Price Effects as a Benefit of Energy-Efficiency Programs

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ABSTRACT

Increased energy efficiency reduces load on the gas or electric system, the amount of energy that must be purchased or produced to serve customers, and participants' energy bills directly

Where energy is supplied from competitive markets, energy efficiency further reduces the price of that energy, indirectly reducing the energy bills of all consumers when savings are passed on to ratepayers. Those price reductions are typically vanishingly small when expressed in dollars per MWh or per MMBtu of total *consumption.* However when expressed in dollars per MWh or MMBtu *saved,* the cost reductions can be substantial, even rivaling the direct avoided costs.

In the utility industry, this kind of price suppression has come to be known as Demand Reduction Induced Price Effect (DRIPE). This paper describes the basis for including DRIPE as a benefit in program screening. It also describes several categories of DRIPE and approaches for quantifying price reduction benefits for the following energy-sector goods and services:

- electric energy
- electric capacity in restructured markets
- natural-gas supply
- natural-gas market transportation.

Since electric efficiency generally reduces gas use in generation, and lower gas prices produce lower electric market prices in restructured markets, a number of cross-fuel DRIPE effects are identifiable.

For each category of DRIPE, the paper describes the situations in which DRIPE would exist, how DRIPE coefficients can be estimated from historical data or modeling, and how DRIPE should be adjusted to reflect existing supply arrangements and the decay of the DRIPE effect due to demand- and supply-market responses.

How Energy Efficiency Reduces Market Prices

Most commodities, including various energy products, are characterized by an increasing supply curve: the marginal unit price of energy increases with the amount required. For commodities purchased in a competitive market, such as supply-area natural gas, transportation of gas to most gas generators, and electric energy and capacity in the regional transmission organizations, all consumers pay the market-clearing price, as illustrated in Figure 1. If the market has to supply quantity S_1, the price will be P_1, and customers would pay $S_1 \times P_1$ (the entire shaded area).

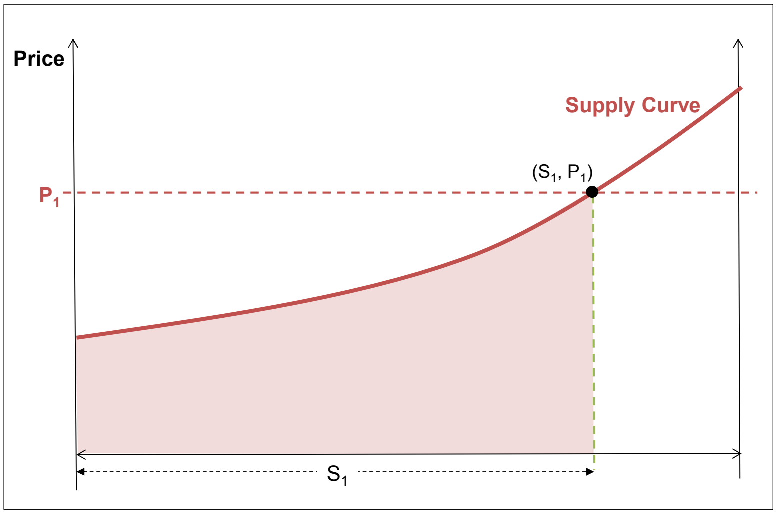

Figure 1. Demand and prices.

Reducing consumption of the energy product reduces the amount of energy that participants must purchase. Such savings are generally reflected in DSM screening as part of the avoided cost. The same demand reduction also slides the market-clearing point on the supply curve to the left, backing down the most expensive supplies (e.g., the least efficient power plants), resulting in lower prices for all the remaining loads, as illustrated in Figure 2.

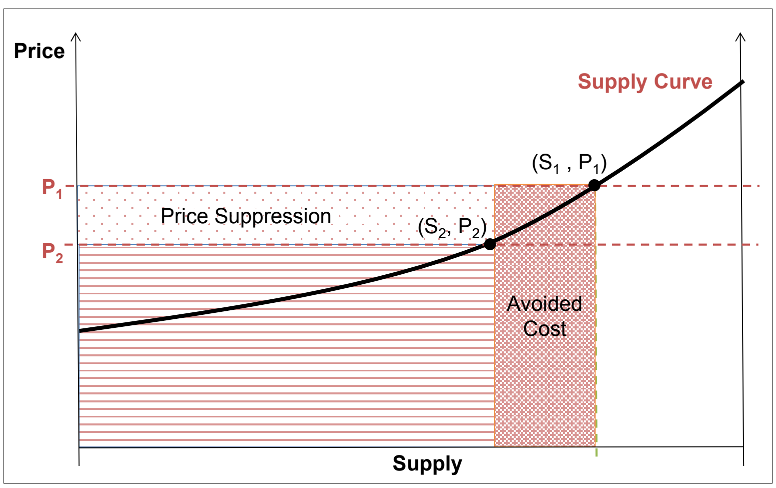

Figure 2. Price effects of demand reductions.

