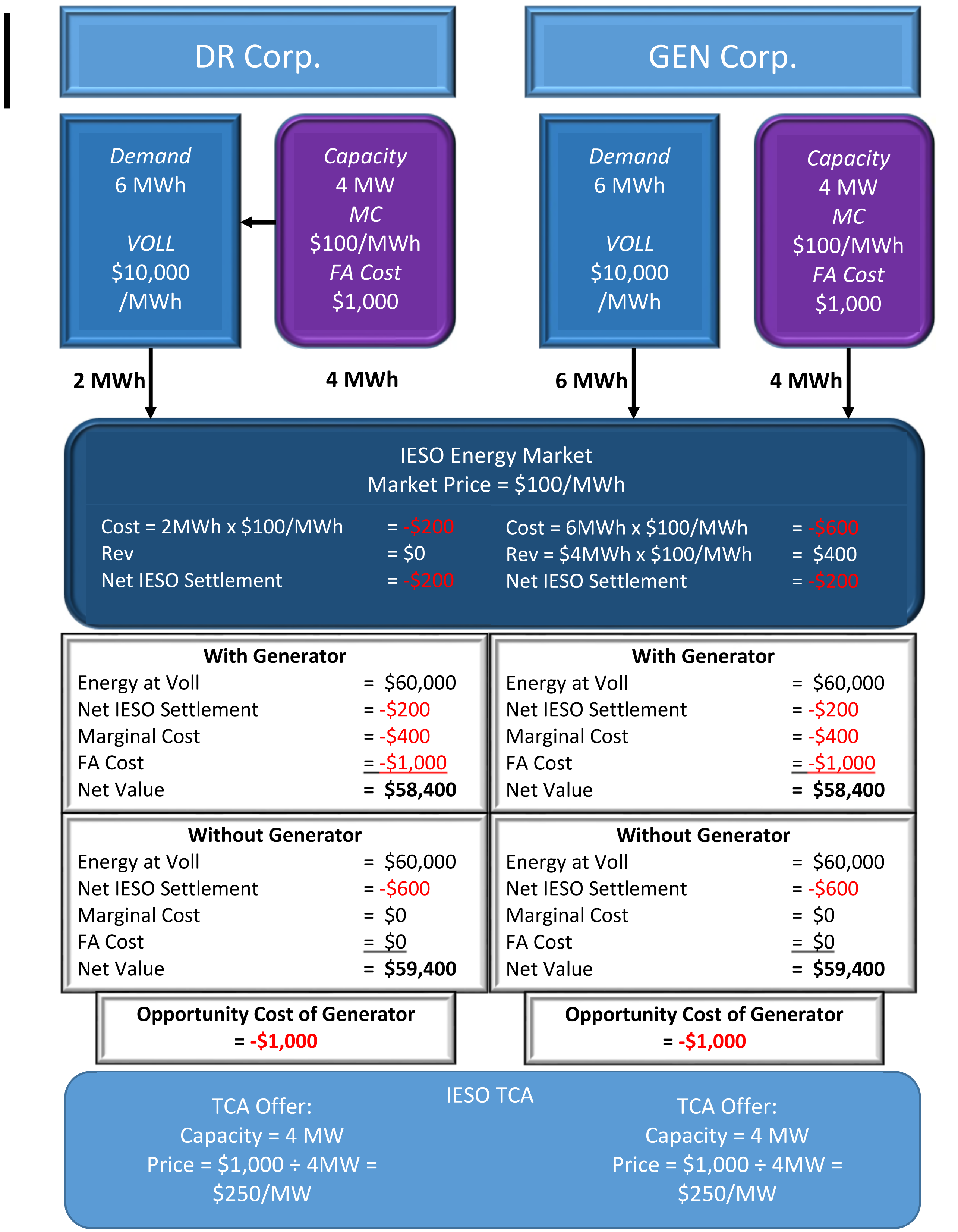
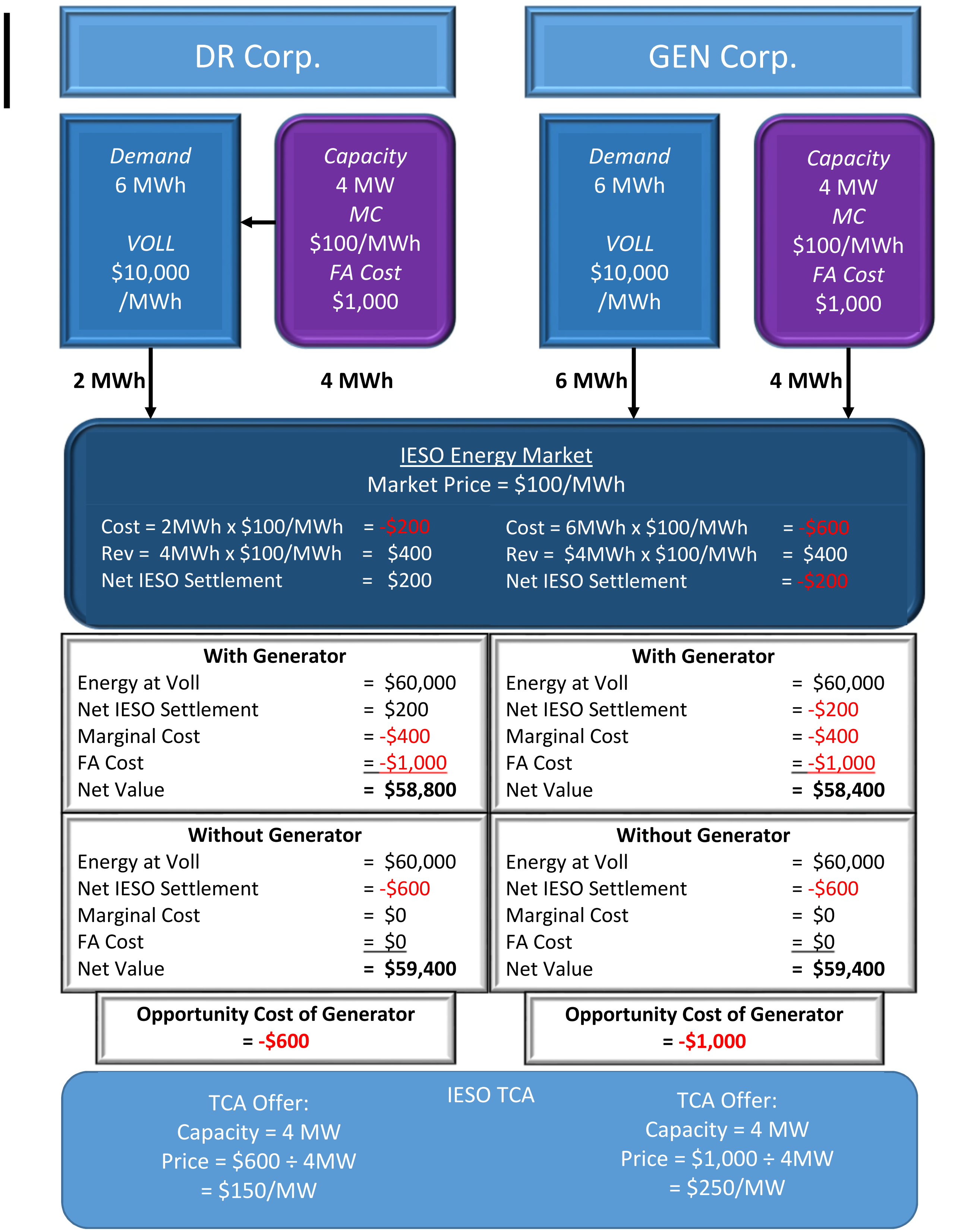
# Figure 1.A: No