Energy Efficiency Benefits to All Customers

Price-Mitigating Effects for Ohio

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Table of Contents

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Introduction

Energy efficiency programs produce five kinds of benefits in restructured electric markets, including Ohio.

1. Direct reductions in volumes of energy that electricity providers must buy to meet customer demand. Most of these benefits flow to the customers who participate in the energy efficiency programs.
2. Direct reductions in volumes of electric generation capacity required. Those benefits may flow to the participant (e.g., for a large industrial customer paying directly for their capacity charges) or be spread over a large group of customers (e.g., for all the customers on the utility's default service, when it can buy less capacity to serve load).
3. Lowering market prices, which benefits all energy customers. The market prices that can be affected by load reductions include electric energy prices, capacity prices, and the price of natural gas (which affects the market-clearing price for electricity).
4. Reduction in the need for transmission and distribution investments, which also benefits all energy customers.
5. Reduction in line losses, which are shared with all customers.[1]

This report addresses only the third item, price mitigation, which is also sometimes called price suppression or Demand Reduction Induced Price Effects (DRIPE). Price-suppression benefits for all Ohioans from the state's 2017 utility energy efficiency programs – independent of any other benefits – are estimated to be approximately $2 per month for a typical residential customer.

[1] Losses in transmission and distribution lines vary with the square of load, so a 5% load reduction cuts those loses by about 10%.

Effect of Load on Market Prices

The price paid by electricity customers in Ohio is determined by prices in the competitive electric energy markets administered by the PJM independent system operator, which administers generation and transmission markets for generation services in its territory, stretching from New Jersey and Virginia to northern Illinois. PJM dispatches power on a least-cost basis for the entire region. Due to transmission limitations and line losses, prices often vary among the various utility service territories.

The PJM administers several markets for generation services, including an energy market that matches output to needs on a minute-by-minute basis;[2] a capacity market that contracts with suppliers three years in the future, to ensure highly reliable supply; and a group of "ancillary" services that fine-tune the system balance. In 2018, 73% of the generation charges to customers were for energy, 25% were for capacity, and just 2% for ancillary services.[3] This report discusses the effect of load reduction on prices in the energy and capacity markets.

PJM estimates the market-clearing price of energy for each hour on a day-ahead basis and revises those estimates as available generation is dispatched to meet actual load in real time. Prices for Ohio are set for four zones: AEP, DEOK, ATSI (FirstEnergy) and Dayton.

In a centrally-dispatched electric generation market system, the market price in any hour is the result of the intersection of the demand curve (a nearly vertical line, given the limited short-term response of load to market price) and the supply curve composed of prices bid by owners of generation and other resources. Every resource (mostly generators in PJM, but also some imports and demand response) offering energy into the market at or below the market-clearing price is paid the market-clearing price for that hour.[4] The energy supply curve varies from hour to hour, depending on the availability of generation, fuel prices and other factors. As illustrated conceptually in Figure 1, the supply curve rises as required output rises, and usually becomes steeper as output rises. The left end of the price curve would include wind, solar, nuclear, and other resources that have low costs of producing energy (once the owner has committed to the capital costs and expenses necessary to make plant available to run). Coal and gas combined-cycle plants would be in the middle range, and older oil- and gas-fired peakers would make up most of the rapidly rising right end of the curve.

