THE EFFECT OF STATE-LEVEL FUNDING ON ENERGY EFFICIENCY OUTCOMES

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ABSTRACT

Increasingly, states are formalizing energy efficiency policies. In 2010, states required utilities to budget $5.5 billion through ratepayer-funded energy efficiency programs, investing in both electricity and natural gas programs. However the size and spread of energy efficiency programs was strikingly different from state to state. This paper examines how far each dollar of state-level energy efficiency funding goes in producing efficiency gains. Many states have also pursued innovative policy actions to conserve electricity. Measures of policy effort are also included in this study, along with average electricity prices. The only variable that is consistently correlated with energy usage intensity across all models is electricity price. As politicians at local, state, and Federal levels continue to push for improved energy efficiency, the models in this paper provide a convincing impetus for focusing on strategies that raise energy prices.

This thesis is dedicated to everyone who helped along the way.

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listened, and commiserated.
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Introduction

With climate change gaining an ever stronger foothold in the policy arena, states have begun to search for an energy portfolio that promises a secure future. While the country as a whole has made major strides in the development and deployment of renewable energy resources, policymakers are also seeking ways to use existing resources and infrastructure more efficiently. Energy efficiency policy has become a major focus of Federal, state, and local-level policies. Energy efficiency offers a variety of benefits, including lower energy bills for consumers, improved air quality, greenhouse gas reductions, and deferred costs for utilities as less pressure is exerted on existing infrastructure. Increasingly, states are formalizing energy efficiency policies. In 2010, states required utilities to budget $5.5 billion through ratepayer-funded energy efficiency programs, investing in both electricity and natural gas programs. This is a leap of more than 25 percent from 2009, when state-level efficiency budgets included $4.3 billion for these types of programs (Sciortino et al. 2011).

Figure 1. State-level budgets for electric efficiency programs.
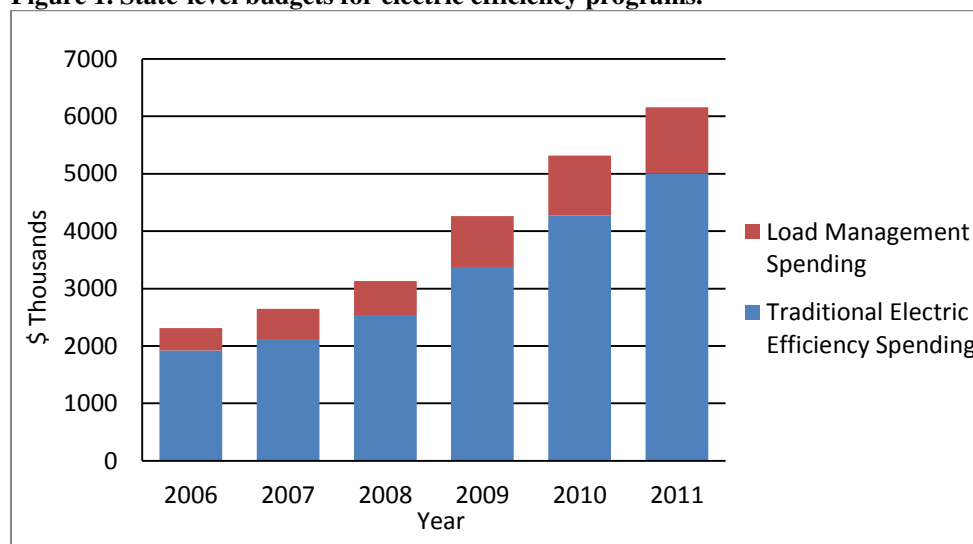
Note: Compiled from data published by the Consortium for Energy Efficiency.
Reflects reported efficiency budgets.

In large part, the increase in state-level energy efficiency programs is reflective of a push by the Federal government. In 2009, the American Recovery and Reinvestment Act (ARRA) allocated $16.8 billion for programs spearheaded by the Office of Energy Efficiency (EERE), the body that supports research, development, and deployment of energy efficient technologies for the U.S. Department of Energy (Department of Energy 2012). Of this, more than $11 billion was passed directly through to states for investment in customized energy efficiency programs (Ibid). President Obama has continued to reinforce energy efficiency as a policy priority. *Blueprint for a Secure Energy Future* – a White House document outlining the administration's energy plans – highlighted cutting consumer energy bills specifically through energy efficiency upgrades in homes and commercial buildings (White House 2011). In February 2011, President Obama said that "making our buildings more energy-efficient is one of the fastest, easiest, and cheapest ways to save money [and] combat pollution (Ibid)." Further emphasizing his priority of energy efficiency, the President issued an Executive Order in August 2012 focused on industrial energy efficiency and combined heat and power (White House 2012).[1]

Several studies have shown that energy efficiency improvements can result in economic benefits (i.e. Granade 2009). Thus, at the firm level there is a significant argument for individual businesses to take the lead in making capital investments in energy efficiency. Why then, are states investing heavily in policies and programs that encourage firms to do what economics should dictate private industry pursuing even without government intervention? Scholars often point to the energy efficiency "gap," wherein firms, and in fact the nation as a whole, do not achieve the maximally beneficial level of energy efficiency (Alcott and Greenstone 2012).

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[1] Combined heat and power is also known as cogeneration, whereby the waste heat from a manufacturing process is used to generate electricity of the waste heat from generating electricity is used to create steam, which can be used for heating. It effectively increases the efficiency of electricity production.