If energy-efficiency programs reduce load from S_1 to S_2, the price would fall from P_1 to P_2, and customers would pay $S_2 \times P_2$ (the striped area). The avoided cost would normally be estimated as some portion of the shaded rectangle from S_1 to S_2, often as the area under the supply curve. The savings to customers from the elimination of the stippled area ($S_2 \times (MC_1 – MC_2$) is due entirely to reduction in the price of the load that still must be met after the load reduction. In some circumstances, especially in the short term, the price suppression over a large load region can be more valuable than the direct avoided costs.

Where Does Energy Efficiency Reduce Consumer Prices?

This price effect only operates where prices are set by markets, with a single price for each product.[1] For resources priced by cost-of-service regulation, consumers pay only the cost of the commodities, not the market-clearing price, so there is no price suppression effect, as illustrated in Figure 3. Under cost-of-service regulation, customers pay only for the area under the cost curve, which is the conventional avoided cost.

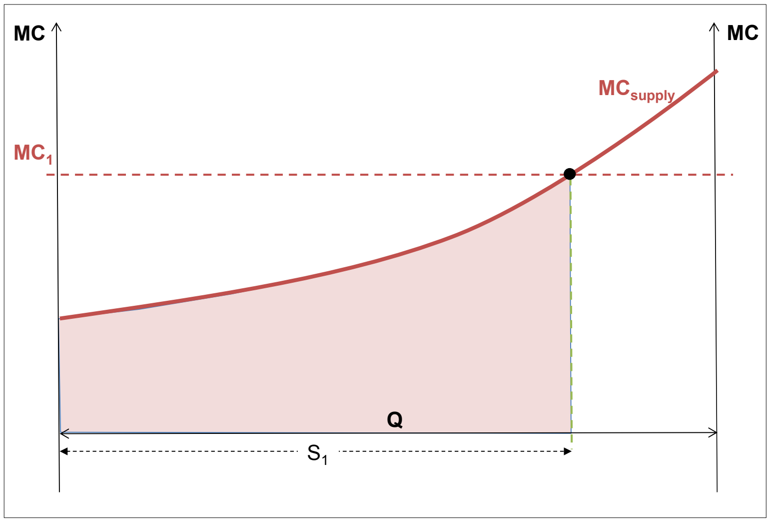

Figure 3. Demand and bills with cost-of-service regulation.

Most gas utilities purchase the bulk of their transportation and storage services from the supply regions under facility-specific cost-of-service rates, which are not affected significantly by market conditions, but purchase most of their gas in the supply regions at spot or short-term contract prices. The same is true for delivery customers of local delivery companies (LDCs) who purchase their own gas. Vertically integrated electric utilities (which included almost all investor-owned utilities until the 1990s, and still includes most IOUs) generally charge cost-of-service rates for their generation plant, but pass through market prices for fuel from the spot and short-term contract markets. Those fuel costs may include market-based transportation costs, especially for natural gas.

In the regional transmission organizations of ISO-NE, NY ISO, PJM, and ERCOT, and the Illinois portion of MISO, most IOUs no longer own generation. They either purchase all generation services from the competitive market or else customers purchase generation services from third parties who obtain the service from the markets. Even if the generators in those restructured markets have long-term contracts for fuel supply and delivery, they will base their energy prices on the market price of fuel, since they can usually sell unused fuel into the market. Hence, their bid prices include the delivery "basis," the spot price for transportation from the

[1]The single price may be set at the wholesale level, and may vary for different customers at the retail level, after the adjustments by the utility and marketers.

supply area. Table 1 summarizes the components of wholesale electric and gas costs subject to price suppression.[2]

Table 1. Extent of market prices subject to price suppression effects

Utility Type	Fuel at Source	Fuel Delivery	Non-Fuel Generation Costs
Natural Gas LDC	Almost all	Little	—
Integrated Electric	Most	Some	Little or none[3]
Restructured Electric Distribution	Most	Most	Most or all

Table 2 provides a more-detailed summary of the direct and cross-fuel price-suppression effects for a region with primarily restructured electric utilities. The lower section of Table 2 indicates that a reduction in electric load directly reduces the market prices of electric energy and capacity, reduces market prices of gas supply and delivery for electric generators (further reducing the electric energy price indirectly), and reduces market prices of gas supply for retail gas users.