Energy Payments for DR Resources



## Figure 1.B: Energy Payments for DR Resources



## Figure 2.A: No Energy Payments for DR Resources

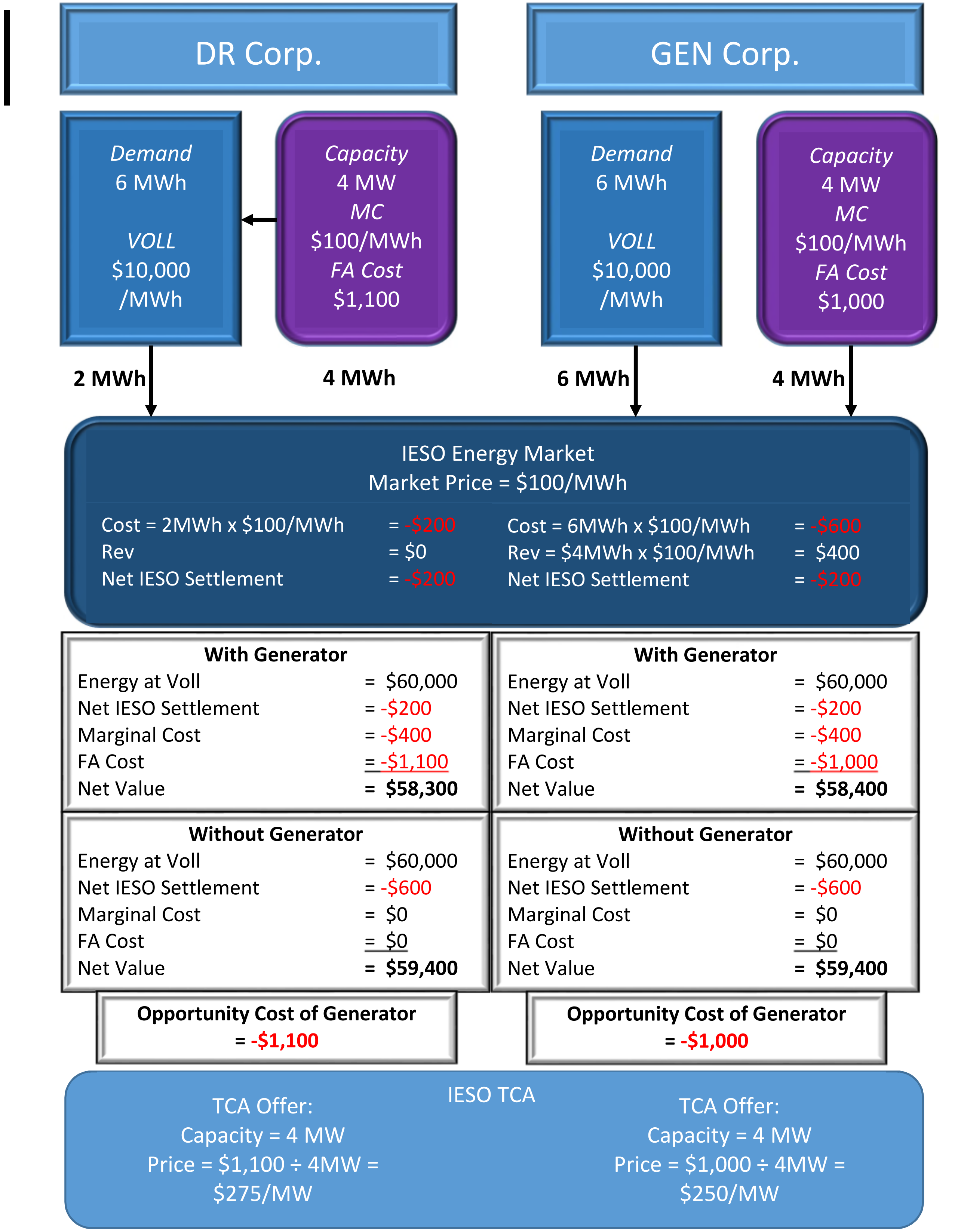


Figure 2.B: Energy