

Effects of State Government Policies on Electricity Capacity from Non-Hydropower Renewable Sources*

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Abstract:

This paper ascertains which state policies are accelerating deployment of non-hydropower renewable electricity generation capacity into a state's electric power industry. A state fixed-effects model is used to simultaneously estimate the effects of multiple state policies in all fifty states. As would be expected, policies that lead to significant increases in actual renewable capacity in that state either set a Renewables Portfolio Standard with a certain level of required renewable capacity or use Clean Energy Funds to directly fund utility-scale renewable capacity construction. A surprising result is that Required Green Power Options, a policy that merely requires all utilities in a state to offer the option for consumers to purchase renewable energy at a premium rate, has a sizable impact on non-hydro renewable capacity in that state.

Keywords: renewables; energy policy

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1. INTRODUCTION

Renewable energy has recently become an important aspect in the U.S. electricity generation mix and a primary focus of government policy for environmental and energy security/price volatility reasons. First, the public's growing concern for the environment and progressively stringent regulation of emissions in the electric power industry has driven policies to increase the amount of renewable energy in the electricity generation portfolio. Electricity production from renewable resources creates little, and often zero, emissions of the pollutants that result from traditional fossil fuel generating technologies. More renewable energy use helps utilities in their emissions compliance obligations. Moreover, the prospect of compliance with any future carbon emissions regulation would further strengthen the incentive to shift toward cleaner electricity generating technologies.¹

Second, recent uncertainty in the U.S. energy supply due to political concerns in the Middle East countries and other foreign oil producing countries as well as volatility in oil and natural gas prices have led to a push to increase U.S. energy independence through a greater domestic energy supply and to decrease the impacts on the economy from any price shocks in the fossil fuel markets, such as the natural gas price spikes in 2000-2001 and following the 2004 and 2005 hurricane seasons.²

¹ Smith et al. (2000) estimates the displacement of emissions from the Massachusetts Renewables Portfolio Standard.

² Bird et al. (2005) explains the market factors behind wind power deployment, which include the volatility of natural gas prices. GDS Associates (2001) supported this factor as well in the reasoning behind the enactment of Hawaii's Renewables Portfolio Standard. The delivered price of natural gas to electric utilities has risen from \$2.62/million cubic foot (MCF) in 1999 to \$8.45/MCF in 2005 (Energy Information Association Annual Energy Review 2005). In addition to rising fuel prices, some assert that renewable policies have economic development benefits (Rabe, 2006).

Complementing federal policies such as the production tax credit, state governments have taken actions to increase renewable energy capacity and generation, with 41 of the 50 states enacting policies to encourage the use of renewable energy in their state.³ Individual state policies show a great deal of variance. The objective of this paper is to determine which state policies have led to increased deployment of aggregate non-hydro renewable energy capacity into a state's electric power industry.⁴ The literature on state renewable energy policies consists mainly of case studies on policy effectiveness. Only one previous paper uses econometric methods to estimate the effects of various state policies on renewable capacity. Menz and Vachon (2006) measure the impacts on wind capacity in 39 states for 1998-2002. In contrast, my paper uses panel data from all 50 states for 1996-2003 to estimate the effects on total non-hydro renewable capacity deployment, not just wind power capacity deployment. It estimates the effects of additional policies, and also controls for differences in the market and political environments.

Three distinctly different types of policies are found to be effective at expanding non-hydro renewable capacity deployment: a command-and-control policy known as a Renewables Portfolio Standard (RPS), a tax-and-subsidy scheme facilitated through a Public Benefits Fund (PBF) or Clean Energy Fund (CEF), and a market-based policy where consumers can express their preferences to buy power from renewable resources at a premium price.

The command-and-control policy targets the utility by mandating a specified level of capacity that must come from renewable energy, and is generally referred to as a

³ See Table 3.

⁴ The electric power industry accounted for 60% of renewable energy production in 2003.

Renewables Portfolio Standard. The tax-and-subsidy scheme collects an additional charge per unit of electricity consumed from all customers in a state and places the proceeds into this Public Benefits Fund or Clean Energy Fund. Monies from the PBF/CEF are used to subsidize renewable capacity deployment through grants, loans, or production incentives. The market-based policy creates a differentiated demand by mandating that utilities must offer their customers the choice to purchase green power, which allows consumers to express their preferences through paying an extra, utility commission-approved charge for “green power.”

The econometric results support many of the conclusions from various case studies with respect to Renewables Portfolio Standard and Clean Energy Fund policies. Moreover, the results presented here also show, unlike previous studies, that the potential for offering consumers the option to purchase renewable electricity at a higher price than conventionally produced electricity can increase renewable capacity in a state.

2. LITERATURE REVIEW

The bulk of the literature in this area uses case studies to determine the specific characteristics of effective state renewable energy policies. There are two main types of case studies: (1) analyses of a specific policy enacted in a particular state; and (2) a summary of the general impacts of a specific policy mechanism used across multiple states, including policy design characteristics that are effective across multiple states. Langniss and Wiser (2003) analyze the Texas Renewables Portfolio Standard, including the achievements of the policy mechanism and the design characteristics that allowed the policy to be effective at increasing renewable energy capacity. It was found that the

clearly defined capacity requirements have been effective in increasing renewable capacity in Texas.