Furthermore, many economists are doubtful of the true costs and benefits associated with energy efficiency, noting that if efficiency is cost-effective, governments should not have to intervene at all (Heffner and Ryan 2010). Is the "negative cost" of energy efficiency a reality? McKinsey and Co. (2009) noted that "energy efficiency offers a vast, low-cost energy resource for the U.S. economy – but only if the nation can craft an innovative approach to unlock it." As firms and residential electricity consumers have failed to become maximally energy efficient, it becomes clear that the government has a role to play in overcoming these market barriers. While the federal government is certainly a large player in encouraging energy efficiency, states have also taken on a major role.

Background

A brief review of state investments in energy efficiency gives a distinct impression of the heterogeneity in both the priority of efficiency and strategies for attaining a more energy efficient economy. In 2010, every state except Louisiana and West Virginia allocated funding through their rate-payer bases for electricity efficiency programs (Sciortino et al. 2011). However the size and spread of energy efficiency programs was strikingly different from state to state. For example, California, New York, Florida and Massachusetts accounted for about 50 percent of the total amount budgeted by states for electricity efficiency in 2010 (Wallace and Forster 2011). Fourteen states had special industrial sector incentives for electricity efficiency, while 34 had adopted specific energy efficiency standards for commercial buildings (Sciortino et al. 2011).

State-level policies for electricity efficiency are important in that they are able to strike a balance between customization and large-scale effects. However there are some drawbacks to energy efficiency policy at the state level that can affect both policy making and implementation.

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Even the most well-meaning state may find themselves at odds with the realities of budget limitations. Louisiana, for example, is one of the few states that have no energy efficiency policies in place, according to the American Council for an Energy Efficient Economy. The state legislature is currently not considering any legislation related to electricity efficiency. In its place, some municipalities have attempted to fill the gap. New Orleans has several incentives in place for residential energy efficiency, but these do not have the scope and scale that a state-wide program might have. Furthermore, the municipality does not have the same ties to utilities that often aide states in efficiency policy making. In 2008, no utilities in Louisiana reported spending targeted at electricity efficiency (Eldridge et al. 2008).

Louisiana, however, is an outlier when it comes to its lack of energy efficiency programming. States have generally pursued a wide array of programs targeted at energy efficiency. Doris et al. (2009) break down energy efficiency policies into the following categories:

- Policies focused on building efficiency, including building codes, appliance standards, and labeling and education.
- Policies focused on the transportation sector, including fuel efficiency standards, technical assistance, and urban planning and behavior change.
- Policies targeted at industrial users, including specialized incentives, technical assistance, and research and development.
- Policies focused on the power sector, which generally tend to be incentive-based.

There is significant overlap between these policy types. For example, in 2009, 15 states offered energy efficiency funding programs for which industrial users were eligible in addition to

other end-users (Doris et al. 2009). Furthermore, states are increasingly turning to all-encompassing policy mechanisms such as an Energy Efficiency Resource Standard (EERS). As of 2011, 24 states had policies establishing specific energy savings targets (Sciortino 2011). Like other state-led energy efficiency initiatives, the stringency and flexibility of these policies varies markedly. For example, Massachusetts set an EERS in 2009 that required them to reduce electricity usage by 2.4 percent of retail sales by 2012. This target was binding, reflecting the serious attitude Massachusetts takes toward energy savings. Other states, meanwhile, vary both in the level of savings required by their EERS and the mechanisms they set to enforce standards. Texas, for example, set a standard that calls for a 25 percent reduction in load growth in 2012, rather than a reduction from total retail electricity sales.[2] Texas also placed a cost cap on the policy, giving the state an exit strategy if the policy proves excessively expensive (Sciortino et al. 2011).

While a state's EERS is a good illustration of the effort the state plans to put into energy efficiency in the medium term, the question of how effort translates into success remains. This paper examines how far each dollar of state-level energy efficiency funding goes in producing efficiency gains. Does effort matter, or does it all come down to the bottom dollar? As ARRA funds run dry but the Federal government continues to push for a more energy efficient economy, it is increasingly up to states to fill in the gaps. Does increased energy efficiency funding lead to better outcomes?

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[2] Load is an engineering term that means the physical demand on the electricity system.

Literature Review

Energy efficiency improvements are often hindered by market barriers that state-level government is in a unique position to overcome. Scholars have pointed to a variety of barriers, though specific in-state barriers to energy efficiency implementation may be unique. Gillingham et al. (2009) outline a number of potential market failures that may account for under-investment in energy efficiency. On a basic level, the authors note that prices paid by consumers for electricity generally do not incorporate externalities, and thus do not reflect the true cost to society of energy usage. They also note there are information problems, wherein consumers do not receive the best or most accurate information about energy efficiency upgrades. Split incentives are also a major problem in the energy efficiency marketplace, as building decision makers may not be the ones facing the costs or savings of energy usage.

Sutherland (1991) argues that the conservation literature is overly liberal in their use of the term "market failure", and that most barriers to energy efficiency are not true market failures in the economic sense. He makes clear that while a "market failure" results in an inefficient allocation of resources, a "market barrier" is simply a market condition that discourages energy-efficiency investment relative of an estimated cost-effective level. Sutherland argues that the high discount rate consumers place on energy efficiency investments reflect real costs. However, he still identifies a number of areas in which true market failures play a role in the underinvestment in energy efficiency, including the external costs of energy consumption and the lack of insurance against energy-related risks.