Table 2. Matrix of load reductions and market-price effects in New England

Reduction in Retail Load	Affected Cost Categories	Affected Cost Component
Natural Gas	Own-price (retail gas price)	Gas Supply
	Cross-fuel (electric energy prices)	Gas Supply
		Gas Delivery Basis
Electricity	Own-price (electric energy prices)	Electric Energy
		Electric Capacity
	Cross-fuel (gas prices for power)	Gas Supply
		Gas Delivery Basis
	Cross-fuel (retail gas price)	Gas Supply

Is Price Suppression a Benefit?

The role of price suppression in program and portfolio evaluation varies with the specific test being applied. The relevant tests include the Utility Cost or Program Administrator Cost Test, measures of rates and bills, the Total Resource Cost (TRC) Test, and the Societal Test. Details of the application of these tests vary among jurisdictions, so the following discussion is intentionally general.

Price effects are definitely relevant to the Program Administrator Cost Test, which estimates the effect of energy-efficiency efforts on the funds flowing through the utility system. These costs include utility bills for variable and fixed costs and generation (or gas supply) services provided by non-utility suppliers in competitive markets. To the extent that energy

[2]For example, for natural-gas local-distribution companies almost all fuel at the source is subject to price suppression, but only a little of the fuel delivery costs.
[3]Some vertically integrated utilities depend significantly on market purchases. They will be more affected by changes in regional market prices than their peers.

efficiency reduces market prices, and those prices flow through to customer bills, a dollar reduction due to lower prices is equivalent to a dollar reduction from lower usage.

Price suppression is also relevant to the assessment of the effects of energy efficiency on rates and bills.[4] Lower prices for gas and electricity purchased from the market reduce both rates and bills.

The effects of price suppression are more subtle with the TRC and Societal tests. The TRC Test is implemented differently across jurisdictions, but generally attempts to capture all the costs and benefits to a group of consumers. In the 1980s, the target group was generally limited to the customers of a single utility; over time, that group has been expanded to include utility customers jurisdiction-wide (often including electric, gas and water customers) and sometimes persons in the jurisdiction as something other than utility customers (such as taxpayers) and even to some people outside the jurisdiction (such as those harmed by pollution from the jurisdiction's energy use).

The Societal test formally expands the group targeted for benefits to include a broader universe, defined as "society."

In practice, the target group of the TRC and the society of the Societal Test do not generally include everybody. For example, regulators have always valued oil at its market price, not the price of production in Texas or Saudi Arabia, excluding the benefits to the producers of increased oil use. Similarly, power purchases, whether from the competitive market, an independent power producer, or a neighboring utility, are invariably valued at the price charged, ignoring the generator's profits. By that standard, the efficiency-induced reduction of prices to consumers should be counted as a TRC and Societal benefit, but the reduced income to fuel suppliers and power generators should be excluded, with price suppression counted as a benefit under those tests. Price suppression has been accepted as an energy-efficiency benefit by regulators in Massachusetts, Delaware, Connecticut, the District of Columbia, and Rhode Island (Wickendon 2013, 5). On the other hand, regulators in Maine have available the same regional analysis as the other New England states but have declined to include price suppression as a benefit in screening energy-efficiency programs.[5]

Some observers (e.g. Lesser 2010) have noted that price suppression results in a transfer that benefits consumers at the expense of producers, and thus concluded that price suppression is not a benefit under the TRC and/or Societal tests. That conclusion follows only if the regulator applying the test considers the welfare of the owners of the gas producers and the merchant generators to be as important as the welfare of the utility customers.

Price suppression has been advanced as a benefit of renewables (PUCO 2013; PJM 2009, 2; Martinez et al. 2011, 8, 29, 41, 50, 51), nuclear units (Tranen 2012, 11) and coal units (Aydin, Graves, and Celebi 2013, 14–15), as well as a benefit of energy efficiency.