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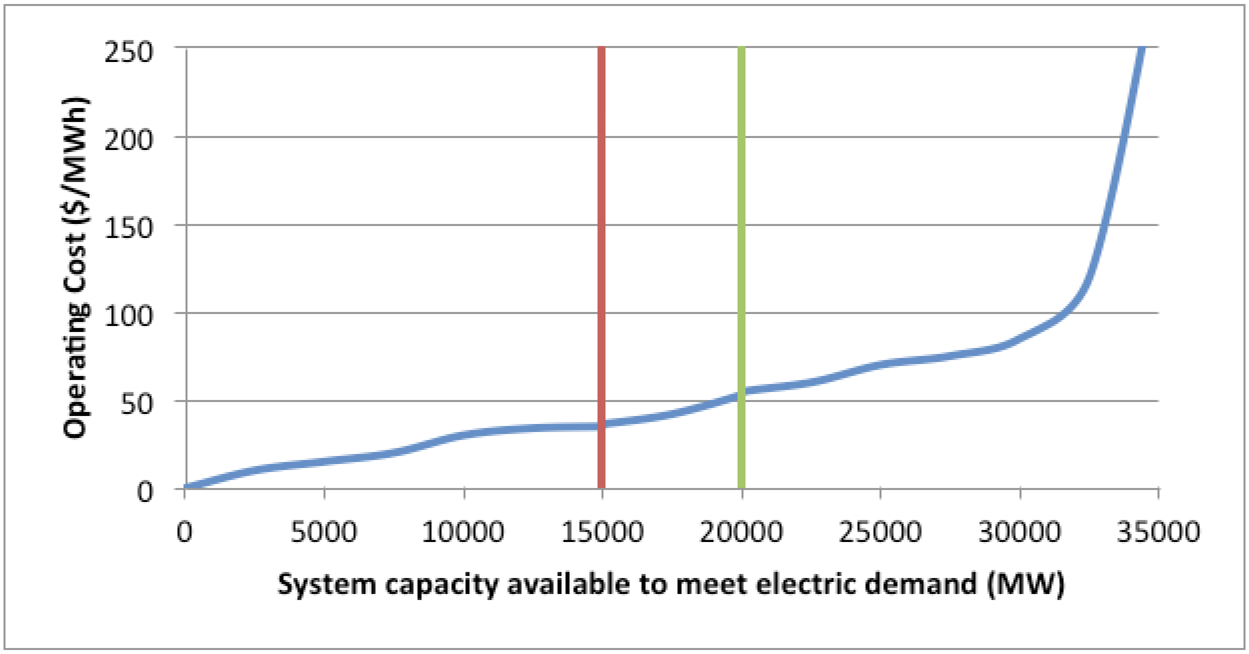
[2] PJM actually decides how to dispatch generation in multiple steps, including a day-ahead dispatch, in which PJM schedules generators, including the ones with long start-up times, and a real-time dispatch, in which PJM matches the actual available generation to actual load.

[3] 2018 State of the Market Report for PJM, Monitoring Analytics, Volume 1, 3/14/2019, p. 18.

[4] The price-setting process is slightly more complicated than this simplified description, since unit dispatch is constrained by unit start-up time, ramp rate, minimum up time and down time, limited daily and weekly water supply for storage hydro facilities, and similar factors.

Figure 1: Illustration of Electric Energy Supply Curve and Effect of Load Reduction



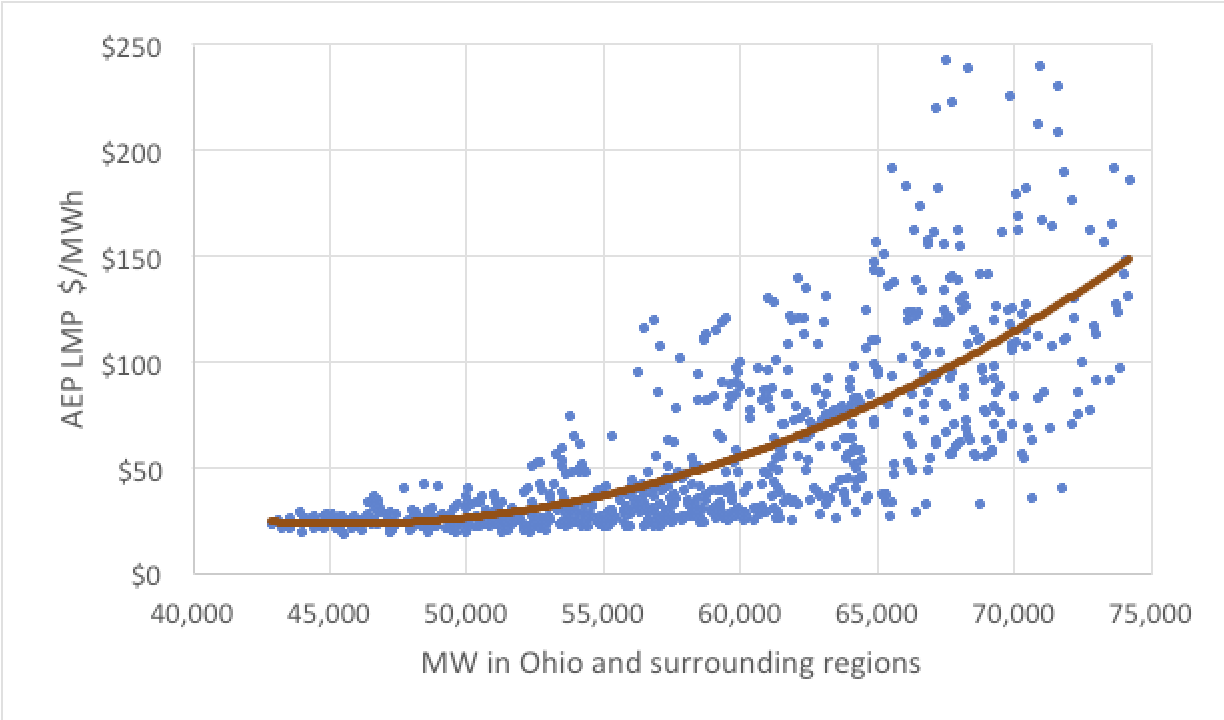
Reducing demand at any given time avoids the need to obtain supply from more expensive resources, and therefore will almost always reduce the overall market price of electricity. In this example, reducing load from 20,000 MW to 15,000 MW reduces the market price from about $52/MWh to $40/MWh.