Tietenberg (2009) also notes that non-market barriers to energy efficiency exist. These barriers are "behavioral," meaning consumers are often not willing to exert the time or energy

necessary for upgrades, despite promised savings. Hirst and Brown (1990) also emphasize behavioral barriers to energy efficiency. The authors note that at time policies may the culprit, as governments may misplace incentives. However, it is assumed that over time states will learn from their mistakes and this behavioral barrier will be reduced or eliminated. Hirst and Brown pointed to perceived risk of energy efficiency upgrades and lack of sufficient information as other major behavioral barriers to investment in efficiency. Nearly twenty years later, Tietenberg (2009) confirmed that these barriers still exist. To combat both behavioral and market barriers, states have stepped in to write a variety of policies – from incentives, to codes and regulations – some with more success than others.

Rebound Effect

Unlike electricity conservation, which is often the focus of many demand-side policies, energy efficiency is a measure of the energy services provided per unit of energy input. (Gillingham et al. 2009). On aggregate, energy efficiency is generally measured as the level of Gross Domestic Product (GDP) per unit of energy consumed (Metcalf 2008). Ultimately, energy conservation may or may not be the result of increasing energy efficiency. A significant amount of research has focused on the relationship between the two, with many scholars pointing out the potential for a "rebound" effect. First defined by Khazzoom (1980), the "rebound" effect refers to an increase in the supply of electricity with a corresponding decrease in the effective price, as utilities and consumers become more efficient in their use and production. The result may be an increase in demand in response to price decreases, which may result technological efficiency gains (Greening et al. 2000).

The size of this rebound effect may determine whether investment in energy efficiency is really worth it in the long run. Herring (2006) argues that the rebound effect is more than the simple relationship between decreasing cost and increasing use of a resource. Rather, indirect effects and general equilibrium effects will cause energy users to adjust their usage of many resources in response to decreased energy prices, and that though the traditional rebound effect may be small, there are larger forces at work that may lead to increases in overall energy consumption due to efficiency activities. However, most scholars are in agreement that the rebound effect is small, on the order of ten to 20 percent, and thus policies that target efficiency will lead to decreased overall usage in the long-run (Greene et al. 1999, Greening et al. 2000).

In their economic analysis of energy saving and energy efficiency concepts, Oikonomou et al. (2009) discuss potential solutions to the rebound effect. The authors argue that policy makers should not be dissuaded from energy efficiency investments due to the existence of a rebound effect. Rather, energy policy should be integrated with financial policies. Market-based policies can help minimize the rebound effect by setting the costs paid by consumers for electricity close to true social costs, reducing negative externalities.

The Role & Efficacy of States in Energy Efficiency Policy

Since there is general agreement that energy efficiency is a worthwhile investment, what then makes states such dominant players in this particular policy arena? Certainly, the federal government and local municipalities are not sitting on the sidelines, but many of the most important energy efficiency policies have been spearheaded by states. Doris et al. (2009) argue that while the federal government has the advantage when it comes to setting uniform standards and building cross-state utility regulations, its limited ability to tailor policies and the potential

for over-regulation makes many energy efficiency policies better suited for state governance. States generally have strong relationships with utilities, and are able to adapt policies to the needs of the local population. Thus, states are able to tailor policies and simultaneously make larger policy impacts than municipalities and local governments could hope for, and perhaps most importantly are in a unique position to constrain growth in electricity supply through demand-side management (Doris et al. 2009).

As a strategy for reducing electricity demand, there are varying expectations regarding the effectiveness of state-level energy efficiency policies. The Western Governors' Association (2006) Energy Efficiency Task Force authored a report projecting that western states could reduce electricity usage by 20 percent in 2020 through energy efficiency policies alone. Earlier studies showed far smaller savings. Loughran and Kulick (2004) studied electricity sales from 1989 to 1999 and found that energy efficiency spending only led to electricity sales reduction of about one percent. However much has changed in recent years, and a more recent study by Berry (2008) found that states that exert more effort in implementing energy efficiency policies see significant savings in electricity usage.

Goulder and Stavins (2011) point out that states are an important source of experimentation when it comes to energy efficiency policy. However, they also highlight some potential problems in states taking the lead in energy policy, especially at a time when the federal government has signaled that policies like a clean energy standard or an energy efficiency resource standard could be appropriate steps to take for federal energy strategy. Though Goulder and Stavins specifically examine potential regulatory overlap in a clean energy standard, their conclusions would also hold when applied to an EERS. Any market-based credit trading scheme could lead to significant leakage, wherein firms in states with limitations tighter than federal

standards will find themselves with excess credits. Goulder and Stavins predict this will lead to reduced prices for federal credits, and firms in states that did not previously have an EERS will not need to rely as much on switching to cleaner energy or investing in energy efficiency upgrades.

This study assesses the outcomes of state-level spending on energy efficiency. By observing the effects of the marginal dollar spent on energy efficiency funding, it is possible to infer the importance of efficiency spending in relation to other budget items. Moreover, including sectoral spending (i.e. residential, commercial, and industrial) in the model will allow comparison between spending types. Ultimately, reducing overall energy consumption is an important goal for the country as a whole. Targeting sectors and programs that are the most effective at promoting efficiency will allow policy makers to distribute funds more wisely.

Data Description

Three primary sources of data are used for this analysis. The Energy Information Agency (EIA) provides a public dataset on annual state level energy characteristics called the State Energy Data System (SEDS). SEDS information on energy prices and consumption was downloaded from the EIA website in September 2012. Observations are at the state level, and also include the District of Columbia. The study uses only information from 2005 – 2010. At the time of analysis, SEDS data had not yet been published for the year 2011. Although SEDS data reaches back several decades, limiting the scope of the data to the years 2005 – 2010 allowed 306 observations to be used in the study. Data for energy were given in both billion Btu and million kilowatthours. Since the study is interested in electrical efficiency outcomes, the

choice was made to examine electrical consumption in terms of kilowatthours (kWh)[3]. Prices

and consumption data are given for the state as a whole, but also divided into sectors. EIA data

also includes information on state gross domestic product and state population, which are

coupled with consumption information to calculate energy efficiency outcomes.