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[4]This category includes the archaic Rate Impact Measure (RIM) Test, which ignores the distribution of rate effects over time and customer classes, as well as the effect of programs on overall portfolio equity; those factors are reflected more systematically in modern rate and bill analyses. Iowa, Indiana, and North Carolina still rely on the RIM in part (Daykin, Aiona, and Hedman 2011, 3, Table 1) and at least some Florida utility companies still use it.

[5]Vermont and New Hampshire are largely sheltered from market prices by power-plant ownership and long-term contracts. Vermont is considering whether to include the price-suppression benefits for its small market exposure and/or the rest of New England (Vermont PSB Docket No. EEU-2013-7).

Is Price Suppression Real?

There is little question that reducing load reduces prices. The logic underlying Figure 2 is compelling in itself. Admittedly, a supply curve is a theoretical construct, and real-world electricity prices in any area will vary around the estimated supply curve with variations in such other factors as: fuel prices; plant availability by type and location; loads in the area and surrounding areas, and transmission availability. The same is true for gas prices, which are driven by pipeline availability, wellhead freeze-ins, demand in other areas, and sometimes prices of alternative fuels. Hence, a plot of energy price versus any specific measure of load will be a scatterplot of price points.

Evidence for a direct relationship between demand and price is widespread, both from empirical data and from modeling studies. A quick review of natural-gas futures (for Henry Hub, or for basis on constrained pipeline systems) shows the strong response of prices to winter loads. The same is true for spot market prices for gas.

The DRIPE coefficient can be stated in a number of ways, including the following for electricity (and comparable measures for gas DRIPE and cross-fuel effects):

- *Price reduction per unit load reduction* (e.g., Δ¢/kWh per GWh saved).
  This is the form most directly estimated from data or modeling.
- *Total cost reduction per unit load reduction*
  (e.g., total bill reduction per kWh saved = GWh affected × Δ$/MWh per GWh saved)
  This is the most useful form, since the dollar-per-MWh value can be added to other avoided costs and used in screening programs and measures.
- *Percentage price reduction per percent load reduction*
  This form is most useful for comparing and extrapolating analyses over time and space, where market prices may differ dramatically but the price elasticity of supply may be much more consistent.[6]

Monthly electric forward prices generally reflect both the higher winter cost of natural gas and the higher electric load in the summer, while daily and hourly prices reflect actual fuel prices, loads, and outages.[7] Figure 4 shows the relationship between hourly demand and locational price for the ISO-NE hub in August 2013, while Figure 5 shows the relationship between EIA's projections of annual natural-gas demand (2012) and wellhead price for a variety of demand conditions.

[6]For example, in an electric system with gas at the margin, the Δ$/MWh per MWh saved will vary with gas price, but the elasticity of supply, determined primarily by the heat rates of various generators, may be much more stable.
[7]Expectations of maintenance outages are probably also reflected in the monthly forward prices, but they are more difficult to discern in those aggregate data.

