Price Effects of Energy Efficiency: Does More Industrial EE Equal Lower Energy Prices for All?

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ABSTRACT

An increasing amount of attention is being given to Demand Reduction Induced Price Effects (DRIPE) as a benefit of energy efficiency and demand response programs. DRIPE refers to the effects on energy prices resulting from decreased demand. Although these effects are typically relatively small rate reductions, they can have a very large absolute value as they are spread across all of the customers in the market. While the theory behind DRIPE represents a simple example of downward shift in the demand curve along the supply curve in the wholesale energy markets, quantifying its effects has proven far more complicated. Successive reports estimating DRIPE have honed a methodology for projecting its effects, which has been accepted by an increasing number of states. Still, significant questions remain surrounding the duration of DRIPE, the effects of demand reductions on transmission and distribution costs, and the role of the industrial sector in both contributing to DRIPE as well as in benefiting from the reduction in energy rates.

Introduction

Many states, especially in New England, are beginning to recognize Demand Reduction Induced Price Effects (DRIPE) as a quantifiable benefit of energy efficiency and demand response. DRIPE is a measurement of the value of efficiency in terms of the reduction of wholesale energy prices seen by all retail customers. The reduced energy demand due to efficiency programs allows for the shedding of the most expensive resources on the margin and lowering the overall costs of energy. This reduces the wholesale prices of energy and demand, and this reduction, in a relatively deregulated market, is in theory passed on to retail customers. The reductions in energy prices are small; however, the absolute dollar impacts are significant as the price effects are applied across all usage. New technologies and practices have the potential to further enhance these effects in the future. For example, smart manufacturing technologies and real-time monitoring create instant visibility of energy consumption patterns and can foster greater industrial participation in demand response (therefore lowering prices during peak demand and other high-cost periods), as well as enable deeper, continuous energy savings (therefore lowering pressures to invest in new supply capacity).

DRIPE is usually conceptualized as a downward movement by the demand curve in wholesale energy markets, leading to a new equilibrium at a lower price point along the supply curve. However, the simplicity and clarity of this model can be deceiving. The exact effects of energy efficiency on retail energy prices can be difficult to ascertain and depend upon questions such as how long the effects last, how much rebound in demand results from the decrease in price, and how decreased demand affects rates paid for transmission and distribution.

The literature on DRIPE is somewhat uneven. Most of the central questions regarding the effects of energy efficiency on prices have been addressed in some form, with the greatest amount of attention having been paid to the effects in the wholesale markets and the least attention paid to effects on transmission and distribution. In addition, studies of related topics such as demand reduction for crisis mitigation can shed some light on how these effects play out.

Still, many questions remain surrounding how exactly investments in energy efficiency and demand response affect the actual rates paid by customers and how diverse regulatory frameworks might change how these effects play out. To fill the considerable gaps in the body of knowledge on DRIPE will require further research, especially into producing empirical data on the subject, examining the effects of various regulatory frameworks on the way demand reductions translate into prices, and how industrial energy efficiency affects prices in particular.

This paper examines the existing research on DRIPE and closely related topics with a view to clarify the gaps in our understanding of DRIPE and its importance for the industrial sector. First, we discuss the various studies on DRIPE in the wholesale electricity markets, in electricity transmission and distribution, and in the natural gas markets. Next, we look at various experiences with DRIPE as a crisis mitigation tool, as well as the extent to which DRIPE can be negated by the rebound effect, and what different states have done with DRIPE from a regulatory perspective. Finally, we contemplate the gaps in the existing research on DRIPE and what these gaps mean for further studies.