As measures of effort, I rely on several indicators compiled by the American Council for

an Energy Efficient Economy (ACEEE). ACEEE publishes an annual State Energy Efficiency

Scorecard which profiles state energy efficiency policies and programs and scores states

accordingly. These scores do involve a level of subjectivity, but Barry (2008) argues they are

accurate reflections of the diversity and intensity of state energy efficiency programs. As such,

they are used as measures of "effort" in this study. Overall ACEEE scores do incorporate budget,

but scores can also be subdivided to indicate effort in a variety of areas, thereby limiting

potential multicollinearity due to budgetary influence. For the purposes of this study, scores for

utility efficiency program budgets have been removed from ACEEE overall scores. ACEEE

scorecards report and quantify state energy efficiency resource standards on a scale of 5 points.

They also rate states on a scale of five points for stringency of building codes. A three point

scale is used to signify the number of state appliance efficiency standards enacted cumulatively

since 2002. State Energy Efficiency Scorecards are available on ACEEE's website. They were

coded by hand for inclusion in this study.

The key independent variables of interest are state energy efficiency budgets. These

observations are compiled by the Consortium for Energy Efficiency (CEE), a trade group of

energy efficiency program administrators. CEE has published annual industry reports since 2005.

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[3] Prices in the original dataset are given in terms of dollars per million Btu. For the purposes of the study, prices
were converted to dollars per kilowatthour using the ratio 1MMBtu = 293.29722222222 kWh.

These reports are available publicly from CEE's website, and include information on state

budgets for energy efficiency. While budgets are not necessarily indicators of spending, ACEEE

argues they more accurately reflect the pace of changes state energy portfolios. Though reported

budgets are subject to change, ACEEE believes they are fairly accurate, and do not misrepresent

trends in energy efficiency commitments as two-year-old spending data might (Molina et al,

2010). In the future, it may be possible to replicate this study using expenditure data, but neither

CEE nor EIA have reliable expenditure data prior to 2009. CEE budgets are collected by

contacting state-level officials. Energy efficiency budgets are reported as a whole, and divided

by sector. CEE also reports gas efficiency budgets and load management program budgets,

which include demand-response efforts led by states. However, the 2005 Annual Industry

Report is far less detailed, and includes only overall energy efficiency budget information. This

data is used in a simple model of the outcomes of energy efficiency, but is dropped for the bulk

of the analysis. Data from CEE Annual Industry Reports include observations for all 50 states

and the District of Columbia, although earlier data collection efforts excluded states that did not

respond to survey requests. After the exclusion of 2005 observations and other missing data

points, 236 observations are used in the analysis of the effects of state-level energy efficiency

outcomes.

Descriptive Statistics

Summary statistics for state-level energy efficiency spending are given in Table 1.

Efficiency spending varied greatly over the period examined. California was continually the

largest spender when it came to energy efficiency, topping out at $1.2 billion in 2010.

Meanwhile, several states never worked with utilities to create a funding pool for energy

efficiency. Small energy efficiency programs may have been implemented in states that reported

no rate-payer funded efficiency programs, but this spending is not reflected in the data.

Furthermore, since the study is examining state-level funding pools, Federal funding for energy

efficiency is not considered. This is especially notable during the 2009 – 2010 time period, when

all states received American Recovery and Reinvestment Act funding for energy efficiency.

Though this funding likely influenced energy efficiency outcomes, excluding it from the study

should not influence results since all states received the large increase in funding during the same

time period. Thus, a two-way fixed effects model will control for abnormalities due to time.

Table 1. Descriptive Statistics for Annual State Energy Efficiency Budgets 2005 - 2010						
Variable	Unit	Obs.	Mean	Std. Dev.	Min.	Max.
Electric and Gas Efficiency Budget	$ (Million)	277	92.25206	203.0197	0	1496.9
Load Management Budget (Electric and Gas)	$ (Million)	209	20.65359	51.64305	0	374.4
Residential Electric Efficiency Budget	$ (Million)	236	23.92924	40.09437	0	267.1
Low Income Electric Efficiency Budget	$ (Million)	236	8.990678	24.05546	0	169.2
Commercial & Industrial Electric Efficiency Budget	$ (Million)	236	39.03898	89.5336	0	625.4
Total Electric Efficiency Budget	$ (Million)	236	81.38475	173.4617	0	1162.5
Total Electric Load Management Budget	$ (Million)	236	19.56949	49.95742	0	374.4

Note: Data from CEE Annual Industry Reports.

This study is concerned with the effects of state-level utility funding for efficiency

programs. However, many states have also pursued innovative policy actions to conserve

electricity. The American Council for an Energy Efficient Economy (ACEEE) has scored states

on policy metrics since 2006. These data are summarized in Table 2. Overall scores include

metrics related to energy efficiency budgets. For the purposes of this study, those metrics have been removed from ACEEE scores. Scores less utility spending reflect state policy actions *aside from* implementing rate-payer funded programs. Though ACEEE scores do involve some level of subjectivity in their generation, Berry (2008) notes that they are a reasonable metric for comparison since methods are spelled out and "scores reflect the diversity and intensity of state energy efficiency programs."

Table 2. Descriptive Statistics for Annual ACEEE Scores					
Variable	Obs.	Mean	Std. Dev.	Min	Max
Overall Score	255	14.91961	10.13989	0	45.5
Utility Efficiency Spending Score	253	4.942688	5.127702	0	19.5
Score Less Utility Spending	255	10.01569	5.912731	0	27

Note: ACEEE scores were not generated in 2007, but 2006 scores have been assumed to hold true for this year.

