# Providing Incentives for Efficient Demand Response

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## Summary

PJM has proposed new demand response payment rules. Demand response programs can provide substantial benefits, if the benefits are appropriately defined and the payments are properly structured. The principle of putting supply and demand options on a level playing field provides the framework for evaluating the sometimes conflicting arguments offered in comments on the PJM proposals.

Some arguments for demand response payments address conditions when locational marginal prices (LMPs) do not provide sufficient incentives for demand reduction because LMPs do not represent the marginal cost of serving load. If the assertion is correct, the principle points to policies to incorporate the full cost in the LMP. For example, the PJM proposal to pay a premium for demand response during the nine percent of hours with the highest LMPs violates the principle of maintaining symmetry with supply options. If the premium is warranted, a better policy would be to incorporate the premium in the LMP applicable in the symmetric way to both supply and demand.

In cases where the LMP does represent the marginal cost of supply, the benchmark for evaluating demand response programs would be the net payments under a system of dynamic pricing and explicit contracts. The net payment to the customer would be the LMP minus the contract price. Paying LMP for demand response without any compensating adjustment would be inappropriate in all cases other than a circumstance where the customer would otherwise take the power for free.

The PJM proposals to pay for demand response provided by customers paying fixed prices and by customers paying LMP can be seen as attempts to approximate the benchmark payment structure in circumstances where there may not be dynamic pricing or the contracts are only implicit. For properly structured demand response payments, an alternative approach would avoid requiring PJM to estimate the fixed prices implicit in customer contracts and tariffs. Using an unbundled transaction model, the demand response system could replicate the benchmark structure by treating the implicit purchase contract as an explicit contract for the demand response quantity estimate. This would inherently provide a better match by creating a settlement system that used the actual price each customer pays without requiring PJM to take responsibility for untangling or averaging the many different customers' contracts and tariffs.

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Demand response programs can provide substantial benefits, but not all the benefits offered in support of demand response payments would justify public policy support or provide a good match between ends and means. Properly structured payments for demand response would follow the benchmark of dynamic pricing and explicit contracts. A survey of the conflicting arguments provides a basis for interpreting alternative payment schemes that adhere to the principle of providing a level playing field between demand and supply options.

## I. Introduction

This paper was prepared at the request of the Electric Power Supply Association in connection with the consideration of demand response programs in the PJM Interconnection.[1] While the concept of demand response is not new, policy for supporting various types of demand response have received additional attention and emphasis. This has led to disputes regarding the correct mechanism for incorporating demand response in the electricity markets that have been developed in recent years, such as the PJM market. These disputes include many related but sometimes conflicting arguments. Facilitating the development of additional demand response resources could provide many benefits, but it is important to consider the costs and the benefits in the context of the existing market structure in order to determine appropriate policy design. The purpose of this paper is to outline the policy implications of some of the conflicting arguments.

## II. Benefits of Demand Response

Support for increased demand response arises from arguments offered for a number of possible avenues for achieving additional benefits, including:

- Making the market more efficient.
- Reducing the price paid for power by load.
- Reducing environmental externalities.
- Providing reliability benefits.
- Reducing the cost of developing additional demand response resources.

[1] The matter deals with the Economic Load Response Program, PJM Interconnection, L.L.C. submission to Federal Energy Regulatory Commission, ("PJM Filing") Docket No. EL09-68-000 (originally Docket No. EL08-12), August 26, 2009.

Although not comprehensive, this list of types of benefits spans a wide range of conditions under which both demand and supply alternatives interact with electricity market design. Separating the arguments helps clarify the role of payments for demand response.

### A. Making Markets More Efficient

Measures that facilitate participation of demand response in the market would permit increased efficiency *if* demand response is properly compensated. As Amory Lovins said a quarter-century ago, "as long as it is cheaper to save electricity than to make it, both utilities and ratepayers can benefit from properly structured utility financial participation in efficiency."[2] The passage of time and the enormous changes that have occurred in electricity markets have not affected the truth of this claim, but a corollary to this observation is that if demand response is improperly compensated, hoped-for increases in efficiency may not materialize, as either too much or too little demand response may be developed. What constitutes the proper structure and level of compensation?

Demand response supporters have emphasized the importance of developing demand response programs that put demand response resources and generation resources on a "level playing field." In this docket, the Demand Response Supporters' Protest asserts that their proposal for paying demand response providers would "ensure comparability between generation and demand-side resources,"[3] and affidavits submitted in support of that protest state, "It is critical that electricity consumption and production trade off on equal footing,"[4] and assert that "demand response should be treated … in a fashion comparable to supply side resources,"[5] and that "[a]nything less … will deprive customers of the benefits that demand response can bring to the electricity markets."[6] These assertions are correct: if demand response and generation are not treated symmetrically, inefficiency is the likely result. The task is to identify the symmetrical treatment.

Economic efficiency can be defined in terms of maximizing social welfare, which is simply the full value that those who consume a good place upon those goods, less the full cost to produce those goods. In a competitive equilibrium with full internalization of all the costs, social welfare is maximized. This means that there are no remaining unconsummated trades that would increase social welfare, because the cost for each producer to supply more of that good than it produces in equilibrium must be greater than the value that each consumer of that good places upon consuming more of that good than

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2 Amory B. Lovins, "Saving Gigabucks with Negawatts," *Public Utilities Fortnightly*, Vol. 115, No. 6, Mar. 21, 1985, p. 24.

3 Comments and Protest of Demand Response Supporters ("Demand Response Supporters' Protest"), Docket No. EL09-68-000, Sept. 16, 2009, at 9.

4 Demand Response Supporters' Protest, Att. B (Affidavit of Dr. Eric Woychik on Behalf of Demand Response Supporters) at 2.

5 Demand Response Supporters' Protest, Att. C (Affidavit of Allen M. Freifeld on Behalf of Demand Response Supporters) ("Freifeld Affidavit") at 23.

6 *Id.*

it consumes in equilibrium. It also means that all of the trades that are currently being undertaken increase social welfare, because the cost for each producer to supply the amount of that good that it produces in equilibrium must be less than the value that each consumer of that good places upon consuming the amount of that good that it consumes in equilibrium.

If the good in question is electricity at a given time and place, and if the electricity market locational marginal price (LMP) is the marginal cost of providing electricity to meet an increment of load at that time and place, then social welfare is maximized if all consumers in that place consume electricity to the extent that the value they place upon that consumption exceeds LMP, and if all producers at that location produce electricity to the extent that their cost of doing so is less than LMP. Therefore, if the procedure for compensating demand response providers ensures that they will not consume electricity in cases when the value of that electricity to them is less than LMP, and that they will consume electricity in cases when the value of that electricity to them is greater than LMP, it promotes an efficient outcome. If the procedure for compensating demand response providers does not produce such results, it does not produce an efficient outcome. Procedures for compensating demand response providers that do not place demand response providers and generators on a level playing field will produce inefficient outcomes.