The Importance of Energy Efficiency's Impact on Energy Prices

While the reductions in rates caused by decreased demand are usually small, expressed in fractions of a cent per kWh, their absolute value can be quite large as it is spread across all of the customers in the market. For instance, in New York state, the rate reduction from DRIPE was estimated to be between 0.4 cents per kWh and 0.9 cents per kWh, which would translate to total savings across the state of between $600 million and $1.5 billion (New York State Energy Plan 2009). In the case of natural gas, the rate effects could be felt nationally. Natural gas rate reductions in particular can be high in absolute terms as they affect a very large customer base. The large absolute value of energy efficiency's price effects can, in turn, dramatically change the cost-benefit analysis of additional investments in energy efficiency. Producing accurate and reliable estimates of the total price effects of energy efficiency investments therefore becomes very important, as inaccurate estimates or the total exclusion of these price effects can lead to an inefficient level of energy efficiency investment. For example, it is quite likely that in many states the exclusion of DRIPE from the calculation of energy efficiency benefits has led to under-investment in energy efficiency as the absolute value of the price reductions from energy efficiency would be greater than the energy efficiency installation cost.

The fact remains that reductions in energy prices have a large absolute value across the market, but a small impact on each individual customer. This can lead to a collective action problem. Since no single customer can reduce demand by a significant enough amount to create a perceivable impact on their own rates, the full benefits of rate reductions resulting from energy efficiency are difficult to realize without coordination among a large number of customers.

Published Findings on the Effect of Energy Efficiency on Prices

The bulk of the published findings on DRIPE come from several states in New England as well as Maryland, as these states have begun including DRIPE in their energy plans. In addition, states such as New York, Ohio, and Illinois have begun to examine DRIPE and are moving towards including it as well.

In Wholesale Electricity Markets

In wholesale electricity markets, DRIPE is usually conceptualized as a downward movement in the demand curve, leading to a new equilibrium being established at a lower price point. This basic theoretical model applies to price effects arising from both energy efficiency and demand response, though the duration of demand reductions is much longer in the case of energy efficiency, as the reductions continue throughout the lifetime of the project as opposed to the few minutes or hours a demand response resource is dispatched. In this theoretical model, DRIPE reduces the marginal cost of electricity as it exposes market inefficiencies by substituting lower cost energy efficiency for higher cost supply. While some economists view DRIPE as simply a transfer from producers to consumers, this substitution of lower cost energy efficiency for higher cost supply means that "some of the loss in welfare to producers is a genuine gain in economic efficiency."(Lazar and Colburn 2013). Thus, the demand reductions brought by energy efficiency not only reduce the price of energy by producing a downward movement of the demand curve, but this price reduction represents an increase in overall economic efficiency insofar as the marginal cost of energy efficiency is less than the marginal cost of energy.

Over the past decade, the methodology for producing data on DRIPE has been gradually honed, though significant challenges still remain. This methodology typically involves reconstructing the electricity supply curve as well as the shift in the demand curve resulting from planned energy efficiency and demand response projects. The vast majority of estimates have limited themselves to the electricity markets, though recently New England has begun incorporating the impacts of decreased electricity demand on the natural gas markets into their estimates (Hornby et al. 2013).

One of the major challenges in estimating DRIPE in the wholesale electricity market has been factoring-in the dissipation of effects. In the years following a reduction in demand, electricity producers gradually react to the new price and the supply curve shifts as well, eventually eliminating the price effects of the reduction in demand. The pace of this reaction by the producers has been the source of much debate. Early estimations of DRIPE assumed that this dissipation of effects would not be total, and that some price reduction would continue in the long run, albeit a much smaller reduction than in the early years (ICF Consulting 2005). In New England, this assumption has been revised, with recent reports assuming that both capacity and energy DRIPE[1] would dissipate within 8 to 11 years (Hornby et al. 2013). However, in reports on other areas such as Maryland, it is still assumed that some degree of effect will continue indefinitely (Exeter Associates 2014). These variations in assumptions around the rate of dissipation of DRIPE have led estimates of the total impact of demand reductions on prices to vary by as much as 300% (Hornby et al. 2011). Given the significant impact that variations in these assumptions has had on the ultimate estimates, it is no surprise that arriving at the most accurate dissipation rate has received a great deal of attention in many studies on DRIPE.