Wiser et al. (2004) considered all Renewables Portfolio Standards and found the pitfalls in the current policy designs. Some key problems in policy designs include insufficient duration and stability of targets, weak enforcement, and narrow applicability of the policy. Other conditions that may impact a policy's effectiveness are the presence of long-term power purchasers and political and regulatory stability.

Petersik (2004) provides a non-econometric analysis of the effectiveness of different types of Renewables Portfolio Standards as of 2003 for the United States Energy Information Association (EIA). He finds that only Renewables Portfolio Standards that mandate a certain level of capacity (number of megawatts) have had any significant impact on renewable capacity deployment. Policies with renewable generation or sales requirements as well as voluntary policy programs were found to have no significant effect.

Chen et al. (2007) compares the results from 28 policy impact projections for state or utility-level Renewables Portfolio Standards and finds that (1) the impact on electricity prices is minimal, (2) wind power is expected to be the primary renewable used to meet policy requirements, and (3) the benefit-cost estimates rely heavily on uncertain assumptions, such as renewable technology costs, natural gas prices, and possible carbon emissions policy in the future.

Bolinger et al. (2001) describe in detail 14 different state Clean Energy Funds, enumerating the regulatory background, funding approaches, the current status of the fund, and the resulting impacts on renewable energy. Programs that fund utility-scale

projects are found to be the most effective at increasing renewable capacity deployment.⁵ Bolinger et al. (2004, 2006) summarize the same 14 Clean Energy Funds. They find that due to delays and cancelled projects actual capacity often is much lower than initially obligated capacity.

Wiser and Olson (2004) examine participation in 66 utility green power programs. They find local green power programs have residential participation rates ranging from 0.02% to 6.45% and averaging 1.39%. However, this study does not look at any state-level Required Green Power Options that require all utilities in a state to offer consumers the option to purchase renewable energy. The paper focuses on participation rates of the utility-based programs, but does not analyze the impact of these local programs on renewable energy generation or capacity.

Bird et al. (2005) summarize federal renewable energy policies, general market factors, and state-specific factors, such as state policies, that are driving the deployment of wind power. The key market factors are the volatility in natural gas prices during the early 2000s and the lowered wind energy generation costs due to larger wind turbines, which have combined to make wind power more competitive with natural gas-fired generation.

Only one paper has attempted to econometrically estimate the effects of state renewable energy policy on renewable capacity. Menz and Vachon (2006) use ordinary least squares to estimate state policy effects on wind power capacity and generation in 39 states for 1998-2002 while controlling for wind power availability, retail choice, and policy dummy variables for Public Benefits Fund, Renewables Portfolio Standard,

⁵ Funding is usually based on actual production, but it is paid in a lump sum once the capacity has been constructed.

Required Green Power Option, and fuel mix disclosure.⁶ Renewables Portfolio Standards, which require a minimum amount of renewable energy capacity or generation, and Required Green Power Options, which require all utilities in a state to offer renewable-based electricity to all consumers for a premium price, are found to have a statistically significant effect on wind capacity deployment. No statistically significant effects were found for Public Benefits Funds, which aid both the funding of energy efficiency, and for Clean Energy Funds, which fund renewable energy programs and projects.

3. MODEL

This paper uses an ordinary least squares approach as did Menz and Vachon (2006), but differs in many aspects. This paper includes state fixed-effects, a larger sample, and additional and more detailed policy variables as well as control variables for a state's electricity market and political environment. Without controlling for differences in market size and political environments, omitted variables may bias the results and lead to incorrect policy interpretations. State fixed-effects are used to control for renewable availability and capacity constructed prior to 1996, which is in large part due to the implementation of prior federal policy at the state level as well as the effects of environmental preferences not captured by other variables.

$$C_{it} = \alpha_0 + \beta * R_{it} + \delta * W_{it} + S_i + T_i + \varepsilon_{it}$$

⁶ Fuel mix disclosure is a policy that requires the fuel mix a power producer uses in its electricity generation to be disclosed to the public. It is believed that consumers will use this information to purchase electricity from power producers that use cleaner burning fuels or alternative energy.

The model estimates total non-hydropower renewable capacity (C_{it}) for 1996-2003, where subscript “i” is the state and “t” is the year of the specific observation. \mathbf{R}_{it} is the vector of seven regulatory policies (Clean Energy Fund, Renewables Portfolio Standard with Capacity Requirements, Renewables Portfolio Standard with Generation/Sales Requirements, Net Metering, Interconnection Standards, State Government Green Power Purchasing, and Required Green Power Option) and \mathbf{W}_{it} is the vector of eight political and economic variables. Vector \mathbf{S}_i is the state fixed-effects dummy variables and vector \mathbf{T}_t are the year variables. The year variables, most of the control variables, and some of the policy variables are interacted with each state’s electricity generation level to control for market size in each state.