### *B. Reducing the Price Paid by Load*

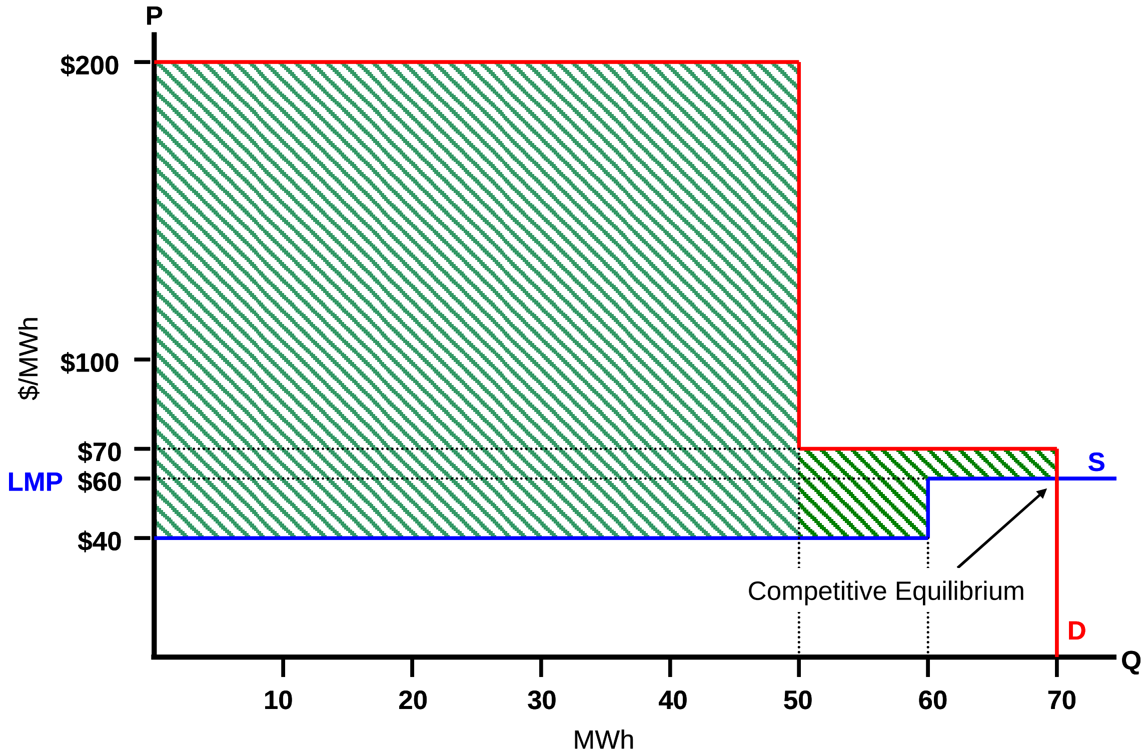
In addition to balancing consumption with the cost represented by LMP in the organized electricity markets, demand response may also decrease the price paid by load for the electricity that load does consume. With a given supply, lower demand should yield lower prices and this is certainly a benefit for the load, at least in the short run. Some of the comments submitted in this proceeding apparently assume that maximizing social welfare and minimizing the price that is paid by load are similar objectives. They are not, for essentially the same reason why maximizing social welfare is not the same as maximizing the revenues that suppliers receive.

In the competitive equilibrium, the difference between the amount that buyers are willing to pay and the costs that suppliers incur is maximized. This criterion takes both the gains to trade that buyers realize (because they can purchase goods for less than the amount they were willing to pay) and the gains to trade that suppliers realize (because they can sell goods for more than the marginal costs of producing those goods) into consideration. In contrast, monopolists generally restrict the quantity of a good that is available so that it is less than would have been provided in the competitive equilibrium. This leads to a reduction in efficiency, as the monopolist will forego the opportunity to sell to some customers, even though the customers are willing to pay more than his marginal cost of production, because this forces up the price charged to the remaining customers, and therefore causes the monopolist's profits to be higher than they would have been in the competitive equilibrium.

Similarly, the amount purchased by a monopsonist (i.e., a single buyer) will generally not be the amount purchased in an efficient competitive equilibrium. Instead, the monopsonist will attempt to purchase an amount that will reduce the price paid, and maximize the difference between the total amount it pays and the amount it was willing to pay (which is the buyer's analog to the net profits earned by a seller). Since the monopsonist is not buying the amount it would purchase in the competitive equilibrium, this once more is inefficient. From the perspective of efficiency and social welfare maximization, reducing consumption to facilitate the exercise of monopsony power is no better a rationale for adopting a demand response program than would be reducing production to facilitate the exercise of monopoly power.

A simple example illustrates how adopting an objective of minimizing prices may lead to inefficient outcomes. Assume that consumers at a given location may wish to consume as much as 70 MWh of electricity. They value the first 50 MWh of potential consumption at $200/MWh, and the next 20 MWh at $70/MWh. Also assume that two 60 MW generators are available at that location: the first generator can produce electricity at a cost of $40/MWh, and the second generator can produce electricity at a cost of $60/MWh. In that case, the competitive equilibrium is for the first generator to produce 60 MWh, for the second generator to produce 10 MWh, and for load to consume all 70 MWh. The LMP is $60/MWh, which is the cost of generating additional electricity using the second generator. Social welfare in this example is $8400, as illustrated by the shaded area in Fig. 1, which is the value that consumers place upon the electricity consumed (50 MWh × $200/MWh + 20 MWh × $70/MWh = $11,400), less the cost to producers of producing this electricity (60 MWh × $40/MWh + 10 MWh × $60/MWh = $3000). It is not efficient to reduce consumption in this case, since the value placed upon consuming the last MWh of electricity consumed, $70/MWh, is greater than the $60/MWh in cost savings that would result from reducing the second generator's output. Therefore, reducing consumption would reduce social welfare.