Descriptive statistics of several important state-level indicators are given in Table 3. The dependent variable of interest, energy efficiency, can be calculated by dividing energy consumption by gross domestic product in each state during the given time period.   State population also plays a role in overall energy consumption. Energy consumption includes electric, gas, and oil consumption.   This high-level variable is useful in identifying the types of energy consumed in each state, and is also necessary for calculating energy efficiency over the entire panel, since 2005 data does not include more focused electric efficiency variables.   While there is significant variation in the below indicator variables between states, variation in the same state over time is not as large.

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Table 3. State-level Descriptive Variables

Variable	Unit	Obs.	Mean	Std. Dev.	Min	Max
State Gross Domestic Product	$ (Million)	306	270169.6	325700.1	22773	1911741
Population	Thousand	306	5932.438	6620.164	514	37338
Total End Use Energy Consumption Per Capita	Kilowatthours	306	109736	50926.39	53045.87	350513
Total End Use Energy Consumption	Million kWh	306	567459	592864.8	43266.08	3451719

Note: Data from EIA State Energy Data System

*Data was converted to kWh using the factor 1 btu = 0.00029307107 kilowatt hours

Table 4 lists descriptive statistics for electricity consumption.   The bulk of this study is concerned with electric efficiency, rather than more general energy efficiency.   Prices are reported by sector.   The average price of electricity is notably higher in the residential sector compared to the industrial sector.   Commercial prices fall in between the two, although generally closer to residential prices, and tend to be similar to average prices of all sectors taken together.   Despite higher prices, electric consumption reached higher levels in the residential sector than in any other sector.   This may explain why many energy efficiency programs specifically target consumer behavior and home retrofits.

Table 4. Descriptive Statistics for State Electricity Prices and Consumption by Sector							
Variable	Unit	Obs.	Mean	Std. Dev.	Min	Max
Electricity Price in the Commercial Sector	Dollars per kilowatthour	306	0.095106	0.033606	0.051523	0.297198
Electricity Consumed by the Commercial Sector	Million kilowatthours	306	25766.26	26507.32	1991	125026
Electricity Price in the Industrial Sector	Dollars per kilowatthour	306	0.072489	0.032524	0.036032	0.260483
Electricity Consumed by the Industrial Sector	Million kilowatthours	306	19463.69	18645.38	230	108300
Electricity Price in the Residential Sector	Dollars per kilowatthour	306	0.109305	0.036701	0.062067	0.324972
Electricity Consumed by the Residential Sector	Million kilowatthours	306	27101.79	26904.64	1822	137161
Electricity Average Price, All Sectors	Dollars per kilowatthour	306	0.093957	0.034924	0.049237	0.292694
Electricity Total Consumption, All Sectors	Million kilowatthours	306	72482.9	67962.46	5497	358458

Note: Data from EIA State Energy Data System. Data was converted to kWh using the factor 1 btu = 0.00029307107 kilowatt hours

Table 5 gives correlation coefficients of relevant independent variables. These variables have not been broken down into sectors, but represent overall state characteristics. Electric efficiency budgets include funding allocated to load management. These correlation coefficients for the most part confirm what we would intuitively expect. More populous states tend to spend more on energy efficiency. There is also a positive correlation between "other" policy activity reflected in the ACEEE scores and budgets for electricity efficiency programs. This would suggests that states that allocated more funding for energy efficiency are simultaneously pursuing a broader menu of policy options targeted at improving efficiency outcomes. Puzzlingly, there is a slight negative correlation between efficiency budgets and electricity prices.

One would expect that as prices for electricity rise, states will spend more on efficiency, which has the co-benefit of reducing energy bills along with energy usage. This unexpected relationship can be explained away, however, by noting that the coefficient is not significant at any level.

Table 5. Pairwise Correlation Coefficients for High-Level Variables				
	Population	Average Electricity Price	Lagged ACEEE Score (Less Utility Spending Score)	Electricity Efficiency & Load Management Budget (one year lag)
Population	1			
Average Electricity Price	0.1314	1		
Lagged ACEEE Score (Less Utility Spending Score)	0.4674	0.4588	1	
Electricity Efficiency & Load Management Budget (one year lag)	0.1206	-0.0437	0.0552	1

Methodology

The ultimate goal of most energy efficiency strategies is to decrease dependance on energy. However, efficiency is not synonymous with conservation. Energy efficiency incorporates the notion of economic growth. While energy conservation may require economies to shrink as they halt operations, energy efficiency includes the idea of growth. Though energy conservation may be a side effect of energy efficiency, it is not a necessary condition. This study was concerned with testing the true *efficiency* gains (or losses) that could result from state-level spending on energy efficiency. For this reason, energy usage intensity (EUI) is the most appropriate dependent variable. EUI does not reflect total energy consumption, but rather the ratio of energy use within a state at time period t to the gross domestic product (GDP) of the state at time t. A smaller EUI is indicative of a state that is able to produce more using less energy.