The dependent variable is the total non-hydropower renewable nameplate capacity in the electric power industry (C_{it}), which includes all nameplate capacity of utilities, independent power producers (IPPs), and industrial or commercial combined heat and power producers that use solar, wind, geothermal, or biomass as an energy source.⁷ The sum of all non-hydropower renewable energy in a state is used instead of the capacity of one specific type of renewable energy because using only one type would preclude any interesting cross-state comparison of policy effects of states with different available renewable energy resources.⁸ For example, comparing the effects of

⁷ Nameplate capacity is the amount of capacity the generator produces under ideal conditions. Non-hydro renewable nameplate capacity is derived from EIA Historical State Electricity Databases found on the EIA website in which solar, biomass, geothermal, and wind nameplate capacity are combined into a single category labeled “Other Renewables.”

⁸ Hydropower is not included in the renewable energy capacity because most hydropower was created well before the mid-1990s, with few changes in capacity or costs over the time period being analyzed. These aspects allow hydropower to be considered a type of “current generating technology,” which includes steam or gas turbines fired by natural gas, coal, petroleum, or nuclear power. For hydropower to be a viable power option there must be an available river or stream as well as a significant change in elevation. Most of these sites in the U.S. already have hydropower capacity in place. Removing

a policy on Maine and Texas using only wind power capacity excludes the policy effects on biomass capacity, which is a more likely renewable choice for Maine. Both types of renewable resources must be included to directly compare the effectiveness of policies across states.

The effects of state renewable energy policies are best estimated using total state non-hydro renewable *capacity* as the dependent variable because several policies mandate or fund a specific amount of renewable capacity. Policies that do not set specific renewable capacity requirements can be measured in capacity terms by controlling for each state's market size, which will be discussed in more detail in Section 4.

A large amount of renewable capacity created before 1996 originated from the Public Utilities Regulatory Policy Act (PURPA), a federal policy passed in 1978 requiring utilities to purchase electricity from Qualifying Facilities (QFs), which are IPPs that meet specific requirements and include renewable-based facilities. For a variety of reasons, the effects of PURPA varied from state to state. State dummy variables (S_i) measure these effects and other unchanging state factors, such as renewable resource availability.⁹

hydropower from the dependent variable allows the focus of the paper to be on the policy effects on the emerging technologies of wind, solar, biomass, and geothermal power.

⁹ (Morris, 2003). There is some concern that expiration and buyouts of PURPA contracts during the 1990s have led to decreases in renewable capacity, especially in California where deregulation in the early to mid-1990s created competition based on price without any consideration of costs or environmental impacts. Any capacity shut down due to PURPA contract expiration after 1996 will decrease the positive effects of any enacted policy. There is also the possibility of a state changing its interpretation and enforcement of PURPA after 1996, which would not be captured in the model.

4. VARIABLES AND DATA

4.1 W_{it} : Economic and Political Variables

Eight variables account for non-policy variability (W_{it}) in nameplate non-hydropower renewable capacity in the electric power industry of each state for 1996-2003. The economic variables measure the percentage of capacity from hydropower and nuclear power in a state, net generation, retail prices, fuel costs, renewable energy costs, and sugarcane production, while the political variable measures a state's preferences for renewable capacity. These variables are interacted with generation to control for different market sizes across states.¹⁰ Table 1 summarizes the data for the dependent variable (RENEWABLE CAPACITY) and the control variables.¹¹

Table 1: Dependent Variable & Control Variables	Mean	Std. Dev.	Min	Max	Median
RENEWABLE CAPACITY (MW)	348.7	827.6	0.00	6177.4	178.5
GEN (TWh)	73.82	64.98	4.95	385.63	51.15
PCT HYDROPOWER (Percentage)	14.14	20.68	0.00	91.59	6.26
PCT NUCLEAR (Percentage)	11.13	12.46	0.00	56.20	7.54
BORDER PRICE (2002 ¢/kWh)	7.58	2.07	4.82	14.49	6.68
RENEW COST (2002 ¢/kWh)	6.93	0.585	6.00	7.79	6.94
FUEL COST (2002 Dollars/MMBtu)	2.086	0.987	0.601	7.431	1.861
LCV SCORE (0 to 100)	43.06	26.51	0	100	38
SUGARCANE PROD CHANGE	88.95	599.33	-1707	4882	0

Total generation (GEN) is the total amount of electricity generated (in terawatt-hours) in a state for a given year.¹² It is expected that more renewable capacity will be found in states that generate more electricity to help meet the higher demand for electricity found in those states.¹³ The other control variables as well as some of the

¹⁰ Electricity generation in a state is has been chosen to represent market size instead of electricity sales in a state because some electricity sales originate from outside a particular state.

¹¹ Data on capacity, generation, and price are found in the Historical Databases of the Electric Power Annual survey on the EIA website. Electricity summary data is available at the state level from the EIA.

¹² A terawatt-hour (TWh) is the same as 1,000 GWh or 1 billion kWh.

¹³ Total generation was chosen instead of total sales because some of the electricity demand for a state's power producers may come from other states. Generation is not contaminated with these interstate sales,

policy variables are interacted with generation to account for market size across states. For example, an increase in fuel costs will have a larger impact on renewable capacity in California than in Rhode Island. Larger states should have more funding to pay for projects to increase renewable capacity. Renewables Portfolio Standards with Sales Requirements set requirements on the percent of generation that must originate from renewable sources. States with more generation will have more total generation that is required to originate from renewable resources, which should lead to more renewable capacity in those states.