**Figure 1: Social Welfare in the Competitive Equilibrium**



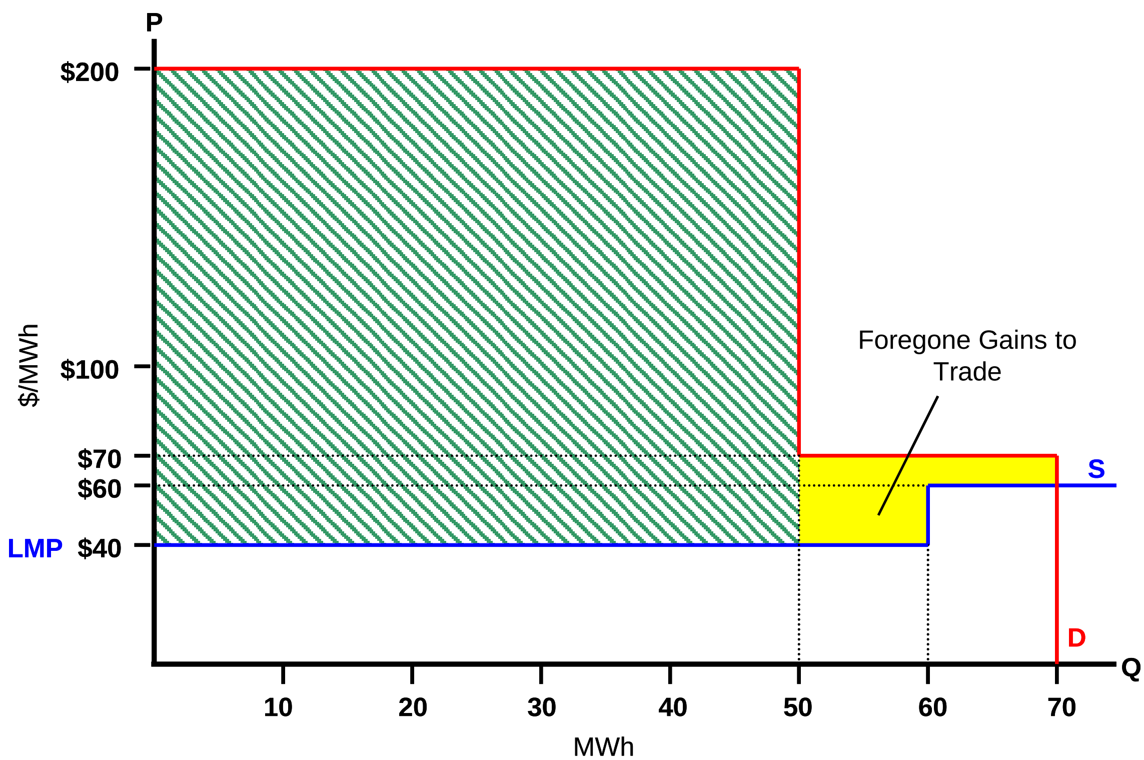

Suppose that a demand response program pays consumers the LMP for each MWh of electricity that they do not consume. Given the structure of this demand response program, it would be in the interest of consumers not to consume the 20 MWh of electricity that they value at $70/MWh, thereby reducing consumption to 50 MWh. This would cause the second generator to shut down and the first generator to reduce its output to 50 MWh, which would cause the LMP to fall to the first generator's marginal cost of $40/MWh. If customers were to consume additional electricity, and were to pay the LMP for it, they would receive electricity that is worth $70/MWh – $40/MWh = $30/MWh more than they are paying for it. But they are better off if they do not consume that electricity, and receive the $40/MWh demand response payment instead. Therefore, it is in their individual self-interest to participate in the demand response program.

Despite the fact that this demand response program has decreased LMP,[7] it has not increased social welfare. Instead, social welfare has fallen from $8400 to 50 MWh × $200/MWh – 50 MWh × $40/MWh = $8000, as illustrated by the shaded area in Fig. 2.

[7] The demand response program has also decreased the amount that consumers pay per MWh consumed, even if the cost of the demand response program is recovered from those who continue to consume electricity. The cost of the payments under the demand response program in this example is 20 MWh × $40/MWh = $800, or $16/MWh for each of the 50 MWh that continue to be consumed; when added to the $40/MWh LMP, that produces a total charge of $56/MWh, which is less than the $60/MWh LMP in the absence of this program. However, slight changes to the assumptions in this example can produce the opposite result: the demand response program can increase the total amount paid by loads that continue to consume electricity even while lowering the LMP they pay.

The reason is that this demand response payment has caused load not to consume electricity that it values at $70/MWh, even though that electricity can be produced at a marginal cost of less than $70/MWh. While the demand response program has produced additional demand response, and has reduced LMP, the demand response that it has produced is inefficient, causing a reduction in social welfare equal to the yellow area in Fig. 2.

**Figure 2: Reduction in Social Welfare Resulting from Programs That Provide Incentives for Inefficiently Large Amounts of Demand Response**




Therefore, it is not appropriate to design demand response programs with the explicit goal of reducing prices, or to recognize such programs as providing "a price mitigation service to all load in the region,"[8] as advocated by Allen Freifeld on behalf of the Demand Response Providers. To be sure, price reductions may be a result of properly designed programs for compensating demand response providers, which would ensure that consumers do not consume electricity when the value they place upon that electricity is less than the marginal cost of producing that electricity. But contrary to Freifeld, price reductions and improvements in efficiency are not the same thing,[9] and making such price reductions the *objective* of demand response programs may yield inefficiently high levels of demand response, as illustrated here.

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8 Freifeld Affidavit at 5.

9 "The reduction in price represents an improvement in the efficiency of the electric grid." Freifeld Affidavit at 8.

### *C. Reducing Environmental Externalities*

The generation and use of electricity imposes costs, many of which are borne by the owners of those generators and passed on to consumers, but some of which may not be. In particular, if the generation of electricity imposes costs in the form of adverse impacts on the environment—e.g., such as those costs resulting from the emission of greenhouse gases. If producers do not bear those costs, they will not include those costs in their offers. Again, from the perspective of efficiency and social welfare maximization, omitting these costs may lead to inefficiently low prices and inefficiently high levels of electricity production and consumption.

In such cases, the development or expansion of programs to provide additional incentives for demand response providers may permit an increase in efficiency.[10] However, the mere fact that such programs lead to additional demand response does not automatically lead to the conclusion that there has been an efficiency gain. That is because the payments made under the demand response program are not connected to the impact of demand response on the externality. As a result, the additional incentives provided by the demand response program may yield more demand response than is efficient, or they may not yield enough. Even if they yield the right amount of demand response, the wrong customers may be providing the demand response. And, most fundamentally, such incentives do nothing to induce electricity suppliers to reduce the environmental externalities they impose on others.

In short, programs that reward demand response providers for their impact on environmental externalities, without providing similar rewards to generators with similar impacts, fail to provide a level playing field. This failure may unnecessarily increase the costs of reducing these externalities. In fact, without a broader program to address environmental impacts as part of the cost of supply, we may not be able to predict even the direction of the effect of a particular demand response in modifying environmental impacts.[11] There are simply better and more effective ways to solve these problems. For example, in the case of greenhouse gas emissions, a price on carbon (through a carbon tax or a cap-and-trade program) would discourage production by resources that emit significant amounts of greenhouse gases. In the longer term, such a price on carbon would discourage development of such resources, while encouraging production by and development of lower emission resources, such as renewables, natural gas, coal with carbon capture and storage, and nuclear power. A price on carbon would also encourage additional demand response, by increasing the price that customers pay to consume electricity, and thereby increasing the amount that they save as a result of not consuming electricity. But it would encourage demand response to the extent, and only to the extent, that demand response is efficient. Pricing carbon and other emissions would encourage customers to stop consuming electricity when, and only when, the value of that electricity to consumers is less than the full cost of producing that electricity, including the costs

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[10] Demand Response Supporters' Protest at 8. Demand Response Supporters' Protest, Att. E (Affidavit of Angela S. Beehler On Behalf of Demand Response Supporters) ("Beehler Affidavit") at 3.