New England has paid the greatest attention to DRIPE of any region in the US. Since 2005, the biennial Avoided Energy Supply Cost reports have produced detailed estimates of the impacts of demand reductions on prices in the region. As the methodology was being created and honed in the first few reports, the estimates differed greatly from report to report (Hornby et al. 2007; Hornby et al. 2009). However, the estimates have become far more consistent in the more

[1] Capacity DRIPE refers to the effect on capacity market prices due to decreased demand, while energy DRIPE refers to the effect on energy market prices due to decreased demand for electric energy.

recent reports as the methodology has been more or less settled, with the major variations in estimates arising from changes in regulations or unforeseen changes in energy markets (Hornby et al. 2011; Hornby et al. 2013). The latest report, published in 2013, estimates that the average summer peak reduction in electricity rates from DRIPE, including both energy efficiency and demand response, over the next 15 years is 3.44 cents/kWh, with much lower rate reductions off-peak and at different times of the year (Hornby et al. 2013). Such a rate reduction spread across all of the electricity consumers in New England implies a very large absolute value decrease in spending on electricity in the market.

Outside of New England, several other states and regions have produced estimates on DRIPE. In New York, the state estimated in 2009 that the initial costs of increasing energy efficiency may lead to higher rates for ratepayers for the first two years of their energy plan, but the net impact of energy efficiency will be to reduce rates thereafter due to the price suppression effects of decreased demand. The estimates for the reduction in rates arising from New York's target of a 15% reduction in electricity demand as compared with the base case are between 0.4 and 0.9 cents per kWh by 2015, which would mean an annual savings by New York ratepayers of between $600 million and $1.5 billion, with this figure decreasing in subsequent years as the price effects dissipate (New York State Energy Plan 2009).

Also in 2009, the PJM Interconnection published an analysis of how increased energy efficiency that could be required by proposed climate change legislation might affect the market. The results of this evaluation were estimates of DRIPE that varied between $3 billion and $18 billion in total savings by the entire customer base, depending on energy prices and the extent of the demand reductions. However, the methodology used is not clear, and it is difficult to say to what extent the figures incorporate effects such as the dissipation of DRIPE (PJM 2009).

More recently, 2014 estimates were published for the price impacts of Ohio's energy efficiency standards. The estimates came to a total savings for Ohio customers of $880 million from wholesale energy price mitigation and $1,320 million from wholesale capacity price mitigation through 2020 (Neubauer et al. 2013).

On the other hand, in the same year, a report on Maryland provided both capacity and energy DRIPE estimates for energy efficiency measures to be installed from 2015-2017, breaking down the effects by region of the state and by year of installation of the measures. Of particular note, these estimates include price increases in some zones in some years due to changes in the import or export of power from these zones and the elimination of low cost marginal generation in the zone (Exeter Associates 2014). This is the only report which includes wholesale price increases as a result of demand reductions.

While there does not exist empirical evidence to settle the various debates surrounding the dissipation rate of DRIPE or the exact magnitude of the price effects, the estimates produced are fairly consistent in showing large savings on electricity throughout any given market. These savings represent a major gain in economic efficiency and likely have some important ripple effects throughout the economy.

In Electricity Transmission and Distribution

While there do not exist any studies that focus on the impact of demand reductions on prices because of decreased distribution costs, there are a few studies on how decreased electricity demand decreases distribution costs, which puts downward pressure on retail rates. One of the key ways in which energy efficiency decreases transmission and distribution costs is through a decrease in line losses. This impact is magnified by the fact that marginal line losses are higher than average line losses, which boosts the effect of increased efficiency on decreasing losses as compared with additional investments in infrastructure. In addition, energy efficiency is typically the most cost-effective method of decreasing losses, which points to a long-term downward pressure on distribution costs resulting from increased efficiency (Lazar and Baldwin 2011).

Separately, various experiences across the US with using energy efficiency as a transmission and distribution system resource have shown that this use leads to a decreased need for investment in T&D infrastructure. This effect is particularly important because investments in T&D infrastructure constitute the majority of power system investments, and decreasing the need for investment can lower electricity costs (Neme and Sedano 2012). This, too, points to a long-term downward pressure on retail prices resulting from energy efficiency.