The following three variables are included in the model to control for market structure. Two of these variables are hydropower capacity (PCT HYDROPOWER) and nuclear power capacity (PCT NUCLEAR) as a percentage of total capacity excluding non-hydro renewables. Hydropower should lead to less non-hydro renewable capacity because hydropower has low marginal production costs, and the capacity typically was constructed many years ago. With lower marginal costs and sunk capital costs associated with hydropower, hydropower will be the first renewable energy to be implemented because it is more economically competitive than most non-hydropower renewables available to the electric power industry. Consumer and/or policy driven demand for renewable-based electricity may not differentiate between hydropower and other renewable sources, which allows hydropower to be a substitute of non-hydro renewables.

Similar to hydropower, nuclear power has low marginal costs of producing base load electricity, has sunk capital costs, and has no emissions. If non-hydro renewable

which may otherwise inflate or deflate the market size measure. Generation and sales are highly correlated (0.952).

capacity is deployed based on economic factors, given similar emissions profiles, greater nuclear or hydropower capacity should decrease the amount of non-hydro renewable capacity.

An alternative possibility is that regulators in states with large amounts of nuclear power encourage power producers to use other resource types to meet new demand. Renewable energy may be used by utilities to alleviate pressure from environmentalists over nuclear power, thus leading to greater deployment of renewable energy capacity in states with large amounts of nuclear capacity. The sign of PCT NUCLEAR will depend on which of these two factors has the larger effect on power producers.

A state's annual weighted average real fuel cost (in 2002 dollars) per million Btus (FUEL COST) measures the impact of both a state's composition of fossil fuel mix and a state's average costs for each fossil fuel type: coal, natural gas, and fuel oil.¹⁴ FUEL COST captures the effects of all these variables, which may have offsetting effects on renewable capacity. FUEL COST is used instead of creating separate variables for the cost and capacity of each fossil fuel for several reasons. First, using

¹⁴ Fuel cost data can be found on the EIA website in the electricity databases section under Monthly Cost and Quality of Fuels for Electric Plants Database (FERC Form-423). The cost per unit, Btus per unit, and number of units purchased for every fuel purchase made by all public utilities are used to obtain a nominal average fuel cost measure. The data are aggregated and deflated using the Consumer Price Index for all goods from the Federal Reserve Bank of St. Louis to get the state's annual average real fuel cost per million Btus in January 2002 dollars. FUEL COST has 30 missing observations for 8 different states. Idaho is the only state without any fossil fuel purchases. Estimates of the fuel costs are used to fill in the missing data. The non-Idaho missing observations are extrapolated from the existing data for a state from 1990-2003. Idaho's observations are generated by using the average fuel costs of the states bordering Idaho. A missing data dummy variable is included in the model to capture any bias created through the extrapolation and approximation.

one variable instead of five variables simplifies the model. Second, data on specific fossil fuel costs are missing for many states.¹⁵

Levelized cost of each renewable source is the estimated real cost of production per kilowatt-hour of electricity over the lifetime of the equipment, including all federal production incentives.¹⁶ It captures the economic competitiveness of each renewable energy type. Renewable energy as well as nuclear and hydropower have little or no fuel cost and very high capital costs, while current generating technologies based on fossil fuel have large fuel costs but lower capital costs.¹⁷ As renewable energy has gotten cheaper to produce, it has become more economically competitive. This implies that decreases in the levelized cost of each type of renewable energy will lead to more renewable capacity. The levelized cost also includes federal production incentive policies that varying over time.¹⁸

Many researchers have tried to estimate the levelized cost of energy for each renewable source. Making such an estimate is beyond the scope of this paper, so the data set being used for this variable was obtained from McVeigh et al. (1999). The estimated levelized cost of energy in the U.S. for each renewable energy source is in real

¹⁵ There are missing fuel cost observations for coal (69), natural gas (65), and fuel oil (58). This might be due to no deliveries of a particular fuel to a state, or it could be the missing observations are due to changes in data reporting requirements during the sample period.

¹⁶ Levelized cost is calculated by a model that accounts for the initial capital costs of constructing the capacity, expected lifetime of the equipment, interest rates on debt, inflation rate, fuel costs, operational and maintenance costs, capacity factor of the equipment, and federal production incentives. Read McVeigh (1999) for a more detailed description of levelized cost used in this paper.

¹⁷ Fossil fuel costs are uncertain for current generating technologies, and technical efficiency of capital equipment is uncertain for renewable energy generation.

¹⁸ The Renewable Energy Production Incentive (REPI) and Production Tax Credit (PTC) were passed in the Energy Policy Act (EPACT) of 1992. The level of the REPI is decided by Congress annually, while the PTC was reenacted in 1999 and 2001.

2002 dollars and is estimated for every five years, from 1980 to 2005.¹⁹ These data points are used to interpolate a polynomial curve that had the best fit (highest r-squared value). Due to this interpolation from estimated data, the cost of energy for each type of renewable energy is a reasonable estimate, but not very precise of the decreasing cost of renewable energy over time in the U.S. The resulting trend lines for each type of renewable energy have a high correlation. So a weighted average of the levelized costs of wind, solar, biomass, and geothermal for the entire U.S. are used to create the new variable RENEW COST, which is an average national trend for renewable energy costs.²⁰

If renewable capacity is being constructed on economic grounds, a rise in the retail price of electricity makes renewable energy more profitable and should have a positive effect on renewable capacity.²¹ However, retail prices in a state may be simultaneously determined with renewable capacity because using more renewable capacity increases the average costs of production, which could lead to higher prices.