[11] Aleksandr Rudkevich, "Economics of CO2 Emissions in Power Systems," CRA International, February 15, 2009. Available at www.hks.harvard.edu/hepg/.

associated with greenhouse gas emissions or other environmental externalities. It would also encourage the production of electricity by resources whose full cost, including the costs associated with these externalities, is lower than the full cost of other resources with higher emissions, and this change in the mix of generating resources might reduce the amount of demand response that is efficient. In sum, pricing carbon or other emissions would address the problem directly, instead of indirectly by tilting the playing field among various options for reducing these externalities.

### *D. Providing Reliability Benefits*

Another argument offered in favor of expanded demand response programs is that LMP is less than the actual marginal cost of electricity. As Alfred Kahn stated in an affidavit filed in this docket, this can arise due to "the increasing probability, as output gets closer and closer to the physical limits of generating capacity, the costs of which are orders of magnitude higher than the marginal costs of actual generation. Such shortages can come on quite quickly, from unanticipated losses of generating equipment, unanticipated surges in demand, or some combination of the two. In such cases, the true marginal costs of energy far exceed LMP."[12]

Although Dr. Kahn did not demonstrate that "the true marginal costs of energy far exceed LMP," there is no doubt that a variety of factors have caused LMPs to understate the true marginal value of electricity in some markets, at some locations and at some times. The general problem goes under the label of needing better scarcity pricing when the system is generation capacity constrained. While PJM has developed procedures for modifying prices to reflect the cost of possible shortages, with the intention of addressing concerns such as Dr. Kahn's, it is possible that those procedures may not fully reflect those costs, thereby yielding understated LMPs. In addition, offer caps and market power mitigation measures interact with inadequate scarcity pricing to depress prices determined in the dispatch. Furthermore, procedures for committing resources may cause excessive amounts of capacity to be committed, thereby reducing the marginal cost of producing electricity (and LMP) since committed resources must operate at minimum load levels. These pricing matters are of active concern before the Commission, and there is work underway to develop better policies to address these pricing defects.[13]

If we assume that Dr. Kahn's assertion is correct, and that the marginal cost of electricity sometimes exceeds LMP, then the ability for customers to avoid paying LMP if they reduce consumption will provide less of an incentive for them to reduce consumption than it would provide if LMPs fully reflected the marginal cost of energy. As a result, it is likely that there will be a suboptimal amount of demand response, and the development or expansion of programs to provide additional incentives for demand response providers might result in efficiency gains, as consumers who would have reduced consumption if they had faced the full marginal cost of power, but do not reduce consumption if they

[12] Demand Response Supporters' Protest, Att. A (Affidavit of Alfred E. Kahn) at 5.

[13] William W. Hogan, "On an 'Energy Only' Electricity Market Design for Resource Adequacy," Harvard University, September 23, 2005. Paul R. Gribik, William W. Hogan and Susan L. Pope, "Market-Clearing Electricity Prices and Energy Uplift," Harvard University, December 31, 2007. Available at www.whogan.com.

only must pay LMP, might reduce their consumption if given an additional incentive to do so. But once more, just as in the case of environmental externalities, simply because such programs lead to additional demand response does not automatically lead to the conclusion that there has been an efficiency gain. The additional incentives may yield more demand response than is efficient, or they may not yield enough. Even if they yield the right amount of demand response, the wrong customers may be providing the demand response. And, most fundamentally, such incentives do nothing to induce electricity suppliers to produce electricity, even at very high costs, when the value of electricity is very high.

If demand response providers are rewarded for contributions to reliability that are not included in the LMPs, but generators that produce electricity at those times do not receive such rewards, that is not a level playing field. Demand response programs that compensate demand response resources on this basis, but which fail to compensate generators in equivalent circumstances, may produce inefficient outcomes. Again, there are better ways to solve these problems. If LMPs are suppressed for any or all of the reasons described above, and they do not fully recognize the reliability value provided by resources when there is a shortage or near-shortage, procedures for calculating LMPs should be modified so that they properly reflect that reliability value.[14] Similarly, if suboptimal commitment procedures or flawed market power mitigation procedures suppress LMPs, the solution is to modify those commitment procedures so that they do not commit excess capacity or to modify those market power mitigation procedures so that they permit resources to submit offers that accurately reflect their marginal costs.

If LMPs are properly determined, so that they more accurately reflect the incremental cost of electricity at each time and location, and if properly calculating those LMPs causes them to rise, the higher LMPs would encourage demand response, by increasing the price that customers pay to consume electricity, and thereby increasing the amount that they save as a result of not consuming electricity. But the higher LMPs would encourage demand response to the extent, and only to the extent, that demand response is efficient. They would encourage customers to stop consuming electricity when, and only when, the value of that electricity to consumers is less than the full cost of producing that electricity, including the impact on reliability resulting from serving that load. Those LMPs would also encourage the production of electricity by resources whose costs are lower than those LMPs—but higher than the LMPs that would have been calculated using pre-existing procedures that caused LMP to be less than marginal cost—and the resulting increase in the amount of generation that is available in such circumstances might change the amount of demand response that is efficient. Getting the LMPs right would address the problem directly, instead of indirectly and suboptimally.

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14 A reform of the operating reserve demand curve implementations would be one policy to better price reliability and help solve the "chicken-and-egg" dilemma of stimulating more demand-side bidding. See William W. Hogan, "A Model for a Zonal Operating Reserve Demand Curve," MIT Presentation, October 15, 2009, available at www.whogan.com.

### *E. Reducing the Cost of Developing Additional Demand Response Resources*

Another argument for providing additional incentives to demand response providers relates to the learning curve associated with identifying loads that can effectively provide demand response, and integrating those resources into the grid, from both an operational and a market perspective. The argument is that subsidizing these resources now will promote their development, thereby driving down the cost of developing additional resources, which would eliminate the need to subsidize them in the future. This is closely related to the learning-by-doing benefit that may create an externality not incorporated in market prices.

The challenge is not the same thing as overcoming the transaction costs that are associated with organizing efficient demand response—i.e., the costs of identifying resources that can provide demand response, assessing their operations, and determining which changes in those operations would permit them to provide demand response in a cost-effective manner. The transaction cost problem may be a real obstacle, but the transaction costs are also real costs. Unless there is some policy that easily eliminates the transaction costs, there is no reason to single out these costs as identifying an externality that must be overcome by special payments. Reducing transaction costs and developing a profitable operation is a challenge for business but not a sign of a market failure. In other words, getting started with a technology and learning how to improve that technology so that it can be competitive on its own provides a positive (i.e., a beneficial) externality, because these improvements in such a technology lower the costs that will be incurred by developers using that technology in the future, but most of these benefits may not be realized by the entities developing these improvements in the technology. Consequently, granting subsidies to encourage learning-by-doing could produce substantial benefits that could not be captured in private markets. In contrast, transactions costs would apply to each customer that might be able to reduce its consumption. Since there is no externality created here that benefits others, there is no reason to subsidize these costs to ensure efficient outcomes.

