Analysis of Load Payments and Expenditures under Different Demand Response Compensation Schemes

PJM Interconnection

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Introduction

On March 18, 2010 the United States Federal Energy Regulatory Commission ("FERC" or "Commission") issued a Notice of Proposed Rule Making ("NOPR") regarding compensation of demand response in wholesale energy market in docket RM10-17-000 ("DR NOPR"). This DR NOPR has incorporated by notice the original filing made by PJM in docket EL09-68-000 regarding compensation for demand response in its wholesale energy market and associated comments and interventions made by various parties regarding PJM's filing.

In conjunction with the DR NOPR, the Maryland Public Service Commission ("MD PSC") submitted to PJM on April 9, 2010 a formal request for analysis that models different demand response pricing alternatives related to so-called "LMP – G" pricing and "full LMP" pricing of demand response in all hours and in the top 100 hours at three different levels of demand response. The formal request submitted by the MD PSC is included as Attachment A to this analysis.

The MD PSC requested the analysis provide estimates of compensation paid to demand response under different compensation schemes by remaining load that did not demand respond, reductions in expenditures resulting from reduced LMPs resulting from demand response to remaining load that did not demand respond, and the "net cost/benefit to all ratepayers" consisting of reduced expenditures less payments made to support the compensation scheme.

Characterization of the Analysis

The analysis requested by the MD PSC is an analysis of payments to demand responders, reduced expenditures to load that did not engage in demand response, and the net difference between the reduced expenditures of load that did not engage in demand response and the payments made by that load to demand responders in order to maintain the analyzed compensation mechanism while leaving the load serving entity revenue neutral.

The amount of demand response in each scenario is taken as given in the analysis and is not driven by differences in demand response compensation.

The analysis also assumes a rate structure at the retail level where any parties that demand respond, do not have the difference between their assumed baseline consumption and actual consumption metered or billed by the LSE. For example, suppose a load has an assumed baseline consumption level of 5 MWh for a particular hour and pays a fixed rate of $90/MWh. In the absence of demand response the customer would be metered at 5 MWh and pay a total of $450 for that hour. However, if the load customer engaged in demand response and consumed only 3 MWh, only the 3 MWh would be metered and billed and the customer would pay a total of $270 for that hour.

The requested analysis is not a full cost-benefit analysis as the request centered on payments made to demand response and reduced expenditures for load customers not engaging in demand response. No request was made, and consequently no attempt was made to examine the changes in production cost associated with demand response.

The requested analysis is also not a market efficiency analysis to examine increases or decreases in market efficiency related to the various pricing mechanisms for which the MD PSC requested the analysis. Such an analysis would require specific knowledge and examination of generation supply curves which PJM does possess, and robust estimates of willingness to pay and price elasticity of demand which are much more uncertain and require many assumptions to model.

Finally, the analysis undertaken by PJM is not a behavioral analysis of how much demand response would change under different demand response compensation schemes as this would also require robust estimates of willingness to pay and price elasticity of demand which are much more uncertain as well as many assumptions regarding the ability of demand to receive and respond to price signals from the wholesale market.

Modeling Strategy

In order to conduct the analysis, PJM ran future year scenarios in PROMOD, which is used by PJM staff for market efficiency analyses as a part of the Regional Transmission Expansion Planning (RTEP) process. PROMOD commits resources on a weekly basis and then minimizes the bid production cost of maintaining system energy balance (supply equal to demand) in all hours while maintaining system reliability including ensuring that no transmission facilities are overloaded.

For each yearly scenario run in PROMOD for this analysis, PJM staff captured the hourly zonal LMPs and hourly loads for each transmission zone. The base case without demand response uses forecast system peak loads and hourly loads. Demand response is represented by a separate yearly run with the desired reduction in peak and hourly loads from the base case.

Modeling Scenarios and Assumptions

PJM ran eight year-long scenarios for the future year of 2012 for the entire RTO.

Four scenarios used a natural gas price of $8/mmBtu at four different levels of demand: forecast demand over the entire RTO, 1.5 percent reduction in demand in the BGE and Pepco zones, 3 percent reduction in demand in the BGE and Pepco zones, and a 4.5 percent reduction in demand in the BGE and Pepco zones.

The other four scenarios used a natural gas price of $6/mmBtu at the same demand levels used in the $8/mmBtu gas prices scenarios: forecast demand over the entire RTO, 1.5 percent reduction in demand in the BGE and Pepco zones, 3 percent reduction in demand in the BGE and Pepco zones, and a 4.5 percent reduction in demand in the BGE and Pepco zones.