Using the state's retail price could also lead to multicollinearity problems with fossil

¹⁹ The data points for 1985, 1990, and 1995 were estimated based on actual cost information while 2000 and 2005 were forecasts made in 1999. The polynomial curves have an order of two for biomass and geothermal and three for solar and wind.

²⁰ The weighted average for each year is based on the sources' share of total non-hydropower net summer renewable capacity in the U.S in 2002. Net nameplate capacity data for each type of renewable energy are not available from the EIA, making net summer capacity the closest available alternative measure. Even though there is a cost of energy estimate for both solar thermal and solar Photovoltaic, the solar capacity data are not segregated into these two types. A non-weighted average of solar thermal and PV is taken to get the levelized cost for total solar capacity. Since all solar power accounts for less than 2.5% of total non-hydro renewable capacity in the U.S., it is unlikely that using some weighted average of solar thermal and solar PV would make any significant difference. Summer capacity refers to the maximum output generating equipment is expected to supply to a system demonstrated by tests at the time of summer peak demand. Nameplate and summer capacity have high correlation, but are not identical due to different operating conditions across utilities. Definition of nameplate is in Footnote 7.

²¹ Average retail price is based on all sales in the market: residential, commercial, industrial, and "other" customers. Data are available from the EIA Historical Databases. Average retail price data are originally in nominal terms for each month. Two steps have to be taken to adjust the data into real terms for each year. First, the monthly data are divided by the CPI for all goods to get the monthly data into real terms. Second, monthly electricity sales are used to get a weighted average price for each year. The resulting variable is the real average retail price for each state and year in January 2002 dollars.

fuel costs because higher fuel costs will lead to higher electricity prices. To control for this endogeneity and possible multicollinearity, the model must use a proxy for a state's retail price. A proxy must be correlated to the endogenous variable and have no impact itself on the dependent variable. The weighted average real retail price per kilowatt-hour of the bordering states (BORDER PRICE) is an ideal proxy for retail prices because it meets both of these requirements.²² Using BORDER PRICE instead of the state's retail price removes the possible collinearity with FUEL COST as well.

Florida, Hawaii, Louisiana, and Texas use the byproduct of sugar production from sugarcane as a biomass fuel. For example, in Hawaii sugarcane is one of the primary sources of biomass. Due to market conditions most of the sugarcane farms in Hawaii were shut down over the 1990s, removing the fuel source for much of the biomass capacity in the state. Changes in sugarcane production are likely to have an impact on the amount of biomass capacity in a state. The change in total tons of sugarcane production from 1996 levels (SUGARCANE PROD CHANGE) is included in the model to control for its impact on renewable capacity. SUGARCANE PROD CHANGE is the only control variable not interacted with generation.

A political variable is included to measure changes in renewable energy preferences in a state. The League of Conservation Voters (LCV) rating is used to determine if policy preferences for environmental protection increase renewable energy capacity independent from its policy effects. The League of Conservation Voters (LCV) annually publishes the "National Environmental Scorecard," which rates all

²² Bordering states are all states that either share a border, such as Arizona and New Mexico, or meet at a corner, such as Arizona and Colorado. The prices are weighted by sales in the bordering states. The correlation of retail price to BORDER PRICE is 0.836.

congressional votes on conservational issues by each representative.²³ For example, if there are ten total votes in a year on environmental issues and a congressperson voted in favor of conservation six times, his or her LCV rating would be 60.

An average of all the votes by a state's representatives is taken to get the average House of Representatives score (LCV SCORE). The scores from the House of Representatives are used instead of the Senate because representatives have a shorter term in office than senators, two years versus six years. The shorter term creates greater pressure on representatives to act according to their constituents' preferences.

A high LCV rating for a state indicates that the state's constituents are environmentally friendly and are more likely to demand electricity from renewable energy, all other things being equal. Consumers or environmental groups in states with higher LCV ratings may be more likely to pressure utilities to use greater amounts of renewable energy no matter which, if any, policies have been enacted by the state.

Policies may be endogenous to higher LCV ratings because states with congresspersons who vote for federal pro-environmental policies may be more likely to enact state pro-environmental policies. The policy endogeneity issue is not addressed in the body of this paper because LCV SCORE is not a strong enough predictor of state policies to be a satisfactory instrument. Note also that removing LCV SCORE from the regression does not change the other results.

²³ Data from the "National Environmental Scorecard" is available from the League of Conservation Voters website, www.lcv.org. The LCV rating has been used in prior studies, including Baldwin and Magee (2000), Kalt and Zupan (1984), and Nelson (2002).

4.2 R_{it} : Regulatory Policy Variables

Seven of the independent variables are policy variables capturing the effects of different types of renewable energy regulation, either by a state's legislature or Public Utility Commission (R_{it}).²⁴ Most policies are enacted through state legislation, and then enforced by the Public Utility Commission (PUC). There are a few instances, however, in which a PUC adopts guidelines without state legislation. No legislation or PUC action is required for state governors to use executive orders to create a state government green power purchasing agreement or to set voluntary goals for generation.