Once more, this argument may be correct. But it does not follow that providing additional incentives for demand response providers would necessarily yield improved efficiency. Any such problems should be addressed through programs that are specifically designed to deal with them. These "learning by doing" concerns would be best addressed by limited and targeted pilot programs that estimate the amount of demand response that would need to be integrated into the system in order to provide the necessary amount of "learning" and assess whether the cost associated with subsidizing such programs can be justified, given the anticipated amount of subsidization that will be necessary to provide the required amount of learning. This would not be generalized demand response but would limit eligibility for the program to the quantity and types of resources required in order to provide the required amount of learning.[15] In contrast, approaches that provide additional compensation to all demand response providers may

[15] Arthur van Benthem, Kenneth Gillingham and James Sweeney, "Learning by-Doing and the Optimal Solar Policy in California," *The Energy Journal*, Vol. 29, No. 3, 2008. Pages 153-176.

not address the problems they are intended to address, and may cause other problems. The additional compensation may not induce development of sufficient demand response to realize the program's objectives, in which case the anticipated efficiency gains resulting from the program will not be realized. Alternatively, the additional compensation more demand response than was needed to meet the program's objectives, in which case a significant portion of program expenditures may be wasted because they will be subsidizing the development of more demand response than is necessary to realize the program's objectives. Finally, the program itself may not be cost-justified, in that its cost may exceed the benefits expected to be reaped from it even if the program induces development of the desired amount of demand response. Once again, it would be better to address the problem directly, instead of indirectly and suboptimally.

### *F. Matching Ends and Means*

These latter benefits often argued for demand response—namely, that additional demand response will reduce consumption and therefore reduce environmental externalities associated with generating electricity for consumption, that it will provide reliability benefits by reducing consumption in cases where LMP is less than the marginal cost of electricity, and that, by encouraging more rapid growth of demand response resources, it will promote their development and facilitate integrating them into the grid—may be reasonable goals. In each case, it is possible that current market outcomes are inefficient, and that modifications are required to increase the amount of demand response and improve efficiency. Consequently, in each of these cases, it is possible that increasing compensation for demand response providers would improve efficiency. But in each of these cases, it is also possible that simply increasing compensation for demand response providers would reduce efficiency, because increasing compensation for demand response providers does not target the core problem asserted in each case—which are that environmental externalities are not reflected in prices, that LMPs are less than marginal costs, or that some critical amount of targeted demand response must be developed and integrated into the grid in order to decrease costs for follow-on providers. Simply increasing payments to demand response providers, without any attempt to tie these payments to these underlying problems, might address these problems, or it might not. If it does address these problems, it is by happenstance, not design.

It would be much better to develop programs that specifically address these problems, as described above. In the case of environmental externalities, such a program would recognize that actions on both the demand and supply sides can reduce those externalities, and would select the most efficient mix of generation and demand response while incorporating environmental consequences. In the case of reliability benefits, such a program would provide prices that accurately reflect the marginal cost of electricity at the time that electricity is provided. In each of those cases, such a program would operate on a level playing field.

Consequently, broad-based programs for compensating demand response providers should not be based on the presumption that payments made under those programs will address any of the problems described above. Instead, they should instead be addressed through other initiatives that focus on ensuring that LMPs incorporate costs associated with environmental externalities and the reliability value of electricity during shortage and near-shortage periods, and subsidizing development of demand response to the extent that the learning-by-doing benefits resulting from this development justify such subsidies. Programs for compensating demand response providers should focus on improving market efficiency—i.e., giving loads incentives to consume electricity when the value they place upon that electricity is greater than LMP, and not to consume electricity when the value they place upon it is less than LMP.

## III. Evaluating the impact on efficiency of various proposals for compensating demand response providers

Setting aside the problems described above, which could and should be addressed by policies designed to deal with those externalities, there is still the question of how to treat demand response even when we assume that the LMP captures the full marginal cost of production and delivery. This assumption is implicit in many of the analyses of demand response compensation.[16] The arguments center on how to treat demand response seen as a wholesale market transaction on a level playing field with a generator, but when the demand responder is subject to retail rates that might affect the incentives to reduce demand when LMP is high.

Under the proposal for compensating demand response providers made by PJM in this docket, PJM would use one procedure to calculate payments made to a customer that reduces consumption if that customer pays the LMP at its location for the electricity it consumes, and a different procedure to calculate payments made to such a customer if it pays a fixed price for the electricity it consumes. Some such bifurcation could be justified because the incentives for the two groups of customers are different. As a result, it is necessary to use different procedures for determining the compensation, if any, that each group of customers is due to ensure that each group has an incentive to act in an efficient manner.

Before examining the PJM proposals, it is useful to look at a simpler case that can provide a clear benchmark when considering the details of alternative programs. The benchmark describes the analysis applicable when there is a combined system of dynamic pricing and forward contracts for fixed quantities.[17]

### *A. Dynamic Pricing and Contracts*

Dynamic pricing is a common term for the use of the relevant real-time or day-ahead LMP to charge for the electricity consumed or pay for the electricity purchased. Hence, without other arrangements, customers participating in the spot market pay the LMP for the electricity consumed. Of course, faced with a default of dynamic pricing, customers may make arrangements to sign a contract for a fixed price to purchase a given quantity of electricity.

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[16] Independent Market Monitor for PJM, "Barriers to Demand Side response in PJM," Monitoring Analytics, July 1, 2009. James Bushnell, Benjamin F. Hobbs, and Frank A. Wolak, "When It Comes to Demand Response, Is FERC Its Own Worst Enemy?", *The Electricity Journal*, Vol. 22, No. 8, October 2009, pp. 9-18.

[17] PJM Market Monitor, *Id*. Bushnell et al., *Id*.

Suppose that the customer has arranged a contract with a generator to purchase a given quantity of electricity at a fixed price. It is clear that the customer owns the power and could consume the power or sell it back to the system operator. Because of the contract, the customer would purchase the power at the fixed price. And when the customer sells the power back to the system operator, the appropriate price paid by the system operator would be the market clearing price, the LMP. Given the contractual right to the power, the customer would be paid the LMP, but it would also have to pay the fixed price under the contract. The net transaction for the customer would be the LMP minus the fixed price of the contract.

In practice, this net transaction would likely be described as a simple resale of power, and never be described as a demand response. From the perspective of the system operator, however, the net power flow from the two transactions is indistinguishable from a demand response. The advantage of the separation of the net transaction into the separate components of purchase under an explicit contract and sale in the spot market is to clearly identify the proper payments. Applying the symmetry principle, the same transaction through purchase and sale of the power should have the same net payment as the demand response.

The net payment is the result of the two transactions, first the purchase by the customer and then the sale by the customer. Note that if the contract is for a fixed quantity at the LMP, then the price in each transaction is the LMP, and the net payment to the customer is zero. The customer avoids the payment at LMP by not taking the power.