Figure 2 looks specifically at one month of hourly prices in the AEP zone, versus the loads in Ohio, the rest of the DEOK and AEP zones (parts of Kentucky, West Virginia, Michigan, Indiana, Virginia), the APS zone (in West Virginia, Virginia and Pennsylvania) and parts of western Pennsylvania (including FirstEnergy's Pennsylvania Power). Figure 2 also shows the quadratic trend-line for the data.

At very low load levels, price does not appear to vary much with load. Once the load gets to about 50,000 MW (which it did 85% of the time in January 2018), price starts to rise along with load. Figure 2 shows a large amount of scatter around the trendline; this is not surprising, since hourly market prices are affected by loads outside the specific area used in the analysis, power plant outages, transmission constraints, solar and wind output, the operation of pumped and storage hydro facilities, and dispatch constraints.[5]

[5] Depending on projected market conditions over a day or week, PJM may decide to keep some coal plants—which cannot shut down and restart quickly—running overnight for the next day (reducing prices at low and high load levels on that day) or shut the coal plants down to avoid the costs of keeping the plants operating overnight (resulting in higher market prices through the day).

Figure 2: AEP hourly energy price as a function of load, January 2018



In the traditional utility structure, where utilities own their own power plants, customers pay for the fixed costs and the actual operating costs of the utility's generation resources, including wholesale purchases and sales. But for restructured utilities such as in Ohio, the price of generation services is set by the market-clearing price.

Some very large electric customers may pay the hourly energy prices directly, through retail electric suppliers. Most electric customers pay for generation services through rates that are fixed for months or up to a couple years in advance, through the utility's standard service offer (SSO) or through a rate offering from an electric generation supplier or a government aggregation. Those contract prices are based on suppliers' expectations regarding the hourly market prices.

Reducing demand reduces the market-clearing price and hence the prices paid by suppliers and prices that suppliers offer to customers. This effect is referred to as "price suppression" in the general economic literature. More recently, the reduction in prices in the wholesale markets for electric capacity and energy resulting from the reduction in required supply due to the impact of efficiency programs (and sometimes other reductions in load on the electric system) has been referred to as Demand Reduction Induced Price Effect (DRIPE) in the utility literature.[6] Various utilities, regulators and analysts have treated price mitigation as a benefit to retail customers.[7]

In general, price-suppression effects are very small when expressed in terms of the impact of each MWh of energy conservation on market prices ($/MWh price reduction per MWh saved). Even a significant annual energy efficiency portfolio may reduce prices by a fraction of a percent. However, even very small impacts on market prices, when applied to all the market purchases in a state as large as Ohio, can produce large absolute dollar savings to customers.

The Energy Price Benefit of Changing the Supply-Demand Balance

In a recent report, the Brattle Group (a large consulting firm working primarily for utilities) estimated the effect on Ohio market energy prices of retiring the Davis-Besse and Perry nuclear plants.[8] Brattle estimated that losing the 16.6 million annual MWh of output from these two plants would raise prices about $1/MWh (0.1¢/kWh), which would cost Ohio customers about $177 million annually. Table 1 presents the Brattle estimates and computes the reduction in generation prices and Ohio energy bills per MWh of energy added to the left hand of the supply curve in Figure 1 or Figure 2.