Figure 2. State Energy Usage Intensity Over Time
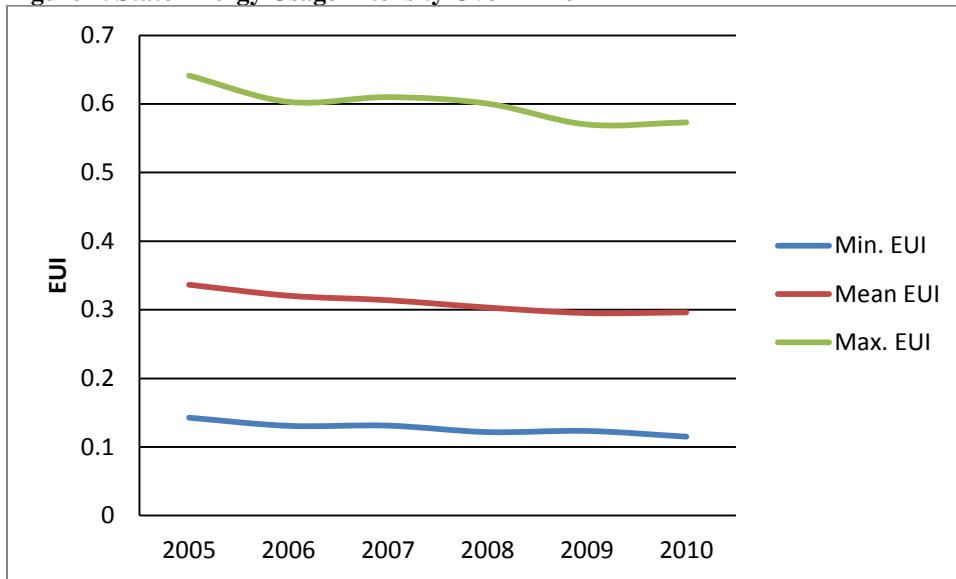
Note: EUI calculated from EIA State Energy Database System.

The primary goal of this paper is to examine the relationship between state-level spending on energy efficiency programs and energy efficiency outcomes. Efficiency spending should show relatively swift results. However, since both spending and energy consumption is reported annually, an element of lag time is included in the model to account for delays in implementation, and to give a more complete picture of the results of the year's worth of spending. Models 1, 2, and 3 examine variations on models using an independent variable representing overall energy efficiency spending reported by state representatives. Model 4 analyzes the effects of two categories of energy efficiency spending: load management and traditional energy efficiency spending.

A secondary goal of this paper is to assess the effects of other major energy efficiency strategies. An independent variable for policy measures is included in all four of these models. This variable does not reflect spending, but is a systematic score that sums all other policy actions taken by the state in the year *t-1*. As discussed in the previous section, this score has a measure of subjectivity, but since assumptions and methodology in score generation is carefully

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laid out by ACEEE, it is a fairly systematic representation of "other" policy actions taken by states to encourage energy efficiency. Other dependent variables include state population and average electricity prices.

The bulk of the paper uses a two-way fixed effects model to determine the effects of the dependent variables on EUI. The general model examined is as follows:

$$EUI_{it} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_4 + \beta_4 X_4 + \alpha_{it} + \varepsilon$$

X_1 = ln(energy efficiency budget) at time t-1. This variable is split into two explanatory variables in Model 4 to represent different types of energy efficiency spending, and into three explanatory variables in Model 5 to represent spending in different sectors.

X_2 = policy variable score at time t-1 as compiled by ACEEE.

X_3 = electricity prices in state i at time t. Model 3 also examines the effects of sector-specific electricity prices.

X_4 = population in state i at time t.

α_{it} = Two-way fixed effects within states and years.

Results

Results of the five models examined in this paper are shown in Table 6. For an initial assessment of the relationship between the explanatory variables and energy usage intensity, I generated a simple ordinary least squares (OLS) model. Commonly, omitted variables that reflect the size of states (GDP, population) confound simple OLS models for energy usage intensity. However, since the dependent variable in this paper is normalized for GDP, and

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population is included in Model 1, OLS gives the expected directional results. Greater spending on energy efficiency results in a smaller EUI. In other words, states that spend more on energy efficiency are able to produce more output for every unit of energy they consume. However, the coefficient for spending is only statistically significant at the $\alpha = 0.10$ level. Coefficients for energy efficiency policy scores and electricity prices were far more statistically significant, with prices showing most striking negative correlation. Higher electricity prices, averaged over all sectors of the economy, are correlated with states with lower EUI's, suggesting that high prices effect energy usage behavior and efficiency decisions.

Table 6. Estimated Coefficients for Determinants of Energy Usage Intensity

Explanatory Variable	Model 1	Model 2	Model 3	Model 4	Model 5
ln(total efficiency budget)	-0.00679* (0.00388)	-0.00112 (0.00114)	-0.0070 (0.00128)		
ln(electric efficiency budget)				-0.00327 (0.00236)	
ln(load management budget)				0.00141 (0.00227)	
ln(res. efficiency budget)					-0.00631 (0.00433)
ln(low inc. efficiency budget)					0.00433** (0.00213)
ln(com. & ind. efficiency budget)					0.00229 (0.00348)
ACEEE Policy Score	-0.00746*** (0.00144)	-0.00002 (0.00056)	0.00013 (0.00060)	0.00090 (0.00092)	0.00090 (0.00075)
Avg. Electricity Price	-1.5871*** (0.1832)	-0.62227*** (8.10e-06)		-0.61054*** (0.17687)	-0.71924*** (0.18259)
Res. Electricity Price			-0.56364 (0.35123)		
Ind. Electricity Price			-0.06111 (0.22595)		
Com. Electricity Price			0.05761 (0.32531)		
Population	5.48e-08 (1.04e-06)	-7.57e-06 (8.10e-06)		-5.27e-06 (0.00001)	-0.00001 (0.00001)
Overall R-Squared	0.575	0.2402	0.2439	0.3196	0.2707
Observations	150	150	150	105	119
Model Description	OLS	Two-Way Fixed Effects	Two-Way Fixed Effects	Two-Way Fixed Effects	Two-Way Fixed Effects

Notes: Number in parentheses is standard error
***p<0.01, **p<0.05, *p<0.10.