Policy dummy variable values are determined by a policy's enactment date, zero before enactment and one after enactment. The "enactment" date is the year that the policy is passed by the state legislator, created through an executive order, or announced as a mandate under new PUC guidelines. Some of these policies allow a grace period for power producers to meet the new regulations. The "effective" date is the year that the policy requirements must be met. The average lag from the "enactment" to "effective" date is a little over one year, but can be longer for Renewables Portfolio Standards. The enactment year is a better choice to determine when the policy begins to impact the power producers. Once a power producer becomes aware of a future requirement, it may begin to construct any necessary renewable capacity. These actions could lead to large amounts of renewable capacity being constructed between the enactment date and effective date.

²⁴ Information on renewable policies is available on the Database of State Incentives for Renewable Energy (DSIRE) website, www.dsireusa.org, which is a project of the Interstate Renewable Energy Council and funded by the U.S. Department of Energy. The information is compiled from many different sources, including federal and state officials, public utility commissions, and renewable energy organizations. The source of the information is included within each policy description. Bollinger et al. (2001) includes additional information on the enactment and design of Public Benefits Funds.

Regulatory policies described below include a Renewables Portfolio Standard with a Capacity Requirement, Renewables Portfolio Standard with a Generation/Sales Requirement, Clean Energy Fund, Net Metering, Interconnection Standards, State Government Green Power Purchasing, and Required Green Power Options. Table 2 summarizes the data for the policy variables.

Table 2: Policy Variables	States	Non-Zero Observations
CEF: CAP FUNDED	8	51
RENEWABLES PORTFOLIO STANDARD	14	66
RPS: CAP REQ	4	27
RPS: SALES REQ	6	39
NET METERING	31	187
INTERCON STANDARDS	21	90
STATE PURCHASING: PCT REQ	6	14
REQ GREEN POWER OPT	5	16

The first policy that will be discussed is a Renewables Portfolio Standard, which specifies an amount of a state’s electricity production, sales, or capacity that must be renewable-based. Renewables Portfolio Standards can be differentiated into three main structural forms, policies that set (1) mandatory renewable generation or sales levels, (2) voluntary renewable generation or sales goals, and (3) mandatory renewable energy capacity requirements.

The first type of Renewables Portfolio Standard sets a percentage of total generation or sales for each power producer/retailer that must originate from renewable sources, usually increasing every year or every few years. For example, Arizona’s tiered renewable levels that have to be met began at 0.2% in 2001 and increased by 0.2% each year, resulting in a requirement of one percent in 2005. Most other states’

Renewables Portfolio Standards have similar structures, but vary in percentage levels and enforcement dates.²⁵

Iowa, Minnesota, Texas, and Wisconsin have mandated utilities to install a certain level of megawatts of renewable capacity.²⁶ As long as the requirements are implemented effectively, renewable capacity requirements should increase renewable capacity by the same number of megawatts required by the mandate. These capacity requirements will make this type of Renewables Portfolio Standards more effective in this model because they target actual capacity construction versus generation or sales-based Renewables Portfolio Standards.

The differences between Renewables Portfolio Standards can be accounted for in the model by two variables: a variable that measures the size of the renewable generation or sales requirement (RPS: SALES REQ) and a variable that measures the size of the capacity requirement (RPS: CAP REQ).²⁷ The capacity requirement size and date are used to extrapolate the expected requirement for each year assuming a linear function, where the power producers increase capacity by the same amount each year until they meet the final requirements, to form the variable RPS: CAP REQ.

RPS: SALES REQ is an even more complex variable. The generation/sales requirement, which usually sets a target about five years after enactment, is linearly interpolated backwards to the enactment date of the policy. For example, a policy

²⁵ In 1998, Wisconsin introduced mandatory capacity levels before it enacted a Renewables Portfolio Standard with mandatory generation or sales in 1999. Two states (Illinois and Hawaii) with Renewables Portfolio Sales Goals (not requirements) are counted as Renewables Portfolio Standards with a sales requirement. The only result that changes when these non-mandatory goals are treated as a requirement of zero is the coefficient on RPS: SALES REQ becomes smaller and becomes less significant for all specifications. All other coefficients remain relatively unchanged.

²⁶ Minnesota has had both types of Renewables Portfolio Standard since 2001. A voluntary generation goal was enacted in 2001, while the capacity requirement was enacted in 1994.

²⁷ Capacity requirements range from 50 to 2000 MW, and generation/sales requirements range from 0-30%.

enacted in 1996 with a sales requirement of 1.0% beginning in 2000 would be linearly interpolated to be 0.2% in 1996 and increase by 0.2% each year until it reaches 1.0% in 2000. Although the requirement is not enforced until 2000, it would be necessary for power producers to begin construction at least several years before 2000 to get the necessary capacity constructed in time to meet the sales requirement.