One of the great advantages of the design of organized markets such as in PJM is the ease of making these transactions. The purchase under the contract is simple to report in the settlement system and the sale at LMP in the spot market is automatic.

This method of payment for demand response seems obvious in the case of an explicit contract for a fixed quantity. By specifying the right to the given quantity of power, and separating the transactions to purchase the power and sell the same power, the efficient payments at the contract price and LMP are clear. The task then is to devise the system for demand response payments in the situations where the contract quantities are not fixed in advance and the contracts are only implicit. This is the case, for example, under a full requirements model where customers have the right to take their full requirement at an applicable price which may or may not be the LMP.

### *B. Customers Who Pay the LMP*

Under PJM's proposal, demand response providers who pay LMP would not be eligible for any additional payments in most hours.[18] That places them on a level playing field with generators: since generators receive the LMP at their locations for the amount of

[18] Both customers that pay the LMP and customers that pay a fixed price would be eligible for supplemental payments for demand reduction during the nine percent of hours with the highest LMPs. PJM Filing, at 21.

electricity they generate in each hour, they have an incentive to produce electricity whenever they can do so at a cost that is less than LMP. Similarly, since loads that do not consume electricity in those hours save the LMP, they have an incentive to consume whenever the value of the electricity they would consume exceeds LMP.

The consequences of this approach are illustrated in one of the affidavits accompanying the Demand Response Providers' Protest. In that affidavit, Ron Belbot of Severstal Sparrows Point described his facility's past participation in PJM's demand response programs, and the impact that changes in these programs will have on operations at Sparrows Point. Mr. Belbot stated,

> In 2006 and 2007, Sparrows Point participated in the PJM Economic Demand Response Program…. With the ending of the compensation levels in the program, Sparrows Point stopped participating in the program.
>
> Sparrow Point's curtailments were produced by increasing generation with purchased fuels at our internal powerhouse and by curtailing various operations in the plant. When the locational marginal price ("LMP") in the BC zone is above the strike price for generating power on either natural gas or fuel oil, the plant will still increase generation and reduce the amount [of electricity] being purchased, but the savings created by the avoided cost of power is not sufficient to warrant curtailing any of the operation in the plant without the addition of the payment.[19]

This provides a striking example which illustrates the major point about treating demand response symmetrically with generation. The Sparrows Point generator is on the customer side of the meter; to PJM, its use is indistinguishable from demand response. The economics are clear, and the operation of the generator whenever the LMP is greater than the cost of running the generator is the efficient decision. In other words, when Sparrows Point can produce electricity internally at a cost that is less than LMP, it will. And the saving on purchasing the power at the LMP is all that is needed to precipitate the efficient decision. This demand reduction is just like supply from a generator, as is evident from the fact that it actually is supply from a generator.

But Sparrows Point will not undertake other actions to reduce load when the costs of doing so exceed LMP. That is exactly the behavior that LMP was intended to induce.[20] In contrast, demand response programs that make payments to such customers when they do not consume electricity—payments that are over and above the savings they realize as a result of not having to pay the LMP when they consume electricity—will be inefficient and will violate the principle of putting generation and load on a level playing field. Such programs may induce customers such as Sparrows Point to reduce consumption by

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[19] Demand Response Supporters' Protest, Docket No. EL09-68-000, Sept. 16, 2009, Att. D (Affidavit of Ron Belbot on Behalf of Demand Response Supporters) at 1-2.

[20] William W. Hogan, "Contract Networks for Electric Power Transmission," *Journal of Regulatory Economics*, Vol. 4, September 1992.

reducing load in cases when the costs they incur to reduce load exceed the marginal cost of generating additional electricity to serve that load. When LMP reflects the full marginal cost, this would be inefficient because social welfare is maximized when producers whose marginal cost of production exceeds LMP do not produce electricity. Therefore, customers who pay LMP for their consumption should not receive any supplemental payments.

### *C. Customers Who Pay a Fixed Price*

This leaves the issue of payments to customers that do not pay the LMP, but which instead pay a fixed price for the electricity they consume. To illustrate how these payments should be calculated, consider a customer with a contract to purchase power at its location, for C, a price fixed in that contract. Suppose that the LMP at that customer's location at a given point in time exceeds MV, the marginal value the customer places on the electricity it is entitled to purchase at that time under that contract. In that case, it would be efficient for the customer not to consume the electricity, but instead to sell that electricity into the market. Alternatively, if the LMP at that customer's location is less than MV, it would be efficient for the customer to consume the electricity.

The cells shaded in green in Table 1 below illustrate which actions make the customer better off in each of these scenarios. First, consider the scenario where LMP > MV. If the customer does the efficient thing and sells this electricity, the payment it would receive for that electricity is the LMP. If the LMP exceeds the contract price, the customer would realize a profit on electricity purchased under the contract, equal to LMP – C. If the LMP is less than the contract price, the customer would realize a loss of LMP – C. On the other hand, if the customer consumes the electricity, it realizes the marginal value of the electricity, but it pays the contract price for the electricity. Therefore, if MV exceeds the contract price, the customer realizes a net gain of MV – C if it consumes electricity that it values at more than the price it pays for it, and if MV is less than the contract price, the customer realizes a net loss of MV – C if it consumes electricity. Since the LMP is greater than MV, the customer is better off in either case if it sells the electricity than if it consumes the electricity. Consequently, the contract does not encourage the customer to consume electricity when it is not efficient for the customer to consume electricity.

Next, consider the scenario where the LMP is less than the contract price. In this case, if the customer sells the electricity, it is paid LMP and must pay C under the contract, leaving it with LMP – C. If the customer consumes the electricity, it realizes the value MV as a result of having consumed the electricity. It still must pay C, so it realizes a net benefit of MV – C. Since LMP is less than MV, the customer is better off consuming the electricity. Once more, the incentives provided to the customer are consistent with efficient behavior, as the contract does not discourage the customer from consuming electricity when it is efficient for the customer to consume electricity.

**Table 1: Customer with a Contract to Purchase Electricity for C**

| | LMP > MV | LMP < MV |
|---|---|---|
| Customer Does Not Consume Electricity (and Sells It Instead) | LMP – C | LMP – C |
| Customer Consumes Electricity | MV – C | MV – C |

Now consider a customer that pays a single fixed price F for each MWh of electricity that it consumes. (For the moment, I will assume that F simply reflects the cost of the "generation component" of the fixed charge. I will relax this assumption in the next section.) If this customer is not eligible for any payments under the demand response program, it will realize the marginal value of electricity, MV, whenever it consumes electricity, and it will pay the fixed price F. If it does not consume electricity, it will not receive any payments or incur any costs. Therefore, it has an incentive to consume whenever MV > F, and not to consume whenever MV < F.