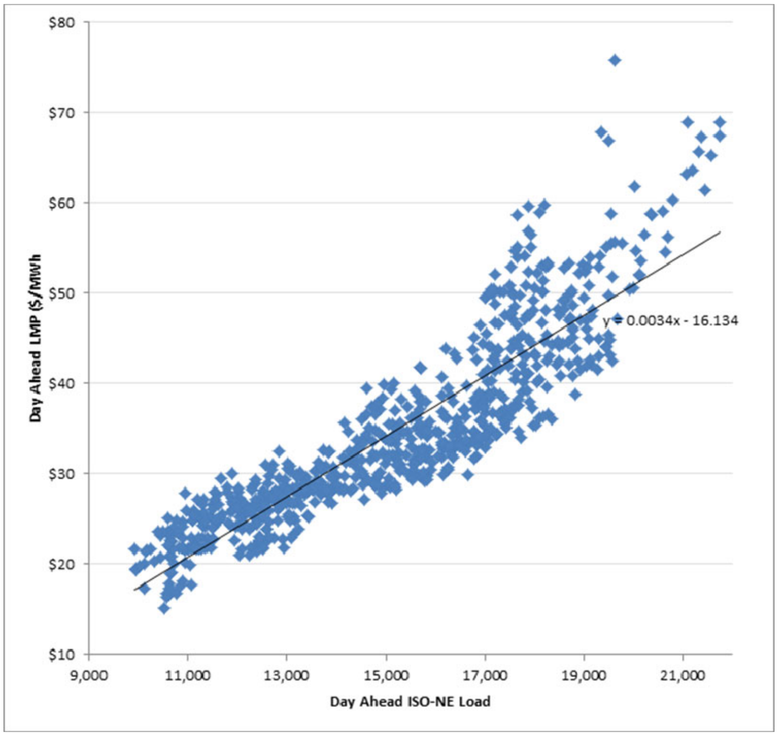

Figure 4. Locational marginal price (LMP) for ISO-NE hub August 2013. *Source:* ISO-NE (2013).

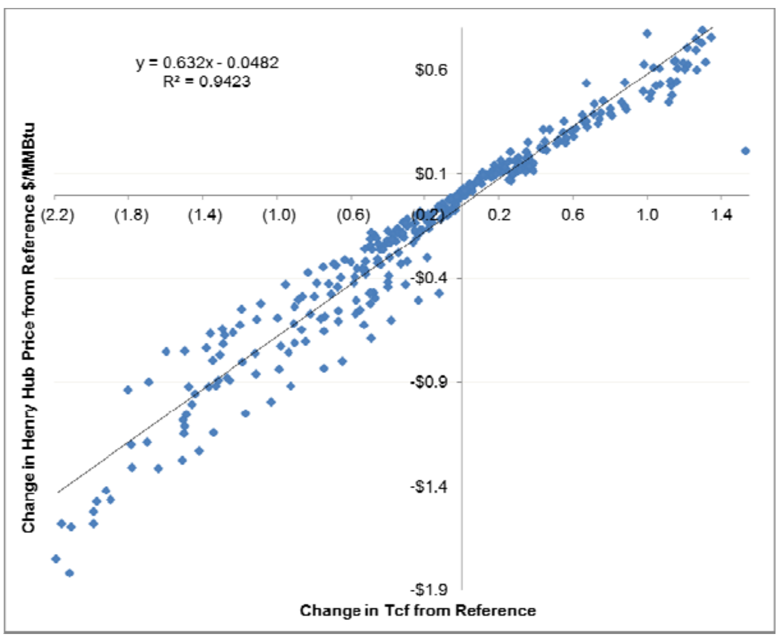

Figure 5. Projections of gas demand and price changes. *Source:* EIA (2012)

From the data expressed in Figure 5, the AESC Study Group (2013, Sec. 7.3) estimated that EIA's modeling implied a $0.632/MMBtu decrease in Henry Hub gas price for every quadrillion-Btu (10^9 MMBtu, or quad) decrease in annual gas consumption.

Wiser, Bolinger, and St. Claire (2005, 9–16) summarize a number of analyses in the period 1998 to 2004 that estimated the effect on North America natural-gas prices of reducing gas use through gas or electric energy-efficiency programs and/or renewable energy. While the results of those studies varied widely, the majority suggested that each quad reduction in gas consumption would decrease wellhead price by \$0.07/MMBtu to \$0.25/MMBtu. While that is a small reduction in price per unit of gas saved, it applies to a large amount of gas. Wiser, Bolinger, and St. Claire (2005, 17–19) reports implied price elasticities of supply from the bulk of those studies between −1.0 and −1.5. In other words, for each dollar of gas saved directly by an efficiency program, the price effects save consumers another \$1.00 or \$1.50.

Figures 6 and 7 illustrate how New England gas load drives the basis (the difference in market prices) from TETCo M-3 in Pennsylvania and New Jersey to the Algonquin pipeline citygates, in the winters of 2011/12 and 2012/13.[8]

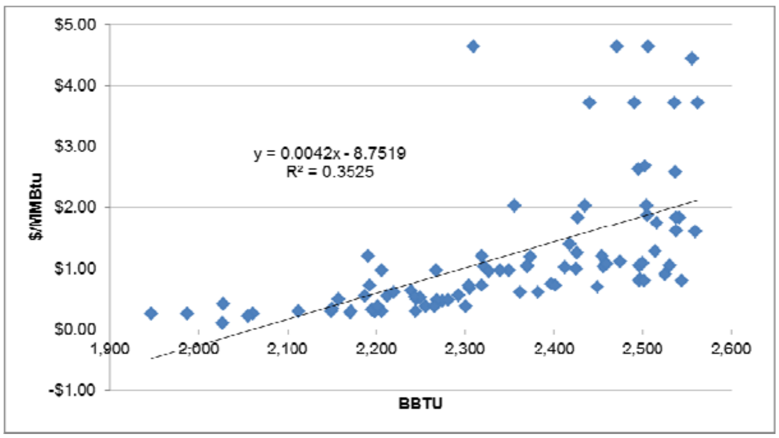

Figure 6. Gas transportation basis mid-Atlantic to New England as function of New England gas load, Winter 2011/12.