Other modeling assumptions are the same as those used in the 2009 market efficiency analysis in the 2009 RTEP. In all scenarios the 2013 RTEP transmission upgrades Trail, Susquehanna-Roseland, and Carson-Suffolk are in service.

Review of Cash Flows under Different Demand Response Compensation Schemes

The value of energy in the wholesale market, whether it comes from generation or from demand response, is the prevailing locational marginal price (LMP). In thinking about the discussion surrounding the compensation of demand response, the question is the manner does the value of demand response accrue to market parties impacted by demand response whether it is through a direct payment or through avoided cost, and to which market parties does the value of demand response accrue.

Additionally, for the load serving entities (LSEs) serving the load engaging in demand response, cash flows and avoided costs resulting from demand response may or may not leave the LSE revenue neutral from a wholesale energy market perspective. One reasonable goal from a regulatory perspective may be to ensure that the LSE is left revenue neutral from a wholesale energy market perspective so that LSE does not have an incentive to prevent what would otherwise be efficient demand response, or to promote demand response beyond what would be its efficient levels.

Compensation of "LMP – G"

Assume the usual rate structure at the retail level where any parties that demand respond, do not have the difference between their assumed baseline consumption and actual consumption metered or billed by the LSE. Direct compensation in the wholesale energy market at the prevailing locational marginal price (LMP) less the generation portion of the retail rate is designed to coordinate with the usual retail rate structure assumed above so that the total compensation accruing to the load engaging in demand response in the form of avoided cost and direct payment is equal to the value of energy saved by demand response, LMP.

An example helps show this principle. Consider a load that pays a fixed retail rate with a generation portion of that rate equal to $110/MWh. The load provides 1 MWh of demand response when the LMP equals $200/MWh. The load by reducing usage 1 MWh avoids the $110/MWh generation portion of the retail rate from a wholesale energy market perspective. If the load also receives "LMP – G" as a direct payment which is equal to $200/MWh - $110/MWh = $90/MWh, then the total compensation accruing to the load engaging in 1 MWh of demand response is exactly equal to the value of that demand response of $200/MWh, but accrues through two avenues: avoided cost of $110/MWh and a direct payment of $90/MWh through the wholesale market.

From the perspective of an LSE, "LMP – G" compensation is also revenue neutral from a wholesale energy market perspective. Using the same numbers in the example from the previous paragraph, the LSE with the load engaging in demand response loses $110/MWh in revenue with the 1 MWh of demand response. However, the LSE also gains $200/MWh in avoided cost by not purchasing power in the wholesale energy market to serve the 1 MWh of load reduced, or in the alternative gains $200/MWh in energy market revenue if the 1 MWh of demand response frees up generation that can be sold in the energy market. In PJM, the direct payment of "LMP – G" made to demand response is then billed to the LSE of record, which in this example is $90/MWh. Overall, from an energy market perspective, the LSE is left revenue neutral as the avoided cost or revenue gain of $200/MWh resulting from the demand response is offset by the combined lost revenue from demand response of $110/MWh plus the direct payment of $90/MWh paid to the demand responder and billed to the LSE.

The same principle discussed above applies to load being served by an LSE at a retail rate that is equal to the prevailing LMP. From the demand responder's perspective, the $200/MWh value of energy reduced by the 1 MWh of demand response accrues to the demand responder entirely through the avoided cost of $200/MWh as the "LMP-G" payment is equal to $200/MWh - $200/MWh = $0/MWh. From the LSE's perspective its reduced revenue from the load at the LMP of $200/MWh is offset by the avoided cost or increased revenue of $200/MWh made possible by the 1 MWh of demand response.

From the perspective of the remaining load that has not engaged in demand response, and to the extent that demand response results in reduced wholesale energy market prices, the remaining load will experience reduced energy market expenditures as a result of the demand response. The amount by which expenditures decline will depend on the amount of the price decrease precipitated by the demand response. Moreover, because the LSE is revenue neutral as a result of the "LMP – G" compensation scheme, the reduced expenditures to remaining load are not offset or eroded by any additional payments that are made by the remaining load to make the LSE revenue neutral.

Compensation at "Full LMP"

Again, assume the usual rate structure at the retail level where any parties that demand respond, do not have the difference between their assumed baseline consumption and actual consumption metered or billed by the LSE. Direct compensation in the wholesale energy market at the prevailing locational marginal price (LMP) without offset ("Full LMP") takes the perspective that the direct payment to loads engaging in demand response should be directly paid the market value of energy, LMP, without regard to the retail rate structure. Under the assumed, usual retail rate structure the total compensation accruing to the demand responder in the form of avoided cost and direct payment exceeds the market value of energy reduced and requires the LSE to recover additional costs from remaining load in order to remain revenue neutral.