As this table shows, this customer no longer has an incentive to do the efficient thing—which is to consume when the marginal value of electricity is greater than LMP, and not to consume when the marginal value of electricity is less than LMP—in some circumstances. Therefore, charging customers a fixed price yields inefficient outcomes in some cases, which are shaded in red in Table 2 below. If LMP > MV > F, then the customer is better off consuming electricity, as is illustrated in Table 2, even though this is inefficient. And if LMP < MV < F, then the customer is better off not consuming electricity, even though this is inefficient.

**Table 2: Customer that Can Purchase Electricity for the Fixed Price of F**

| | LMP > MV | | LMP < MV | |
|---|---|---|---|---|
| | MV > F | MV < F | MV > F | MV < F |
| Customer Does Not Consume Electricity | 0 | 0 | 0 | 0 |
| Customer Consumes Electricity | MV – F | MV – F | MV – F | MV – F |

Finally, consider the customer that pays a single fixed price F for electricity that it consumes, but also assume that it receives a payment of LMP – F when it elects not to consume electricity, as proposed by PJM. It continues to realize the marginal value of electricity, MV, whenever it consumes electricity, and to pay the fixed price F.

As Table 3 demonstrates, the addition of this payment for non-consumption restores the incentive for this customer to consume electricity only when it is efficient for it do so. If LMP > MV, meaning that it is not efficient for this customer to consume, then LMP – F > MV – F, so the customer is better off if it does not consume, and accepts the payment instead. And if LMP < MV, meaning that it is efficient for this customer to consume, then LMP – F < MV – F, so the customer is better off if it consumes electricity than if it accepts the payment for non-consumption. Consequently, the payment structure that

PJM has proposed counteracts the incentives for inefficient behavior that result from charging customers fixed prices.[21]

**Table 3: Customer that Can Purchase Electricity at a Fixed Price of F Receives a Payment of LMP – F When It Does Not Consume**

| | LMP > MV | | LMP < MV | |
|---|---|---|---|---|
| | **MV > F** | **MV < F** | **MV > F** | **MV < F** |
| Customer Does Not Consume Electricity (and Receives Payment) | LMP – F | LMP – F | LMP – F | LMP – F |
| Customer Consumes Electricity | MV – F | MV – F | MV – F | MV – F |

### *D. Fixed Prices Consisting of Generation and Non-Generation Components*

The preceding discussion assumed that the fixed price, F, consisted merely of a generation component. In fact, the fixed price that such customers pay consists of three parts: a generation component, G; a transmission component, T; and a distribution component, D. For simplicity, I will combine the last two components into a single non-generation component, NG = T + D. Under the PJM proposal, an entity that is eligible to pay the fixed price F would only receive a payment of LMP – G, not LMP – F, if it did not consume electricity. If it consumes electricity, it would continue to pay F, and it would continue to realize the marginal value of that electricity, MV, so it would realize a net gain of MV – F.

In cases when it is efficient for the customer not to consume electricity, because the LMP is greater than the marginal value of that electricity, the customer still has an incentive to do the efficient thing, which is not to consume electricity. This is not surprising: Since F is greater than G, LMP – G is greater than LMP – F, so the payment for non-consumption is larger than I assumed in the analysis above. If a payment of LMP – F was sufficient to induce the customer not to consume when it would be inefficient for that customer to consume, certainly a larger payment would continue to be sufficient to induce that customer to behave in that manner.

However, as Table 4 illustrates, paying LMP – G for the customer not to consume, rather than LMP – F, will provide an incentive for customers not to consume in some cases when it would be efficient for them to consume. Suppose that the LMP is less than the marginal value of electricity, meaning that it is efficient for the customer to consume electricity, but also assume that the LMP is greater than MV – NG. Since LMP > MV – NG, subtracting G from each side of the equation yields LMP – G > MV – NG – G. Since the fixed price, F, is simply the sum of the generation component G and the non-generation component NG, that means that LMP – G > MV – F. Consequently, this

[21] This conclusion is implicitly based on the assumption that the amount by which this customer has reduced its consumption can be accurately measured, which should not be taken for granted. *See,* for example, see James Bushnell, et al., *Id.*

customer is better off if it does not consume electricity, even though it would be efficient for it to consume electricity.

**Table 4: Customer that Can Purchase Electricity at a Fixed Price of F Receives a Payment of LMP – G When It Does Not Consume**

| | LMP > MV | LMP < MV | |
|---|---|---|---|
| | | LMP > MV – NG | LMP < MV – NG |
| Customer Does Not Consume Electricity (and Receives Payment) | LMP – G | LMP – G | LMP – G |
| Customer Consumes Electricity | MV – F | MV – F | MV – F |

As Table 3 demonstrated, paying these customers LMP – F not to consume electricity when they would pay F to consume electricity ensures that they have efficient incentives. In contrast, paying them LMP – G not to consume when they would pay F to consume electricity distorts those incentives. PJM's proposal is based on the assumption that only G, and not NG, should be deducted from LMP when calculating payments for non-consumption because NG is intended to represent non-generation portions of the fixed charge. But the fact is that NG is part of the fixed charge that a customer would avoid if it did not consume electricity. Therefore, there is no reason why it should not be subtracted, along with G, when calculating the payment to be made for non-consumption. The PJM proposal would produce more efficient outcomes if it only paid LMP – F, rather than LMP – G, for fixed price customers who reduce their consumption.

### *E. Incentive Payments to Be Made During the Nine Percent of Hours with the Highest LMPs*

In addition to its proposal to pay LMP – G to fixed price customers that reduce consumption, PJM has also proposed to make additional payments that would apply to consumption reductions during the nine percent of the hours in each year whose LMPs are highest. Fixed price customers would receive a payment of LMP, without subtracting G, for reductions in consumption. LMP customers would receive a payment of $75/MWh.

PJM did not really offer any support for these additional incentive payments in its filing, other than to note that they are intended to facilitate development of additional price responsive demand.[22] As noted above in discussion of the LMP – G proposal, a payment of LMP – G to fixed price customers already provides too large an incentive for demand reduction, and will induce consumers to reduce consumption when it is not efficient for them to do so. Increasing that payment will simply exacerbate the problems with the proposal to pay LMP – G, and will lead to additional inefficient demand reduction. Similarly, there is no need to make any supplemental payment to LMP customers to induce them to act efficiently, and making a supplemental payment of $75 per MWh of

[22] *See* Supplemental Report and Submittal of PJM Interconnection, LLC in Support of Further Commission Action on Rehearing, Docket No. EL09-68-000, Sept. 16, 2009, at 29-35.

consumption reduction will simply encourage customers like Sparrows Point to incur costs to modify their operations, even when those costs are greater than the marginal cost of generating electricity, and therefore should not be incurred.