Payments for DR Resources

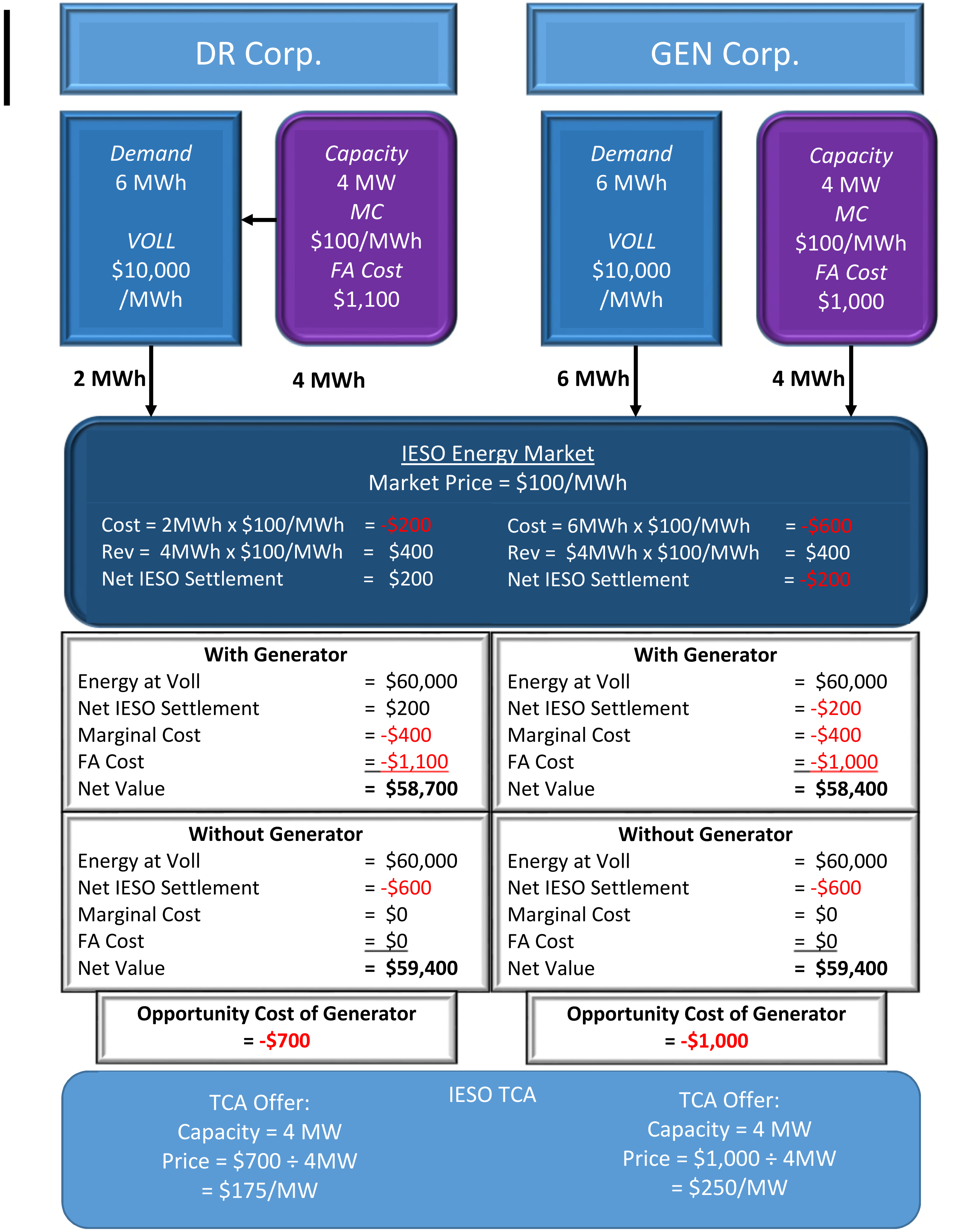
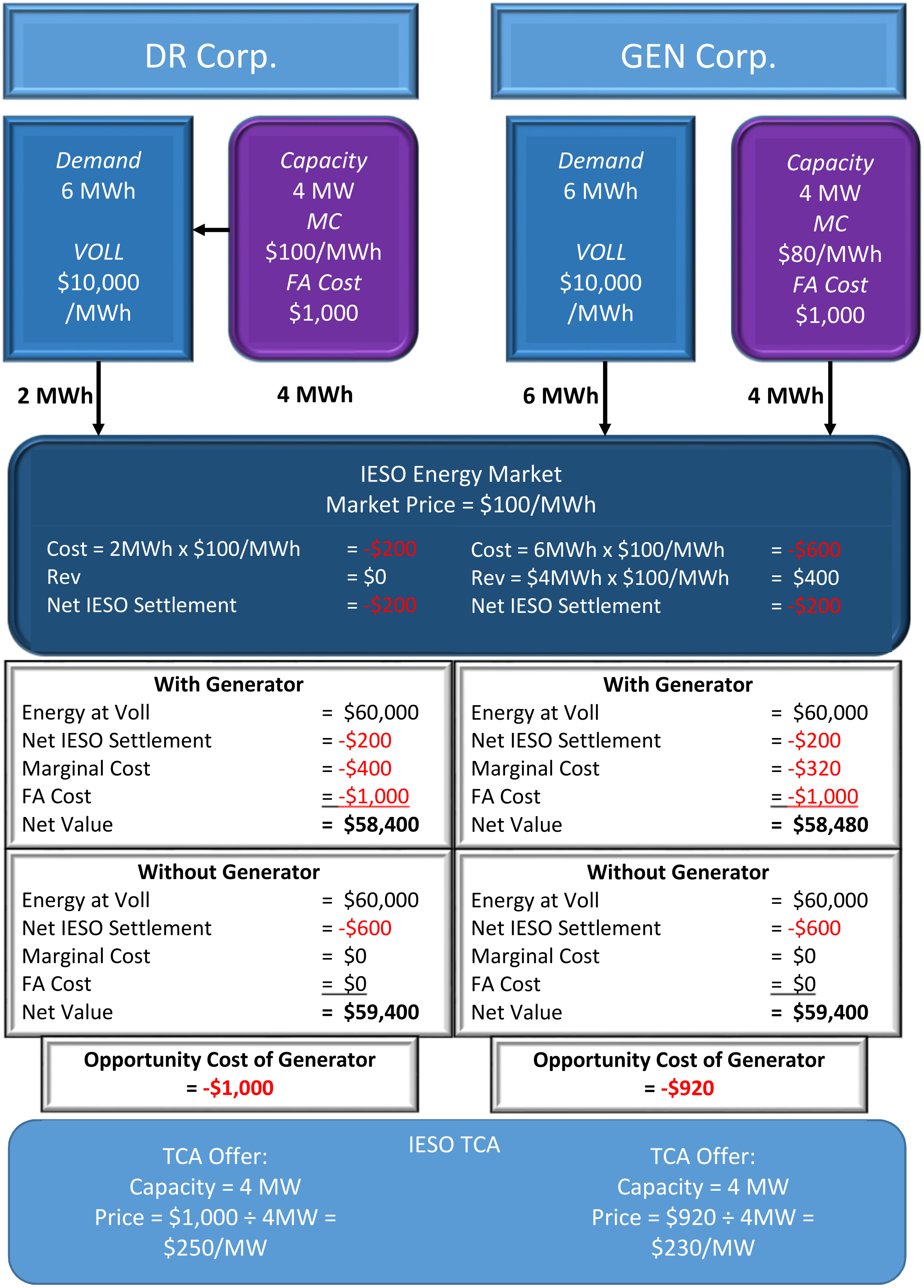