As before an example helps show more concretely the cash flows. Consider the same load as above that pays a fixed retail rate with a generation portion of that rate equal to $110/MWh. The load provides 1 MWh of demand response when the LMP equals $200/MWh. The load by reducing usage 1 MWh avoids the $110/MWh generation portion of the retail rate from a wholesale energy market perspective. If the load also receives "Full LMP" as a direct payment which is equal to $200/MWh then the total compensation accruing to the load engaging in 1 MWh of demand response is the $110/MWh avoided cost plus the direct payment of $200/MWh which equals $310/MWh and exceeds the market value of energy by the generation portion of the retail rate of $110/MWh.

From the perspective of an LSE, "Full LMP" compensation is revenue neutral from a wholesale energy market perspective only if the compensation over and above the market value of energy can be collected from elsewhere, usually from all remaining load being served. The LSE with the load engaging in demand response loses $110/MWh in revenue with the 1 MWh of demand response. However, the LSE also gains $200/MWh in avoided cost by not purchasing power in the wholesale energy market to serve the 1 MWh of load reduced, or in the alternative gains $200/MWh in energy market revenue if the 1 MWh of demand response frees up generation that can be sold in the energy market. For the ease of exposition assume the direct payment of "Full LMP" made to demand response is

then billed to the LSE of record, which in this example is $200/MWh. Overall, from an energy market perspective, the LSE is left revenue deficient in the amount of the generation portion of the retail rate of $110/MWh as the avoided cost or revenue gain of $200/MWh resulting from the demand response is offset by the combined lost revenue from demand response of $110/MWh plus the direct payment of $200/MWh paid to the demand responder and billed to the LSE.

The same principle discussed above applies to load being served by an LSE at a retail rate that is equal to the prevailing LMP. From the demand responder's perspective, the total compensation is twice the $200/MWh value of energy resulting from the 1 MWh of demand response. The compensation accruing to the demand responder is equal to the avoided cost of the 1 MWh of energy not consumed at $200/MWh plus the direct payment made to the demand responder of $200/MWh or $400/MWh in total. From the LSE's perspective its reduced revenue from the load at the LMP of $200/MWh is offset by the avoided cost or increased revenue of $200/MWh made possible by the 1 MWh of demand response and the additional $200/MWh direct payment billed to the LSE leaving it revenue deficient.

As discussed above, from the perspective of the remaining load that has not engaged in demand response, and to the extent that demand response results in reduced wholesale energy market prices, the remaining load may experience reduced energy market expenditures as a result of the demand response. However, because the LSE is revenue deficient as a result of the "Full LMP" compensation scheme, any reduced expenditures to remaining load may be offset or eroded by any additional payments that are made by the remaining load to the LSE to make the LSE revenue neutral.

Analysis Results

The heart of the analysis as requested by the MD PSC is to look at the potential reduction in expenditures for the remaining load that did not demand respond due to the potential reductions in LMP due to the demand response and any potential payments made by the remaining load in order to support the demand response compensation scheme and leave the LSE revenue neutral.

As discussed in the context of the modeling scenarios and assumptions, load reductions were modeled to occur only in the BGE and Pepco load zones, while loads in the rest of the RTO are held constant. Results of potential reductions in remaining load expenditures and the offset for any payment made by remaining load to support the compensation scheme while leaving the LSE revenue neutral are reported by zone (BGE, Pepco) and by gas price scenario ($6/mmBtu, $8/mmBtu) for each level of assumed demand response (1.5, 3.0, and 4.5 percent reductions).

Under each scenario, the value of the reduced expenditures for remaining load minus any payment made by remaining load to support the compensation scheme and leave the LSE revenue neutral are reported in the highest priced 100 hours and in all hours. For the "LMP – G" compensation scheme, this dollar figure is exactly equal to the reduced expenditures for remaining load as there is no need for any additional payments from remaining load to support the compensation "LMP – G" compensation scheme and leave the LSE revenue neutral. This dollar figure is reported in the first column in each table below. Demand response is assumed to occur in all hours in this calculation

as the demand response could come from fixed price or LMP customers and the calculation does not depend on which type of customer is demand responding.