A simple OLS model is unable to account for potential variation in energy usage due to state-level characteristics that do not change over time (for example, typical cultural attitudes within the state). Furthermore, since the time period examined includes major changes in the nation-wide economy, concurrent with a push by policymakers for increased energy efficiency, there are likely time-dependent variables that the OLS model is unable to account for. Models 2-5 used two-way fixed effects to capture these non-measurable variables. An initial examination of the data showed attributed a relatively small amount of correlation to fixed effects.[4] Typically, a correlation between fixed effects and the error term close to zero is an indicator that random-effects are better suited for the model. However, a Hausman test confirmed that a fixed-effects model was appropriate in this scenario.

Model 2 included the same explanatory variables as Model 1, but controlled for state and time fixed effects. Once non-observable variables are controlled for, both spending and policy actions show far less effect on EUI. Neither variable is statistically significant in the model. However, average energy prices remain statistically significant at the $\alpha < 0.01$ level, suggesting that price exerts the greatest influence on energy usage behavior. Policy actions and spending are likely linked to fixed time and state effects, which would explain why they do not appear significant in this model.

Since price appears to be the only statistically significant determinant of EUI, Model 3 examines whether sectoral prices have different effects on energy efficiency outcomes. Interestingly, taken separately, neither residential, commercial, nor industrial prices play a role in determining energy efficiency outcomes. However, a test for joint significance confirms that

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[4] Correlation attributed to two-way fixed effects was -0.0550. A Hausman test to compare random-effects versus fixed-effects calculated a Chi-Squared value of 117.35, with a p-value of 0.00.

these variables play an important role when taken together.[5] Since electricity prices tend to fluctuate concurrently for all economic sectors, this result seems reasonable. The electricity price in any given sector cannot alone influence energy usage intensity.

Model 4 examines different types of energy efficiency spending within states. Traditional electric efficiency spending includes measures taken to upgrade equipment and appliances, education programs, building retrofits, etc. Spending on load management is targeted at reducing peak energy usage through strategic time-management of energy usage. CEE did not differentiate between these two types of spending in 2005, so the sample size is smaller for Model 4. We find that the type of energy efficiency spending does not have a significant effect on EUI outcomes. However, once again the coefficient on price is statistically significant. Model 4 confirms that price variations are far more influential on EUI outcomes than spending or state-level policies.

The final fixed-effect model examined in this paper breaks apart energy efficiency spending categorically. While Model 4 examined two energy efficiency spending strategies, Model 5 traces the pathway of energy efficiency spending through the economy into three categories: spending on Low Income programs, spending on Commercial and Industrial programs, and spending on Residential energy efficiency programs. Low Income energy efficiency programs are popular since government has more influence over low-income housing than private housing. Energy and financial savings realized by low-income consumers have a greater marginal effect than savings realized in other programs, and these savings often accrue partially to state and local governments. Low-income spending is the only budget variable that has a statistically significant effect in any of the four fixed-effects models. Perhaps most

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[5] A test for joint significance for the three sector-level electricity price variables gives $p<0.001$.

importantly, however, Model 5 confirms that average electricity price is negatively correlated with EUI. As prices rise, states use less energy per dollar of GDP. Implications of this price effect are analyzed further in the discussion section.

Discussion

Ultimately, all five models investigated in this paper point toward a single mechanism for manipulating energy efficiency within a state: price. In Model 1's simple OLS structure, we find there is a relationship between budgets for energy efficiency, policy levers, and energy usage intensity. However, controlling for fixed effects eliminates these correlations in all of the following models. The only variable that is consistently correlated with energy usage intensity across all models is electricity price. As politicians at local, state, and Federal levels continue to push for improved energy efficiency, the models in this paper provide a convincing impetus for focusing on strategies that raise energy prices.

It may be the first reaction of some to look at the models presented in this paper and conclude that efficiency spending and efficiency policies are futile. However this is far from the truth. Instead, this paper provides evidence that policies should be targeted at prices. Keeping energy prices low is a priority for most politicians, but the reality is that raising prices is the most effective tool in the political toolbox for encouraging the efficient use of energy. Raising prices also addresses many of the externalities associated with electricity consumption by forcing producers to consider costs beyond the private cost of production. The effects of price increases on efficiency are not minimal. An increase in the average price of electricity of about one cent would reduce EUI by about 0.003. Since average EUI in 2010 was about 0.3, this means we would expect about a 1% decrease in EUI.

Policy proposals to increase the price of electricity have in the past been politically fraught. Though it is generally accepted that electricity prices do not reflect the true costs to society of electricity production and delivery, efforts to rectify the disparity have largely been panned. However, that is not to say it is politically impossible. Supporters of rectifying energy prices spread across many industries. Environmentalists support raising energy prices to better incorporate the harmful effects on both air quality and the global climate associated with our current energy production portfolio. Similarly, clean energy producers note that fossil fuel producers are not playing on a level playing field, since many costs of traditional energy production are borne by society. And increasingly, the public is pushing for cleaner sources of energy. Raising energy prices aligns the priorities of the public, the clean energy industry, and the environmental lobby to clean up the US energy portfolio. Metcalf (2009) believes that the political playing field is evolving in such a way that "a thoughtfully designed carbon tax would address many of the concerns of those who oppose carbon pricing in general."