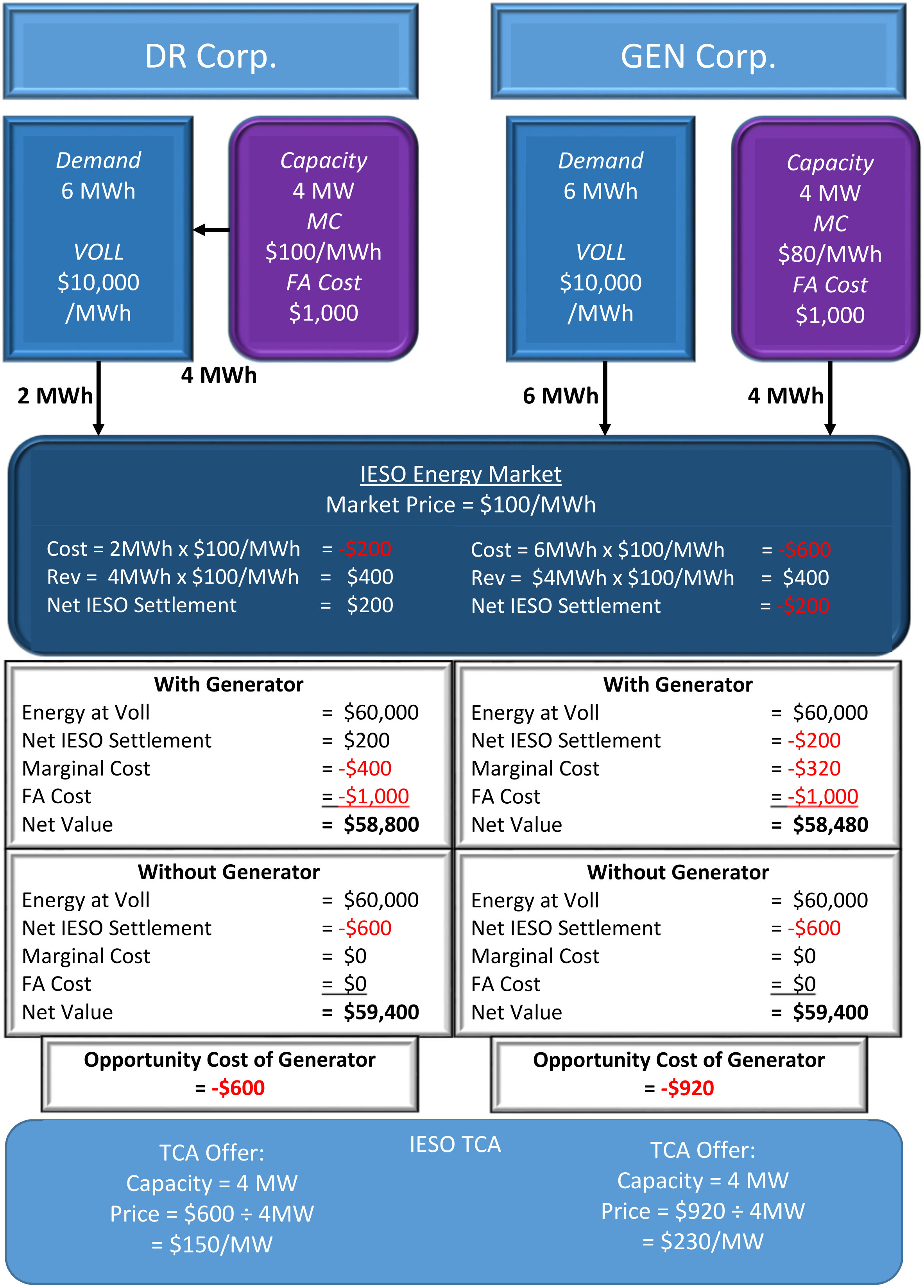


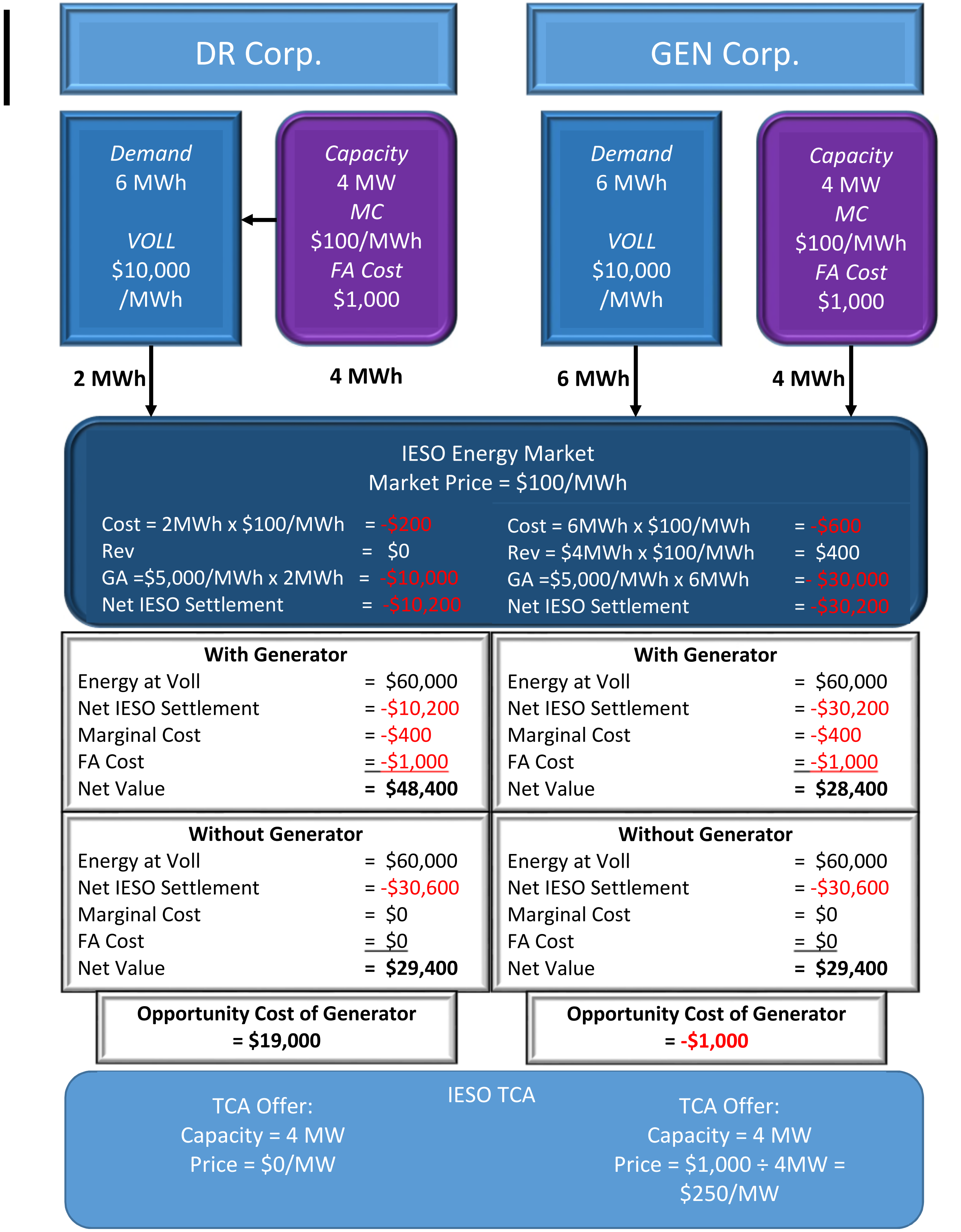
**Figure 3.A: No Energy Payments for DR Resources**



## Figure 3.B: Energy Payments for DR Resources



## Figure 4.A: No Energy Payments for DR Resources



## Figure 4.B: Energy Payments for DR Resources