[6] See, e.g., Avoided Energy Supply Costs in New England Final Report, Avoided-Energy-Supply-Component (AESC) Study Group, December 23, 2005 (updated and expanded in 2007, 2009, 2011 and 2013, 2015 and 2018); Costs and Benefits of Electric Utility Energy Efficiency in MA, Northeast Energy Efficiency Council, Aug 2008; Deployment of Distributed Generation for Grid Support and Distribution System Infrastructure: A Summary Analysis of DG Benefits and Case Studies, Final Report, February 2011, New York State Energy Research and Development Authority, No. 11-23; Ten Pitfalls of Potential Studies, Chris Kramer and Glenn Reed, Regulatory Assistance Project, November 2012; Summary of Progress to Date on Goal to Reduce Electricity Consumption by 15% by 2015 and Recommendations for Next Steps, Maryland Energy Administration, March 2013.

[7] Price suppression is included in the benefits of energy efficiency programs by Massachusetts, Connecticut, Rhode Island, Maryland, Delaware, Vermont, and the District of Columbia. Similar effects are included in the evaluation of the effects of adding or retaining nuclear capacity (including the Brattle report cited below and similar Brattle reports on New York, Pennsylvania and New Jersey nuclear units), wind and other renewable resources (including studies by the New York State Energy Planning Board and Illinois Power Authority), appliance efficiency standards, demand-response programs, and other applications.

[8] "Ohio Nuclear Power Plants' Contribution to the State Economy," Berkman, M., and Murphy, D. on behalf of Nuclear Matters and others, April 2017.

Table 1: Brattle Estimate of Price Effects of Nuclear Output

Case	Power Price ($/MWh)			Electricity Consumption (millions of MWh)	Annual Average Electricity Cost Change	Price effect per MWh supply	
	with Nuclear	without Nuclear	Change			$/MWh price change	Total Ohio benefit
	a	*b*	*c=b-a*	*d*	*e=d×c*	*f=c÷Output*	*g=e÷Output*
Base	$60.52	$61.59	$1.07	165	$177	$0.000000064	$10.67
High Gas Price	$71.64	$72.84	$1.20	165	$198	$0.000000072	$11.93
Low Gas Price	$53.93	$54.78	$0.85	165	$141	$0.000000051	$8.50
Output =	16.6 Million MWh						
Sources:	a, b, c, d, e from Brattle Table 3; output from Brattle Table 1						

Each of the 16.6 million MWh of energy supplied by the nuclear units reduces Ohio prices (averaged over the year) less than a millionth of a cent, as shown in column *f* or Table 1. But that tiny change over millions of MWh (which means billions of kWh) reduces the total bill to Ohio customers by about $1. Brattle estimates that the average effect of the nuclear output over ten years would be about $177 million annually for all Ohio customers. Brattle estimates this benefit as an average over ten years; this benefit may continue for many more years, depending on how quickly the nuclear capacity and whether they would be replaced by renewables or the less beneficial gas-fired plants. If the nuclear output is replaced quickly by renewables, the benefits could drop off faster.

The Energy Price Benefits of Efficiency for Ohio Customers

Reducing energy demand by a MWh in an hour has the same price effect as adding a MWh of energy supply at a low bid price. Hence, the effect of Ohio load reductions from energy efficiency programs should be similar to the effects of having more nuclear generation in Ohio as calculated by Brattle in the analysis described above.[9]

Since the Brattle analysis is for the average annual effect of a fairly constant change in supply over ten years, I computed the average effect in a year in the 2020s of running the 2017 programs over a long period of time. The latest reasonably complete data we have on the programs is from the 2017 program year. My analysis takes into consideration the fact that once a customer implements an efficiency measure, the customer (and other Ohio customers) reap the benefits of the measure for the many years that the measure stays in place.

[9] In fact, load reductions will be more valuable than nuclear generation, for two reasons: more of the conserved energy with be in high-load, high-price hours, while nuclear output is spread evenly over most of the year; and saving a MWh at the customer's equipment saves more than a MWh at the generation level, because lower loads mean lower losses.