On the other hand, there is reason to believe that reductions in demand can lead to increased rates from utilities seeking to recover their investments in T&D infrastructure. Where utilities are operating under traditional cost-of-service regulation, there is some evidence that decreased demand has made it difficult for utilities to recover their investment in transmission and distribution infrastructure because such demand reductions mean lower revenues for utility companies and therefore lower profits for their investors. The decreased profits for investors and the difficulty in recovering investments in fixed infrastructure have led to worries about future troubles in attracting investors to the sector, though these troubles have yet to materialize (Kind 2013). This situation has led some utilities to seek to increase fixed charges on customers in order to increase revenues and recover their investment in infrastructure. Where the regulatory environment has moved away from the traditional model and decoupling has been implemented, this concern about decreased profits is obviated as the utility's allowed revenue is set; however, decreased demand can still put upward pressure on rates as the utility's allowed revenue must be collected from lower unit sales (Lazar, Weston, and Shirley 2011).

In the Natural Gas Sector

There has been some attention paid to the impacts of energy efficiency on natural gas prices in addition to the cross-market DRIPE analysis in New England discussed above and the effectiveness of DRIPE in addressing natural gas crises discussed below. Notably, because gas is traded across a larger geographic area, the impact of DRIPE can be very large and felt by far more customers than is the case with electricity.

As in wholesale electricity markets, energy efficiency reduces gas prices by sliding the gas demand curve to a lower point on the supply curve. The methodology to produce estimates of DRIPE in the natural gas markets can be quite simple if one only uses the inverse elasticity of supply or far more complex if one reconstructs the entire market (Hoffman 2013).

Although there is significantly less written about DRIPE in natural gas markets, there have been some studies of price effects as a benefit of natural gas energy efficiency. Some notable findings have been that the consumer benefits from DRIPE in the gas markets are five times the welfare transfer from producers, meaning that there is a significant net economic benefit, and that the reductions in gas demand impact prices in the entire US, meaning that the negligible decline in gas prices caused by Massachusetts' energy efficiency programs has led to an estimated consumer savings of at least $12 million across the US (Hoffman, Zimring, and Schiller 2013). In New England, DRIPE for 2014 natural gas energy efficiency installations was estimated at $0.296/MMBtu on average across the region for the coming 15 years (Hurley et al. 2013).

Crisis Mitigation

During and after the 2000 California electricity crisis and the mid-2000s natural gas crisis in the Midwest, much attention was paid to the possibility of using demand reductions as a method of avoiding price spikes. The theory behind using demand reductions to ease energy crises is the basis for demand response – it is typically more cost effective to decrease demand instead of increasing supply to meet demand, especially at peak or other high-cost times. In some emergencies, reducing demand is the only option, as supply can no longer be increased. While this would point to the use of demand reductions to ease crises as strictly the domain of demand response, there is also a case that energy efficiency can help to keep prices from reaching crisis levels.

Following the 2000 California Electricity Crisis, several authors suggested that greater encouragement of demand response and energy efficiency would play a crucial role in averting another crisis and keeping wholesale electricity prices low. Both the Congressional Budget Office and the Cato Institute proposed that customers be exposed to the high wholesale cost of electricity as this would incentivize demand reductions throughout the year in the form of energy efficiency as well as short-term demand reductions or demand response at peak prices (CBO 2001; The Cato Institute 2001). These demand reductions would then push a downward shift in the demand curve, lowering wholesale electricity prices.

While exposing customers to the fluctuations of the wholesale price of electricity is typically a characteristic of demand response programs,[2] the prolonged period of high prices in California would have likely also stimulated some investment in energy efficiency as typical short-term demand response measures would prove difficult to maintain for such a long time. Furthermore, a major contributing factor to the crisis was the limited incentive to conserve electricity created by a price structure with high fixed charges and relatively low marginal electricity rates for customers. A detailed quantitative analysis of the electricity supply curve leading up to and during the 2000 California Electricity Crisis, conducted at the end of the crisis in 2000, shows that load reductions had a value to the system, in terms of decreased costs for all ratepayers, of at least twice the market price of electricity most during most hours of the year and significantly more during peak times (Marcus and Ruszovan 2000). This demonstrates that, while demand response could play a major role in averting a crisis, incentivizing energy efficiency would have also had a significant impact in keeping prices lower.