[8]There is considerable scatter in these data due to other loads (New York, Maritimes), changes in pipeline capacity, marketers' errors in forecasting demand, increased anxiety about supply adequacy by the end of January 2013, and other variables. The gas supply system for New England is simpler than for most areas, making it relatively easy to track a close proxy of daily load from data published by the Algonquin and Tennessee pipelines. Depending on the area being studied, comparable analyses for other regions may be more complex than for New England, reflecting inflows from multiple pipelines and the effects of exports to multiple regions.

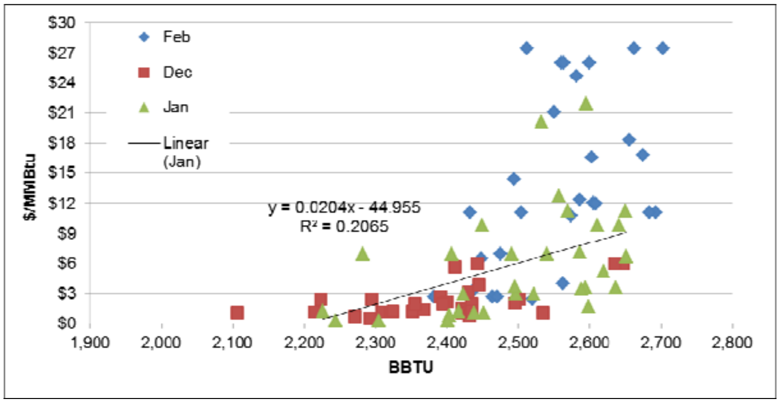

Figure 7. Gas Transportation Basis Mid-Atlantic to New England as function of New England gas load, Winter 2012/13.

The AESC Study Group (2011, 6-63–6-64) summarizes a number of studies of the effect of electric load reduction on market prices for electric energy.

Wiser, Bolinger, and St. Claire (2005, 9–16) summarize the results of 20 studies of the effect of natural-gas demand reductions on natural-gas prices. They find that a 1% reduction in gas demand is generally associated with a 1–1.5% reduction in gas price. Kushler, York, and Witte (2005) found that Midwest energy-efficiency efforts for gas and electricity would produce gas price reductions worth about 39% of the direct avoided costs of those programs, Mosenthal et al. (2006, 6-1–6-8) estimated that the price reductions in New York from a statewide gas-efficiency effort would be about 25% of the direct avoided costs, and Hoffman, Zimring, and Schiller (2013, 7–9) cite two studies as estimating that a 1% decrease in national gas consumption would reduce gas prices between 5.6% and 6.4%.

Any particular observed or modeled price may reflect factors other than demand in that period, including the effect of demand in adjacent periods (affecting the availability of storage hydro, or gas inventories) and supply conditions (e.g., power plant outages), but the trends are usually very clear.

Skepticism about the reality of price suppression tends to focus on two considerations: whether consumers are actually exposed to market prices, and whether the market will respond in ways that offset or eliminate the price change.

Market Exposure and Hedging

Table 1 above summarizes the types of costs for which customers of various types of utilities are exposed to market prices. For most consumers, some portion of that exposure is hedged by their gas and electric providers locking in fixed supply prices and quantities. The degree of hedging varies widely, depending on regulatory policies and historical commitments, among other factors.

Gas utilities generally lock in prices for gas in the supply areas for some of their anticipated winter requirements for the next one or two winters, while gas marketers typically commit to gas supply only for the period for which they have fixed sales contracts with customers, rarely over three years. Hence, LDC gas supply in most areas will be partially hedged reducing the consumer benefit of price suppression substantially in the first year after load is reduced, with the hedging effect falling to zero by year three or four.