The savings in 2026, for example, would be the sum of the load reductions from 2017 measures still in place in their tenth year, the 2018 measures in the ninth year, the 2019 measures in their eighth year, and so on, to the 2026 measures in their first year.[10] The average annual savings from continuing operation of energy efficiency programs would be similar to the lifetime savings of a single year's installations. For the 2017 Ohio programs, that lifetime savings value is about 16.7 million MWh. If the utilities keep running the programs at the scale of the 2017 programs, the average annual savings would be of similar magnitude, or a little more than the annual output of the nuclear units.[11]

At the price-moderation ratio from the Brattle report, the continuing energy efficiency program savings would reduce prices enough to save Ohio customers about $11/MWh saved × 16.7 million MWh saved = $184 million. Since more of the energy efficiency savings will fall in the higher-load hours in which prices are more sensitive to load, the price effect for energy efficiency would actually be somewhat higher than for nuclear generation.

Spread over the 288 million MWh of retail sales in Ohio, the reduction in prices would be about $1.1 per MWh. For the typical residential customer using 833 kWh monthly, that would be worth about $0.95/month, for many years, depending on the life of the savings from the efficiency measures as well as changes in the generation mix over time.[12]

The Capacity Price Benefit of Changing the Supply-Demand Balance

In addition to the energy price benefits, reduced loads will mitigate capacity prices. Every year (usually in May), PJM conducts an auction to acquire commitments from suppliers (generators and providers of energy efficiency and demand-response services) to meet capacity requirements for the PJM RTO as a whole and for transmission-constrained local demand areas that may need to offer higher prices to acquire enough capacity. Ohio generally winds up with the RTO price, but the DEO and ATSI zones (where Duke and FirstEnergy's Ohio distribution utilities, respectively, are located) sometimes have higher prices. The auction acquires capacity for a one-year period starting a little more than three years in the future, to allow for construction of new generation, if needed.[13]

[10] The savings in 2026 would also include savings from pre-2017 installations with lives over 10 years.

[11] An annual payment to keep a nuclear unit on line provides additional energy supply for that one year. The annual payment for an energy efficiency program reduces energy requirements for many years.

[12] A similar effect over time should result from keeping the nuclear plants on line, so this effect may be reflected in the Brattle estimate.

[13] For example, the May 2018 Base Residual Auction (BRA) acquired capacity for the period from June 2021 to May 2022.

The Brattle report acknowledged that there would be capacity price benefits, but attributes only "a modest contribution from higher capacity prices" (Brattle report, p. 5) Brattle does not separately report the effect of changing supply capacity prices, but indicates that it does not expect a large effect:

> Capacity price effects can be difficult to ascertain with confidence, because the market response can be hard to predict (e.g., the extent to which market forces will offset a loss of one source of capacity by retaining others, or adding new capacity). Our analysis here assumed that the market response is significant and the loss of nuclear capacity would be largely offset; this mitigates the capacity price response, yielding a conservatively small overall price effect. (p. 9, footnote 12)

Brattle is correct that it can be difficult for an outside observer to estimate how much a change in demand or supply would change prices in the capacity market, since PJM does not release any information on the auction bid prices, the base auctions are held only once a year, and the rules and conditions of the auctions vary from year to year. Fortunately, PJM itself uses the information it has on the bids and its auction-optimizing software to determine the effect of shifting the supply-demand balance in a series in sensitivity analyses after each BRA.

For each of the last several capacity auctions, PJM has conducted sensitivities for additional and reduced supply, for a change of 3,000 MW or 6,000 MW, and for changes in the MAAC region (New Jersey, Delaware, Maryland, DC, and most of Pennsylvania) and outside MAAC. The most applicable case for the termination of Ohio energy efficiency savings would be the removal of 3,000 MW of supply (which would have an effect similar to adding load) outside of MAAC.

Table 2 shows part of my analysis of the effect on capacity prices and Ohio customers' capacity bills of running the 2017 energy efficiency programs for ten years, using the results of PJM's last five sensitivity studies for reducing supply 3,000 MW outside MAAC. The Commonwealth Edison zone cleared separately from the rest of the RTO in all five years, the DEOK zone cleared separately for 2020/21, and the ATSI zone cleared separately for 2021/22.[14] Table 2 divides the change in price in the sensitivity case by the reduction in supply, excluding the zones that cleared at different prices, to compute the change in price per MW change in the demand/supply balance. I excluded the load change in the zones that wound up with prices different from the price for most of Ohio, because transmission constraints prevented the effect in those zones from fully influencing the price in other zones. Depending on the year, each MW of reduced supply (or increased supply requirement) would increase costs for Ohio customers in the zones that cleared with the RTO by $30,491 to $138,400.