With greater demand response and energy efficiency, a repeat of the 2000 crisis was averted in 2001. Specifically, a 14% reduction in peak demand in July 2001, the result of both increased energy efficiency and expanded demand response programs, helped keep prices from spiking as they had the year before (Weare 2003). While there were certainly other factors in avoiding a repeat of the 2000 crisis, this provides clear empirical evidence that demand reductions can play a role in keeping prices from rising too high.

On the mid-2000s natural gas crisis in the Midwest, several authors suggested that increased efficiency and the deployment of renewables could decrease natural gas prices (Wiser, Bolinger, and St. Clair 2005). The American Council for an Energy-Efficient Economy estimated

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2 Time of use (TOU) pricing is a common type of demand response program which seeks to incentivize demand reductions at peak times and greater demand off-peak by passing on both the higher wholesale prices at peak time and the lower prices off-peak. This pricing method contrasts with the traditional practice of charging a flat rate for electric energy at all times.

that customers could save over $1 billion on gas rates throughout the Midwest due to price suppression resulting from increased efficiency. Broken up by sector, 2006 savings across the region due to price decreases were projected to amount to a total of $163 million for industrial customers, $104 million for commercial customers, and $194 million for residential customers. By the year 2020, these figures should climb to $925 million for industrial customers, $362 million for commercial customers, and $641 million for residential customers (Kushler, York, and Witte 2005). This breakdown of impacts by sector is noteworthy, especially as it makes it clear that, over the long run, the greatest share of the benefits accrue to industrial customers.

The Rebound Effect

Some analysts have posited that price decreases from demand reductions lead to increased consumption by consumers, which pushes prices back up. This effect is known as the Jevons Paradox and has been studied by several economists in relation to energy efficiency. Across the board, the findings of these studies have been that the effects of the Jevons Paradox are minimal and do not significantly offset the reductions in demand resulting from energy efficiency.

In two studies on the rebound of demand due to a reduction in price, the empirical evidence shows that the rebound in demand is less than half the original decrease in demand, with the highest estimated rebound in demand coming from water heaters and air conditioners, while no rebound was found in the case of energy efficient appliances and little rebound was found in the case of lighting (Steinhurst and Sabodash 2011). The rebound in demand resulting from decreased prices is usually between 10% and 30% of the reduction (Gillingham et al. 2013). Based on these findings, it is clear that, while there is some rebound in demand, the effect is nowhere near large enough to totally offset the initial reductions in demand and therefore would not negate the price reduction caused.

State Regulatory Filings

The regulatory bodies in all of the states of New England, as well as several states in other regions, have addressed whether DRIPE should be included in the benefits of energy efficiency as well as which effects should be included and to what degree.

Some states have ordered that DRIPE, including DRIPE benefits outside of the state resulting from the demand reductions within the state, be included going forward in the updated avoided costs used for cost-effectiveness screening of energy efficiency programs. For example, in 2014, the Vermont Public Service Board ordered that 100% of DRIPE within Vermont be included, along with 50% of DRIPE in the rest of the New England pool (Vermont Public Service Board 2014). This decision in Vermont is in line with similar moves by Rhode Island and Connecticut in including considerations of DRIPE in the rest of the New England market, and contrasts with Massachusetts' choice to only include DRIPE within the state (Massachusetts Department of Public Utilities 2009). Other states, such as New Hampshire, have chosen to exclude DRIPE from the benefits of energy efficiency (NH PUC 2014).

The methodology used to estimate DRIPE has also been the subject of much contention in deciding how to include DRIPE among the benefits of energy efficiency. For example, concerns over the variation in the estimated duration of DRIPE led Maryland to decide to use the shortest estimated duration of four years instead of more recent estimates, which predicted that the effects would dissipate after ten years (Godfrey 2015).