Integrated electric utilities vary in their fuel-contracting arrangements, depending on regulatory guidance, cost-recovery arrangements (such as penalties for exceeding forecast fuel costs) and fueling requirements. Some coal plants have fixed or cost-based contracts with local mines (which may even be owned by the utility), while others are fueled with coal from distant basins, shipped by barge or rail at market prices. Some utilities are highly dependent on natural gas for generation, and hedge much of their supply for a year or a few years into the future. Others use gas primarily for peaking, with unpredictable and irregular consumption, and choose to hedge little or none of that supply. Estimating price suppression for a jurisdiction with integrated utilities requires a review of the fuel-contracting policies of those utilities.

Most restructured electric distribution companies (other than those in Texas) provide a default generation-supply option for customers who do not choose other suppliers. Some of those rates primarily flow through hourly market energy prices (as for large New Jersey customers), while others are set quarterly (e.g., large Massachusetts and Connecticut customers) or annually (e.g., Massachusetts and Connecticut households). The utilities generally contract for energy and related services (e.g., capacity, reserves, ancillary services) shortly before the delivery periods, ranging from a couple of months to a little more than a year in advance. Small electric consumers can rarely get marketers to commit to a fixed price more than a year into the future, and even large consumers are usually limited to contract about three years forward. Restructured electric utilities often have some energy and capacity supply for longer terms, either as a legacy of pre-restructuring contracts (such as for QFs) or occasionally from post-restructuring commitments to deal with specific issues, especially the promotion of renewables.[9] Price-suppression effects for most restructured EDCs are thus reduced substantially in the first year or so, with some small hedging often continuing in later years.

Even with the forward purchases and the longer-term commitments a reduction in market price will affect most of the load of a restructured utility within a year or so, and sometimes sooner. The same is true for the gas supply of most LDCs and various portions of the fuel of vertically integrated utilities.

Market Responses and Decay of Price Suppression

Depending on the type of commodity and market conditions, the price suppression due to energy efficiency may not persist as long as the underlying energy savings. For example, in electric energy markets, lower loads will reduce the use of the most expensive generation that would otherwise operate in each hour, but those lower energy prices may have the following effects, listed roughly in the order of the time scale of the response:

- Units with high commitment costs but relatively low running costs (e.g., coal units with high start-up fuel use and low fuel costs) will tend to be left off-line for more days and weeks of the year, requiring the use of more-expensive units in some hours.
- Since the value of being available to produce energy in every hour is reduced, suppliers may reduce investments in maintaining reliability of existing units, resulting in more outages and greater use of more-expensive resources.

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[9]In addition, the Connecticut utilities have a series of contracts for capacity and/or energy from new resources added to relieve transmission constraints and meet operating-reserve requirements; Con Edison expanded the East River cogeneration facility to serve its steam loop.

- Since generators will tend to operate in fewer hours, the benefit to the owner of reducing heat rate and running costs would be reduced, possibly leading to lower expenditures on maintaining efficiency and reducing variable costs.
- Customers will tend to use more of the less-expensive energy.
- In jurisdictions with renewable portfolio standards computed as percent of sales, energy efficiency will reduce the required development of renewable capacity.[10]
- Marginal generating units may be mothballed for seasons or years.
- Marginal generating units may be retired earlier.
- The addition of new resources will tend to be delayed.
- For gas transportation capacity, reduced market prices may reduce the pipelines' incentives to develop additional capacity across constrained interfaces.[11]

Each of these effects, to the extent they apply in a particular time and place, will tend to diminish the price suppression over time.[12]

The lower energy prices will tend to change the mix of generation used to supply the market, which in turn will eventually lead to higher prices, at least partially offsetting the effects of lower loads.

Conclusion

While estimation can be challenging in some situations, reduced energy loads clearly result in reduced market prices. [13] Depending on the degree of cost-of-service regulation, those price reductions will be passed on to consumers for some period of time. Price effects are relevant for the Utility Cost or Program Administrator Cost tests, as well as estimates of the effects of energy-efficiency programs on consumer rates and bills. Unless the regulators conclude that the interests of market suppliers (merchant power generators and fuel producers) are of equal importance to the interests of the consumers in the jurisdiction, price effects should also be recognized in total cost tests, including the Total Resource Cost and Societal tests.