For the “Full LMP” scheme, two different figures are reported in the middle and the far right columns of the tables below. These figures are calculated to provide an upper and lower bound on the reduced expenditures for remaining load less any payments made to support “Full LMP” and leave the LSE revenue neutral. The middle column examines “Full LMP” paid assuming that all demand response comes from fixed price customers in the zone. This is the upper bound on the reduced expenditures for remaining load less any payments made to support “Full LMP” and leave the LSE revenue neutral. Moreover it is assumed that for fixed price customers, demand response will only take place in hours when the LMP is greater than the fixed price for load in the zone. In the BGE zone this fixed price is taken to be $106.10/MWh based on 2008 demand response settlements for fixed prices customers in the BGE zone. In the Pepco zone the fixed price is taken to be $93.10/MWh based on 2008 demand response settlements for fixed prices customers in the Pepco zone. The number of hours where LMP exceeds the fixed rate is limited and the consequent dollar figures are smaller than would be the case under “LMP – G” compensation.

The far right column provides the lower bound estimate on the reduced expenditures for remaining load less any payments made to support “Full LMP” and leave the LSE revenue neutral assuming that all demand response comes only from LMP customers where the retail rate is the prevailing LMP in the hour. Given that LMP is the retail rate, demand response is assumed to occur in all hours of the year. As the results in the tables below will show, the lower bound estimates in the highest priced 100 hours are still positive, but when considering all hours in the year, these estimates are large negative figures signifying that for remaining load, the extra payments necessary to support the “Full LMP” while leaving the LSE revenue neutral is far larger that the reduced expenditures from reduced LMPs resulting from demand response resulting in higher costs to the remaining load versus no demand response at all.

BGE Zone and $6/mmBtu Gas Price

Tables 1 and 2 report the results of reduced expenditures for remaining load less any payments to support the compensation scheme. At a $6/mmBtu gas price there are only 83 hours in which the LMP is greater than fixed price rate. The simple average LMP without demand response is $55.53/MWh, and the simple average LMP for 1.5, 3, and 4.5 percent reductions respectively are $55.25/MWh, $55.04/MWh, and $54.85/MWh.

Table 1: Reduced Expenditures of Remaining Load less Payments Made to Support Full LMP in the BGE Zone in the Top 100 Hours at Gas Price of $6/mmBtu

	Reduced Expenditures No Additional Payments (LMP – G)	Fixed Price Customer Full LMP (G = $106.10/MWh)	LMP Customer Full LMP (G = LMP)
1.5% Reduction	$5,786,209	$4,889,593	$4,697,055
3% Reduction	$6,462,468	$4,616,301	$4,311,204
4.5% Reduction	$8,109,482	$5,306,809	$4,930,235

Table 2: Reduced Expenditures of Remaining Load less Payments Made to Support Full LMP in the BGE Zone in All Hours at Gas Price of $6/mmBtu

	Reduced Expenditures No Additional Payments (LMP – G)	Fixed Price Customer Full LMP (G = $106.10/MWh)	LMP Customer Full LMP (G = LMP)
1.5% Reduction	$13,871,846	$4,889,593	-$17,283,477
3% Reduction	$20,865,819	$4,616,301	-$41,044,952
4.5% Reduction	$29,203,374	$5,306,809	-$63,312,645

BGE Zone and $8/mmBtu Gas Price

Tables 3 and 4 report the results of reduced expenditures for remaining load, less any payments to support the compensation scheme. At an $8/mmBtu gas price there are 169 hours in which the LMP is greater than the fixed price rate. The simple average LMP without demand response is $62.89/MWh, and the simple average LMP for 1.5, 3, and 4.5 percent reductions respectively are $62.56/MWh, $62.31/MWh, and $62.01/MWh.

Table 3: Reduced Expenditures of Remaining Load less Payments Made to Support Full LMP in the BGE Zone in the Top 100 Hours at Gas Price of $8/mmBtu

	Reduced Expenditures No Additional Payments (LMP – G)	Fixed Price Customer Full LMP (G = $106.10/MWh)	LMP Customer Full LMP (G = LMP)
1.5% Reduction	$4,011,633	$3,048,351	$2,824,301
3% Reduction	$5,850,735	$3,854,676	$3,400,531
4.5% Reduction	$7,522,542	$4,498,268	$3,901,284

Table 4: Reduced Expenditures of Remaining Load less Payments Made to Support Full LMP in the BGE Zone in the All Hours at Gas Price of $8/mmBtu

	Reduced Expenditures No Additional Payments (LMP – G)	Fixed Price Customer Full LMP (G = $106.10/MWh)	LMP Customer Full LMP (G = LMP)
1.5% Reduction	$14,658,668	$3,105,543	-$20,747,020
3% Reduction	$26,102,236	$3,510,463	-$44,419,731
4.5% Reduction	$37,714,760	$4,048,669	-$67,447,037

Percentage of Highest Priced Hours Supporting Net Reduced Expenditures in BGE Zone: LMP Customers

Given the large negative values of reduced expenditures less payments made to support "Full LMP" under the assumption of only LMP customers engaging in demand response in all hours, PJM examined the percentage of highest priced hours in the year in which the reduced expenditure less payments would remain positive. Table 5 shows that this percentage of highest priced hours declines with higher gas prices (and higher LMPs) and with increased assumed demand response.