Although this policy does not directly require the construction of renewable capacity, an increase in the required amount of renewable generation may lead to a need for more renewable capacity. If current levels of renewable capacity cannot meet a future generation/sales requirement, additional capacity will need to be constructed.²⁸

A Clean Energy Fund is a state-level program that is often, but not always, created through the restructuring of the electricity market and is used to fund grants, loans, and production incentives for both research and development and actual deployment of alternative energy. Many Clean Energy Funds focus on funding actual renewable capacity deployment, which should lead to more renewable capacity in a state.

Clean Energy Funds are paid for through System Benefits Charges (SBCs), which are additional charges paid by all consumers on their electricity consumption. SBCs can be considered a consumption tax on electricity to fund deployment of renewable capacity in the industry. In Minnesota, a settlement with the electric utility Xcel Energy created a similar fund that is paying for renewable energy research and

²⁸ Some state Renewables Portfolio Standards with generation/sales requirement allow the use of some hydropower electricity to meet the requirement. However, there are normally specific requirements as to which facilities will be eligible, including restrictions on a unit's maximum capacity, type of hydropower, and year of installation. For example, some states do not allow generating units greater than 30 MW to be eligible. One state does not allow any hydropower to originate from dammed hydropower plants. Another state only allows electricity from new hydropower capacity to be eligible. These restrictions will decrease the effectiveness of these policies to increase renewable capacity in a state. However, the complexities of the restrictions make it difficult to create an appropriate measure for these effects.

deployment. Maine created a voluntary fund similar to a Clean Energy Fund for the state's customers to donate money.²⁹

Similar to Renewables Portfolio Standards, Clean Energy Funds must be differentiated to understand how effective these policies are at increasing renewable deployment in a state. The variable used in this model is a variable that measures the amount of capacity that is being funded for utility-scale projects from Clean Energy Funds (CEF: CAP FUNDED).³⁰

Some customers may prefer to build generating capacity to provide their home with some of their own electricity. Net Metering (NET METERING) allows customers that are able to produce more electricity than they consume in a given month to sell any excess to the utility to offset the charges for electricity in months the customer is a net purchaser. The effect of net metering is expected to be negative because if renewable energy demanders produce their own renewable electricity through a solar PV system or small wind turbine, they will demand less renewable capacity from power producers. From a utility perspective, if it is required to reach a renewable capacity or sales target, these customer-owned facilities may serve to offset a utility's needs to build renewable capacity. NET METERING is interacted with GEN to control for the policy's effect based on market size.

Interconnection standards (INTERCON STANDARDS) are a set of guidelines used to safely and effectively connect individual renewable generating units to the

²⁹ Database of State Incentives for Renewable Energy (DSIRE) does not include New Mexico as having a Clean Energy Fund, while Bolinger et al. (2001) verifies that New Mexico does have a Clean Energy Fund.

³⁰ The capacity obligations as of 2003 are interpolated backwards linearly to the enactment year so that an equal amount of additional capacity obligations are made each year and total the overall obligations as of 2003. The data for is variable originated from the Database of Utility-Scale Renewable Energy Projects from the Clean Energy States Alliance (CESA).

electric utility power grid. Some have technical requirements, such as generator type and size limits, mandatory safety and performance standards, and insurance requirements that must be met before a net metering customer can connect to the utility's network. Interconnection standards must be met by any commercial, industrial, residential, or government customer that decides to connect to the grid. Without these state policies, the net metering connections could cause major problems for the grid, power producers, and other purchasers. Interconnection standards increase the costs of "hooking up" to the grid for net metering and may offset some of the negative effect from net metering. INTERCON STANDARDS is also interacted with GEN to control for market size.³¹

State Government Green Power Purchasing policies require that some percentage of a state government's electricity purchases be from renewable sources. These purchase agreements range from 5% to 50% of a state government's electricity purchases. Similar to Renewables Portfolio Standards with Sales Requirements, a State Government Green Power Purchasing agreement increases the need for renewable-based electricity generation. As state government electricity use rises, the renewable generation needed to meet the requirement increases. If the new generation needs cannot be met by current renewable capacity, power producers will need to construct new renewable energy capacity. The size of the State Government Green Power Purchasing requirement, in terms of a percentage of the state government's electricity

³¹ Since only four observations have interconnection standards and no net metering, the interaction term measures the effect of interconnection standards on states that already have net metering policies. Only 86 of the 187 observations (46%) with net metering also have interconnection standards, which removes concerns of multicollinearity.

purchases, is interacted with GEN to control for both the state's purchase requirement and the state's market size (PCT STATE PURCHASING*GEN).

A Required Green Power Option requires utilities to *offer* customers the option to purchase renewable power at a premium. There are two versions of how these options are implemented. The most common type gives consumers the option to make voluntary contributions, called "voluntary renewable energy tariffs" in return for the guarantee that some of the consumer's electricity consumption is produced from renewable sources. Consumers purchase electricity at the market price and then pay a premium for blocks of "green" electricity, usually about \$2 per 100 kWh. The second type allows the producers to charge consumers a higher rate per kilowatt-hour, but only to cover the "additional costs" for electricity from renewable sources. Both the premium block rate and premium per kilowatt-hour rate must be approved by the state's Public Utilities Commission (PUC).