In recent years, major legislative proposals for rectifying the price of energy have taken one of two forms: the basic tax on carbon emissions, or a cap and trade style market system, wherein a cap is placed on emissions and tradable credits are sold or given to polluting firms. On the Federal level, no bill has yet to progress through both the House and the Senate. After the Waxman-Markey cap and trade bill failed on the Senate floor in 2009, climate change has been only hesitantly approached by Federal lawmakers. In February 2013, Senators Barbara Boxer (D-CA) and Bernie Sanders (I-VT) proposed a carbon trade bill that priced emissions at $20 per ton of carbon beyond a set limit. That would translate to an increase in average

electricity prices of about 1.4 cents per kWh[6] and a corresponding decrease in EUI of about

0.002 (about 0.7%). Though this suggests that Federal legislators have not given up on policies

that more accurately reflect energy prices, the bill is widely thought to be a long shot (Volcovici,

2013).

However, state-level prospects for implementing energy price policies are less dire.

Several states have already taken the lead in implementing policies that internalize the social

costs of energy production. The Regional Greenhouse Gas Initiative (RGGI) led the way for cap

and trade programs. Beginning in 2009, the multi-state agreement called for stabilization of

emissions, with declines set to begin in 2015. Currently, Connecticut, Maine, Delaware,

Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont are signed

on to the initiative (Regional Greenhouse Gas Initiative 2010). Though the program is targeted

at emissions, the use of a pricing mechanism suggests these states should also expect significant

efficiency improvements.

California is another state that has not shied away from pricing schemes as a remedy for

artificially low energy prices. The Global Warming Solutions Act (AB 32) sets up an

enforceable cap and trade system within the state (Nunez 2006). The program launched at the

beginning of 2013, so no *ex poste* analysis of the program is possible yet. However, California

has traditionally been a leader in environmental policy. If the program proves successful, it is

reasonable to expect more states will follow suit. Thus, though raising energy prices through

emissions policies may be the third rail of Federal politics, it is clear that there is potential for

pricing mechanisms to play a role at the state level.

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[6] The EPA has calculated an emissions factor of 7.0555×10^{-4} metric tons CO_2 / kWh based on the US annual non-baseload CO_2 output emissions rate, using 2009 data.

This study also points toward important design elements for pricing mechanisms. Namely, this analysis suggests that a carbon tax should be holistic. Model 3 shows that manipulating the price for any single sector has no statistically significant effect on EUI. However, taken together, higher energy prices across sectors are correlated with lower energy usage intensity within a state. The idea of a holistic carbon tax is affirmed by Hoel (1996) in his international analysis of national carbon taxes. Hoel concludes that a carbon tax should not be differentiated across sectors in the economy when attempting to optimize greenhouse gas reductions. This paper shows the same is true when designing a carbon tax to decrease energy usage intensity.

Data Limitations

Data on energy efficiency spending has improved rapidly in recent years. The EIA began to require more complete reporting of energy efficiency spending beginning in 2009. However, this paper relies on CEE data in order to reach back several more years. While CEE data is the most complete source of state energy efficiency budgeting data from the mid-2000s onward, it is important to note that this data set is far from exhaustive. Firstly, early years of CEE data report budgets, but not expenditures. In order to use multiple years of data, this study necessarily focuses explicitly on budgets. While budgets are certainly reflective of spending, they are not a perfect match.

Furthermore, CEE data is compiled through a survey of state-level energy efficiency practitioners. While CEE has strong ties to the energy efficiency programs in each state, there is nevertheless some self-reporting bias within the data. Not all states reported their spending each year. While it is possible this is because the states had budgets of $0 for these years, this was not

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reflected in the CEE data. Rather, these observations were treated as non-response, and were

dropped from the sample. The scope of the data is therefore limited only to states that reported

spending. It is also important to note that spending by other entities is not reflected in the data

set. For example, Federal spending and third-party efficiency spending are for the most part not

reflected in the data.

In the future, it will be possible to perform a more robust analysis of energy efficiency

spending since utilities are now required to report spending to the EIA. However, at the time of

this study, EIA data is quite limited, and reflects only about 2 years of complete efficiency

spending data. Over the next several years, this data set should improve dramatically, making

similar studies far more straightforward.

Conclusion

Ultimately, this paper corroborates what energy economists have been stressing for

decades: price mechanisms are the most effective way to encourage the efficient use of energy.

While this paper can make no claims about the efficacy of energy efficiency policies and state-

level efficiency spending, the models do point strongly to the downward pressure of prices on

energy usage intensity. Policies that raise the price of energy, whether through emissions limits

or taxes, are effective measures for improving energy usage intensity.

This study reinforces the importance of proper energy prices through an analysis of

available data. However, data on energy efficiency investments continues to improve, and states

continue to design out-of-the-box policy approaches targeted at efficiency. This study found no

significant effects of efficiency policies generally. However, many efficiency policies are newly

implemented, and thus results may not yet have accrued. Future research should capitalize on the ever-improving data set of efficiency investments to examine specific policy approaches. Future research should also carefully monitor states with pricing mechanisms in place. Comparing improvements in these states to those that invest heavily in efficiency but hesitate to raise energy prices should shed more light on the importance of incorporating externalities into electricity prices.

We can expect that policy makers will continue to push for the use of policy carrots rather than sticks when it comes to energy usage intensity. In the future, as more states experiment with suites of policy options, we may begin to see these policies have an effect on energy usage intensity. However, this study illustrates that to date, electricity prices are the only statistically significant determinant of state-level energy usage intensity. Rather than ignore this finding in favor of more politically palatable incentives, policy makers should consider ways to incorporate pricing mechanisms into holistic energy policies. Several states have taken the lead in establishing policies directly targeted at more accurate electricity prices. Whether other states will follow suit remains to be seen.

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