Table 5: Percentage of Highest Priced Hours: Reduced Expenditures of Remaining Load Exceeds Payments Made to Support Full LMP in the BGE Zone

	1.5% Reduction	3% Reduction	4.5% Reduction
Low Gas Price ($6)	21%	10%	9%
Base Gas Price ($8)	13%	7%	6%

Pepco Zone and $6/mmBtu Gas Price

Tables 6 and 7 report the results of reduced expenditures for remaining load, less any payments to support the compensation scheme. At a $6/mmBtu gas price there are only 140 hours in which the LMP is greater than the fixed price rate. The simple average LMP without demand response is $54.64/MWh, and the simple average LMP for 1.5, 3, and 4.5 percent reductions respectively are $54.39/MWh, $54.19/MWh, and $54.01/MWh.

Table 6: Reduced Expenditures of Remaining Load less Payments Made to Support Full LMP in the Pepco Zone in the Top 100 Hours at Gas Price of $6/mmBtu

	Reduced Expenditures No Additional Payments (LMP – G)	Fixed Price Customer Full LMP (G = $93.10/MWh)	LMP Customer Full LMP (G = LMP)
1.5% Reduction	$4,505,116	$3,712,694	$3,558,594
3% Reduction	$4,929,250	$3,366,939	$3,098,058
4.5% Reduction	$5,968,781	$3,652,267	$3,352,040

Table 7: Reduced Expenditures of Remaining Load less Payments Made to Support Full LMP in the Pepco Zone in All Hours at Gas Price of $6/mmBtu

	Reduced Expenditures No Additional Payments (LMP – G)	Fixed Price Customer Full LMP (G = $93.10/MWh)	LMP Customer Full LMP (G = LMP)
1.5% Reduction	$10,752,905	$3,548,404	-$18,094,833
3% Reduction	$16,201,234	$3,171,679	-$41,100,761
4.5% Reduction	$22,736,431	$3,145,418	-$62,850,123

Pepco Zone and $8/mmBtu Gas Price

Tables 8 and 9 report the results of reduced expenditures for remaining load, less any payments to support the compensation scheme. At an $8/mmBtu gas price there are 268 hours in which the LMP is greater than the fixed price rate. The simple average LMP without demand response is $61.83/MWh, and the simple average LMP for 1.5, 3, and 4.5 percent reductions respectively are $61.55/MWh, $61.32/MWh, and $61.06/MWh.

Table 8: Reduced Expenditures of Remaining Load less Payments Made to Support Full LMP in the Pepco Zone in the Top 100 Hours at Gas Price of $8/mmBtu

	Reduced Expenditures No Additional Payments (LMP – G)	Fixed Price Customer Full LMP (G = $93.10/MWh)	LMP Customer Full LMP (G = LMP)
1.5% Reduction	$2,741,249	$1,948,223	$1,709,156
3% Reduction	$4,652,143	$3,010,510	$2,549,377
4.5% Reduction	$5,607,656	$3,144,975	$2,512,276

Table 9: Reduced Expenditures of Remaining Load less Payments Made to Support Full LMP in the Pepco Zone in the All Hours at Gas Price of $8/mmBtu

	Reduced Expenditures No Additional Payments (LMP – G)	Fixed Price Customer Full LMP (G = $93.10/MWh)	LMP Customer Full LMP (G = LMP)
1.5% Reduction	$11,742,263	$2,139,701	-$21,042,212
3% Reduction	$21,348,107	$2,232,805	-$43,964,342
4.5% Reduction	$30,305,736	$1,817,601	-$67,203,118

Percentage of Highest Priced Hours Supporting Net Reduced Expenditures in Pepco Zone: LMP Customers

Given the large negative values of reduced expenditures less payments made to support "Full LMP" under the assumption of only LMP customers engaging in demand response in all hours, PJM examined the percentage of highest priced hours in the year in which the reduced expenditure less payments would remain positive. Table 10 shows that this percentage of highest priced hours declines with higher gas prices (and higher LMPs) and with increased assumed demand response.

Table 10: Percentage of Highest Priced Hours: Reduced Expenditures of Remaining Load Exceeds Payments Made to Support Full LMP in the Pepco Zone

	1.5% Reduction	3% Reduction	4.5% Reduction
Low Gas Price ($6)	15%	6%	6%
Base Gas Price ($8)	11%	6%	4%