Knowledge Gaps

Industrial Sector

No studies estimate the price effects of reduced electricity demand in the industrial sector from participation in energy efficiency ratepayer programs, and only one study on the Midwest natural gas crisis includes information on the benefits specifically to the industrial sector resulting from energy efficiency. This gap is particularly noteworthy given the collective action problem with realizing DRIPE benefits. The lack of individual incentives to carry out the investments that would produce significant savings and increased economic efficiency across the entire market points to a significant role to be played by the industrial sector, as it represents some of the largest customers who are, therefore, most able to influence prices and reap the most benefits on an individual customer basis.

Empirical Data

There are no significant works on the effects of energy efficiency on energy prices that include empirical data, and it may prove very difficult to produce any such data. One of the closest approximations of empirical data comes from the Public Policy Institute of California's report on the 2000 electricity crisis; however, these data do not control for the changes in supply that occurred between 2000 and 2001, it is difficult to ascertain to what extent the avoidance of another crisis in 2001 was due to the 14% reduction in peak load as opposed to an increase in supply. Another approximation of empirical data would be found by comparing projections of DRIPE from the AESC reports with actual prices, though it remains difficult to separate the impact of DRIPE from other effects on the prices, as is the issue with the California case.

The lack of empirical data poses a significant challenge for the study of the price effects of energy efficiency and their inclusion among the benefits of energy efficiency. Without empirical data, it is difficult to test the accuracy of projections of DRIPE, in turn making it more difficult to improve the estimation methodology by, for example, comparing the projected time frame for the dissipation of DRIPE to the actual outcome. In turn, this inability to completely vindicate the methodology for estimating DRIPE makes the projections of benefits inherently debatable and therefore complicates any case that they should be included among the benefits of energy efficiency for planning purposes.

Impact of the Electricity Regulatory Framework

Thus far, studies of DRIPE have focused on wholesale electricity markets. They do not consider how DRIPE may have a different impact under other regulatory frameworks, such as in classic vertically-integrated utilities without competitive wholesale energy markets. While there would not be the clear supply curve that can be plotted in competitive electricity markets, it is likely that demand reductions could allow the electricity company to retire some of its most expensive generation capacity.

Of particular note is the impact of demand reductions on rates charged for utilities to recover their investments in distribution infrastructure. While many utilities have claimed that the reductions in demand have forced them to levy fixed charges in order to recover their investments, there is also evidence that demand reductions significantly reduce their losses and the need for such investments. Without a study on the subject, it is difficult to know which effect dominates and how these effects play out over time.

Implications for Further Research

The most significant possible addition to the existing body of literature would be an empirical study of the price effects of energy efficiency. Especially given the wide variation of estimations of the value of DRIPE and the hesitance of some states to include these estimations as a benefit of energy efficiency, it would be very beneficial to produce more clearly reliable data. Furthermore, empirical data would improve the estimations of DRIPE by providing a benchmark to compare with. Producing such data, however, may prove quite difficult as it is not simple to separate DRIPE from other effects on energy prices. It would most likely require a special situation in which both the supply and demand curves are exceptionally static aside from improvements in energy efficiency on the demand side. Barring such a special situation, empirical data would likely be best approximated by a thorough comparison of DRIPE projections with actual market behavior.

Another major possible addition would be to study how the impacts of demand reductions on wholesale prices and transmission and distribution costs translate into retail rates given various regulatory frameworks. Such a study could be completed by carrying out a set of case studies on various electricity markets with diverse regulatory frameworks, in order to create a representative sample of how these markets react to reductions in demand.

Finally, a study of DRIPE in the industrial sector would be an important addition to the body of literature on the price impacts of energy efficiency. This could be achieved by either focusing on markets where industrial energy efficiency is included in utility programs, by quantifying the rate impacts of its inclusion, or by focusing on markets where industrial energy efficiency is not included in order to estimate what would be the impact of its inclusion.

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