Instead, if we assume that the difference between the true marginal cost of energy and LMPs averages $75/MWh in those hours, then a better approach immediately becomes apparent: increase LMPs during those hours by $75/MWh. Since generators would be paid the increased LMP, this approach would permit generators, loads that pay LMP, and loads that pay fixed prices to participate on a level playing field: Generators would see increased incentives to be available, $75/MWh more than they otherwise would have received, for electricity produced during such hours; loads that pay LMP would save an additional $75 in charges for every MWh by which they reduce consumption; and loads that pay a fixed price would receive a demand reduction payment that is $75/MWh higher than it otherwise would have been. This would be considerably more likely to produce efficient outcomes than a policy that makes one supplemental payment (equal to LMP) to fixed-price customers providing demand response, a different supplemental payment (of $75/MWh) to LMP customers providing demand response, and no supplemental payment at all to generators.

Spurring the development of additional demand response resources may be a reasonable objective and consistent with economic efficiency in the long run, but as explained in the discussion of matching ends and means, and as the PJM Market Monitor summarized, "the incentive should be more narrowly tailored to the policy objective and should not be open ended."[23]

## IV. Unbundled Transactions

One way to interpret the different efforts by PJM to devise different demand response payments for different customers is as an attempt to approximate the terms of different implicit contracts for sale of electricity at agreed prices. The agreed quantity is estimated through comparison of actual consumption and a baseline, and the price of the implicit contract is estimated on the basis of the circumstances of the customer. Inherently this involves approximation across heterogeneous customers, especially in the estimation of the price to be netted out of any LMP payment.

Following the discussion above regarding the clarity of separating transactions under dynamic pricing and an explicit contract, there is another approach that would better capture the incentives of the underlying implicit contracts.[24] The basic idea would be to unbundle the demand response transaction into an energy purchase and an energy sale. The estimated quantity would still be a function of the baseline less the actual consumption.[25] Accepting the accuracy of the baseline, this quantity difference would be

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[23] Motion for Leave to Answer and Answer of the Independent Market Monitor for PJM, Docket No. EL09-68-000, Oct. 16, 2009, at 9.

[24] Charles J. Cicchetti and William Hogan, "Including Unbundled Demand-side Options in Electric Utility Bidding Programs," *Public Utilities Fortnightly*. June 8, 1989, pp. 9-20.

[25] The unbundled transaction approach would be subject to the same uncertainty in estimating the baseline.

deemed to have been purchased by the customer under whatever arrangements the customer purchases from the system. The deemed quantity would be added to the measured purchases of the customer or its load serving entity (LSE). The transaction price of the purchase would depend on the normal conditions absent the demand response. Separately, the same quantity would be sold to the system operator by the customer. As with any other spot market energy sale, the customer would be paid the LMP.

For example, if the customer baseline is estimated as 70 MWh and actual consumption is 50 MWh as a result of actions behind the meter (whether demand response or own generation), the notional transaction would be for 20 MWh. The notional 20 MWh would be added to the purchase of the customer or the LSE under the existing tariff conditions. For instance, if the customer is a full requirements customer on a retail tariff with fixed price F, then the customer pays F for 70 MWh. Separately the system operator pays the customer LMP for the 20 MWh of the deemed demand response. The customer would see a net payment of LMP ─ F for the 20 MWh.

This unbundled transaction approach often encounters strong objections because "demand response resources should not be required to pay for energy and capacity they did not consume."[26] However, this is a false argument. A better formulation would be: "customers should not be required to pay for something they did not buy, but in turn customers should not be able to sell something they did not buy." The very essence of demand response programs is that but for the actions of the customer, the notional electricity would be purchased and consumed. It is this deemed energy purchase that is presumably being sold to the system operator. The separation of the net transaction into the purchase and the sale clarifies the underlying economics and makes it clear that putting demand response on a level playing field with generation must require that the net treatment of demand response be the same as the net treatment of the purchase and sale of the notional electricity.

The various PJM proposals are an attempt to simulate these unbundled transactions. However, it would be much less problematic for PJM to simply recreate the unbundled transactions. This would avoid the need for PJM to estimate the implicit contract price. There would still be the need to estimate the notional electricity quantity, but this is not the principal source of dispute. The problem is in estimating the many possible contract configurations and prices that customers might have for purchasing their energy. The price is the major point of uncertainty. The price paid for the demand response would be LMP, but the price to be netted against the LMP could in principle be different for every customer. However, under the unbundled transactions approach, PJM would not have to estimate the price to net out of the LMP—this would occur automatically by adding the notional demand response into the sales to the customer or the intermediary LSE, and the LSE would in turn collect its normal payment for the notional electricity.

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[26] Demand Response Supporters' Protest, Footnote 71, at 22.

If the customer is on a fixed retail rate of F, then for the example above PJM would bill the LSE for 70 MWh. The customer would pay the LSE the fixed price F for the 70 MWh. The customer would in turn sell the notional 20 MWh to PJM at the LMP. The transaction from the customer's perspective would be to receive a net payment of LMP – F for the 20 MWh of demand response. If the LSE had a contract with a generator at price C, the LSE would pay the generator C and the generator's 70 MWh would be delivered to the LSE. The LSE would deliver 70 MWh to the customer. The customer would consume 50 MWh and simultaneously deliver 20 MWh to PJM.

If, on the other hand, the customer did not have a fixed price contract and was purchasing at LMP, there would be a different net payment. The customer would purchase 70 MWh from PJM at LMP. In turn, the customer would consume 50 MWh and sell the notional 20 MWh of electricity to PJM at LMP. The net transaction for the 20 MWh from the perspective of both PJM and the customer would be LMP minus LMP, or zero.

In both cases, the transaction would be implemented in the same way, from the perspective of PJM. PJM would send the customer or the LSE a bill for the total of 70 MWh, to be settled in the way that would occur without the demand response. In turn, the customer would sell the 20 MWh to PJM at LMP, treating demand response and generation as the same. The financial transactions would be transparent and economic dispatch would occur as usual.

This unbundled transaction model is administratively simple and does not require the system operator to delve into the many explicit and implicit contracts that cover customer consumption. The system operator has to estimate the baseline for implicit contracts (which is necessary in any event), but does not have to estimate the implicit price. Given the array of customer contractual arrangements and the estimates of the baselines, the unbundled transaction model with its incentives for an efficient response provides the "properly structured" payments for efficient demand response.

## V. Conclusion

Not all problems in electricity markets are best addressed by demand response programs, and not all benefits claimed for demand response are really benefits that are appropriate as objectives for public policy. The benefits for demand response programs could be substantial, but only with properly structured payments. The PJM proposals for compensating demand response strike a balance in attempting to provide the proper structure for efficient participation by customers in using their own generation or reducing their use of electricity in order to sell the produced or saved electricity to the system operator. The broad principle is to place saved electricity on a level playing field with sources of supply. The benchmark standard is the combination of dynamic pricing and explicit contracts, where the proper payments are transparent. The various PJM proposals attempt to deal with implicit contracts with a range of pricing provisions. An alternative that is more transparent would be the unbundled transaction model which provides efficient payments but does not require PJM to estimate the implicit prices applicable for a wide array of customers.

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