References

AESC 2013 (Hornby, R., P. Chernick, D. White, J. Rosenkranz, R. Denhardt, E. Stanton, J. Gifford, B. Grace, M. Chang, P. Luckow, T. Vitolo, P. Knight, B. Griffiths, and B. Biewald). 2013. "Avoided Energy Supply Costs in New England: 2013 Report" Northborough, MA: Avoided-Energy-Supply-Component Study Group, c/o National Grid Company.

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[10]Whether a reduction in the renewables requirement leads to a reduction in renewable development depends on the costs of renewable energy and the other mechanisms encouraging renewable development, such as utility contracting.

[11]Since pipelines generally increase capacity only when they have firm contracts in hand to cover the incremental costs, and since merchant generators usually do not sign up for long-term pipeline capacity, it is not clear that higher market basis would result in capacity additions beyond those needed to serve firm LDC load and other end users.

[12]See AESC (2011, Sec. 6.3.3; 2013, Ch. 7) for examples of estimation of these decay effects.

[13]While this paper is framed in terms of load reductions from energy-efficiency programs, the effects of additional supply are similar, particularly those of renewables and other resources with low dispatch costs.

AESC 2011 (Hornby, R., P. Chernick, C. Swanson, D. White, J. Gifford, M. Chang, N. Hughes, M. Wittenstein, R. Wilson, and B. Biewald). 2011. "Avoided Energy Supply Costs in New England: 2011 Report" Northborough, MA: Avoided-Energy-Supply-Component Study Group, c/o National Grid Company.

Aydin, O., F. Graves, and M. Celebi. 2013. "Coal Plant Retirements: Feedback Effects on Wholesale Electricity Prices." Cambridge, MA: The Brattle Group http://www.brattle.com/system/news/pdfs/000/000/584/original/Coal_Plant_Retirements_-_Feedback_Effects_on_Wholesale_Electricity_Prices.pdf?1386628173.

Daykin, E. J. Aiona, and B. Hedman. 2011. "Whose Perspective? The Impact of the Utility Cost Test" unpublished paper. Waltham, MA, Portland, OR: The Cadmus Group.

EIA. 2012. "Annual Energy Outlook 2012 with Projections to 2035" DOE/EIA-0383(2012), Apps. B, D. Washington, DC: US Energy Information Administration. Detailed data online at http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2012.

Hoffman, I., M. Zimring, and S. Schiller. 2013. "Assessing Natural Gas Energy Efficiency Programs in a Low-Price Environment" LBNL-6105E. Berkeley, CA: Lawrence Berkeley National Laboratory.

ISO-NE. 2013. Hourly zonal information "2012_smd_hourly.xls." Available online at http://www.iso-ne.com/markets/hstdata/znl_info/hourly/index.html

Kushler, M., D. York, and P. Witte. 2005 "Examining the Potential for Energy Efficiency to Help Address the Natural-Gas Crisis in the Midwest" Report U051. Washington, DC: ACEEE.

Lesser, J. 2010. "Gresham's Law of Green Energy: High-Cost Subsidized Renewable Resources Destroy Jobs and Hurt Consumers" *Regulation* 33(4):12–18.

Martinez, C., J. Deyette, S. Sattler, and A. McKibbin. 2011. "Bright Future for the Heartland." Cambridge, MA: Union of Concerned Scientists.

Mosenthal, P., R. N. Elliott, D. York, C. Neme, P. Chernick, and K. Petak. 2006. "Natural Gas Energy Efficiency Resource Development Potential in New York." Unpublished report prepared for NYSERDA. Albany, NY: New York State Energy Research and Development Authority.

PUCO. 2013. "Renewable Resources and Wholesale Price Suppression." Columbus, OH: Public Utilities Commission of Ohio.

PJM. 2009. "Potential Effects of Proposed Climate Change Policies on PJM's Energy Market." Valley Forge, PA: PJM.

Tranen, J. 2012. Prefiled direct testimony on behalf of Entergy Vermont Yankee in VT PSB Docket No.7862, June 29 2012.

Wickenden, M. 2013. Supplemental comments on behalf of the Vermont Energy Investment Corporation re demand-reduction-induced price effects in connection with a workshop conducted in Vermont PSB Docket EEU–2013–0. Letter dated December 3 2013.

Wiser, R., M. Bolinger, and M. St. Clair. 2005. "Easing the Natural Gas Crisis: Reducing Natural Gas Prices through Increased Deployment of Renewable Energy and Energy Efficiency" LBNL-56756. Berkeley, CA: Lawrence Berkeley National Laboratory.