[14] Commonwealth Edison zone cleared with the rest of the RTO in the actual auction in 2017/18, but separately in the sensitivity. American Transmission Systems Inc. (ATSI) is the transmission provider for FirstEnergy's Ohio and non-MAAC Pennsylvania utilities.

Table 2: Capacity-Price Effect of 10 years of 2017 Energy Efficiency Programs, with RTO prices

Year	RTO Price Increase $/MW-day	RTO Load change MW	$/MW-day per MW	2021 Ohio load for Utilities in RTO (MW) in this Auction					Annual Price Benefit per MW saved	2017 EE peak savings in RTO in this Auction (MW)					Total Annual Benefit $M
				AEP	FE/ATSI	Dayton	DEO	Total		AEP	FE/ATSI	Dayton	DEO	Total	
	a	*b*	*c = a÷b*	*e*	*f*	*G*	*h*	*i = Σe-h*	*j = c×i×365*	*K*	*l*	*m*	*n*	*o= Σk-h + loss & reserve*	*p = j×o×10*
T&D Losses										9.00%	9.49%	7.59%	6.98%		
2017/18	$30.56	2,236	$0.0137	8,638	11,409	3,252	4,445	27,744	$138,400	81.7	73.8	30.6	62.6	313.9	$434.5
2018/19	$23.49	2,240	$0.0105	8,638	11,409	3,252	4,445	27,744	$106,191	81.7	73.8	30.6	62.6	313.9	$333.4
2019/20	$7.06	2,345	$0.0030	8,638	11,409	3,252	4,445	27,744	$30,491	81.7	73.8	30.6	62.6	313.9	$95.7
2020/21	$8.68	2,089	$0.0042	8,638	11,409	3,252		23,299	$35,335	81.7	73.8	30.6		236.0	$83.4
2021/22	$20.80	1,813	$0.0115	8,638		3,252	4,445	16,335	$68,409	81.7		30.6	62.6	219.9	$150.5
Average									$75,765						$219.5

The utilities' 2019 reports indicates that 2017 programs saved about 249 MW, excluding FirstEnergy's claimed load reductions from the C&I Demand Response Program and the Customer Action Programs. Since those savings are at the customer end use, the savings at the generation level is higher, by the amount of the various companies' line losses, which they estimate to be 7% to 9.5%. And since PJM requires about 1.164 MW of resources for each megawatt of load reduction, I increased the savings by another 16.4%.

Considering 10 years of programs, the average annual benefit to customers in the areas that did not separate from the RTO due to the price reductions would be about $220 million.

Table 3 shows a similar computation for the two Ohio zones that separated from the general RTO pricing, DEO for 2020/21 and FirstEnergy/ATSI for 2021/22. Because of the high price effect of changes in supply for the FirstEnergy/ATSI zone, and the large load in that zone, these two years, each for one zone, has an average effect over the five years approximately equal to the price effects of all the load reductions in the other zones and years. The FirstEnergy/ATSI load zone also separated from the rest of the pool for 2015/16 and 2016/17, and other zones within PJM have separated frequently, but it is not clear how likely separation of the two Ohio zones might be in the future.

Table 3: Capacity-Price Effect of 10 years of 2017 Energy-Efficiency Programs, Zones that Separated

Zone & Year	Zonal Price Increase $/MW-day	Zonal Load change MW	$/MW-day per MW	2021 Ohio zonal load MW	Price Benefit per MW saved	2017 EE Peak Savings MW	Total Benefit $M
	a	*b*	$c = a \div b$	*d*	$e = c \times d \times 365$	*f*	$g = e \times f$
DEO 2020/21	$7.50	156	$0.0480	4,445	$77,893	78.0	$65.0
ATSI 2021/22	$105.73	435	$0.2429	11,409	$1,011,456	94.0	$1,040.8
Average over 5 years							$221.2

Note: Column *f* = Table 2, columns *m* and *n*, plus utility losses and 16.4% reserves

These capacity benefits would be worth about as much as the energy benefits estimated in the previous section, even accounting for the small (but unknown) capacity price benefits included in the Brattle estimate. The capacity benefits are likely to persist at least as long as the energy benefits, since lower capacity prices will only discourage expensive capacity resources that would not be selected by PJM.

The total price benefit for continued operation of the energy efficiency programs—combining the energy and capacity price reductions—thus appears to be on the order of $2/month for the average residential customer, in addition to the other benefits listed in the introduction.