Required Green Power Options elicit customer preferences and a crude measure of willingness to pay for renewable energy by allowing consumers to voluntarily pay higher prices for the knowledge that they are supporting renewable-based electricity. The creation of this niche market for renewable energy generation should have a positive impact on renewable capacity. The variable REQ GREEN POWER OPT is a dummy variable, which is interacted with GEN in the model to measure the effect of the policy based on the state's market size (REQ GREEN POWER OPT*GEN).

5. STATISTICAL SPECIFICATIONS AND EMPIRICAL ANALYSIS

Ordinary Least Square regressions with state fixed-effects and robust standard errors are used in this paper to estimate total non-hydro renewable capacity. Robust standard errors are used to account for heteroskedasticity, which was found to exist in the model by using a Breusch-Pagan/Cook-Wesiberg Heteroskedasticity Test.³² Table 3 reports the regression results. Specification 1 includes only the policy variables. Specification 2 includes the economic market and political control variables, and Specification 3 replaces RENEW COST with year dummies interacted with GEN. The following subsections describe the results using the coefficients from Specification 3.³³

5.1 W_{it} : Economic and Political Variables

The coefficient for GEN is insignificant, which cannot be easily interpreted because of how many different ways that a state's generation can impact a state's level of renewable capacity. Although the coefficient is insignificant, generation levels do have effects through other variables that are interacted with GEN, which are explained below.

The percentage of other capacity comprised of hydropower interacted with generation (PCT HYDRO*GEN) is not statistically significant. However, the coefficient for the percentage of other capacity comprised of nuclear power interacted with generation (PCT NUCLEAR*GEN) is positive and statistically significant. A one

Table 3: Total Non-Hydro Renewable Capacity	SPECIFICATION
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³² The result was a Chi-Sq=448 and $P(\bullet) > \text{Chi-Sq}=0.0000$, so there is a significant difference in the variance of the dependent variable, which creates heteroskedasticity.

³³ Results from Specification 2 are nearly identical to results from Specification 3 with the same interpretations.

	(1)	(2)	(3)
CEF: CAP FUNDED (MW)	0.198 (0.107)*	0.144 (0.145)	0.206 (0.124)*
RPS: CAP REQ (MW)	1.245 (0.175)***	1.144 (0.168)***	1.142 (0.168)***
RPS: EFFECTIVE GEN REQ	0.153 (0.056)***	0.108 (0.077)	0.1 (0.071)
PCT STATE GREEN POWER PURCHASING * GEN	0.026 (0.014)*	0.013 (0.017)	-0.002 (0.016)
REQUIRED GREEN POWER OPT * GEN	3.539 (0.667)***	3.318 (1.207)***	3.457 (1.166)***
NET METERING * GEN	0.093 (0.205)	-0.237 (0.214)	-0.033 (0.227)
INTERCON STANDARD * GEN	-0.246 (0.211)	-0.241 (0.195)	-0.24 (0.210)
SUGARCANE PRODUCTION CHANGE (Tons)		-0.011 (0.023)	-0.007 (0.023)
GEN (1 TWh)		-0.184 (1.150)	
FUEL COST (\$/MMBtu) * GEN		-0.154 (0.107)	-0.124 (0.109)
FUEL COST MISSING * GEN		-1.261 (0.843)	-1.167 (0.802)
BORDER PRICE (Cents/kWh) * GEN		0.199 (0.207)	-0.259 (0.117)**
RENEW COST (Cents/kWh) * GEN		-0.712 (0.211)***	
LCV SCORE * GEN		0.024 (0.011)**	0.025 (0.011)**
PCT HYDRO * GEN		0.018 (0.028)	-0.027 (0.024)
PCT NUCLEAR * GEN		0.143 (0.043)***	0.168 (0.052)***
YR1997 * GEN			-0.048 (0.151)
YR1998 * GEN			-0.142 (0.186)
YR1999 * GEN			-0.187 (0.182)
YR2000 * GEN			-0.269 (0.199)
YR2001 * GEN			0.322 (0.247)
YR2002 * GEN			0.25 (0.199)
YR2003 * GEN			0.53 (0.226)**
CONSTANT	309.103 (7.689)***	413.745 (55.340)***	267.888 (50.741)***
Observations	400	400	400
State Fixed-Effects	50	50	50
R-squared	0.598	0.634	0.646
Robust Standard Errors in Parentheses * Significant at 10%; ** Significant at 5%; *** Significant at 1%			

standard deviation (12.46%) increase in the percentage of non-renewable capacity comprised of nuclear power leads to an increase of 2.09 MW per terawatt-hour of generation in a state. So this one standard deviation change in a state with a median generation level (51.15 TWh) leads to an increase of 107 MW. It is possible that utilities with more nuclear power are deploying more renewable capacity because the utilities are focused on diversifying its generation mix, either to decrease the utilities' use of fossil fuels and lower emissions or to alleviate pressure from environmentalists who are upset about the use of nuclear power.

The coefficients on the average LCV score for the House of Representatives interacted with generation (LCV SCORE*GEN) are positive and significant. A one standard deviation increase (26.51 points) in a state's LCV score leads to an increase of 0.663 MW per terawatt-hour of generation. A one standard deviation increase in a state with median generation leads to an increase of 34 MW. Preferences for renewable energy capacity do in fact lead to a small amount of deployment of some renewable capacity, holding policies fixed.

As expected, renewable energy cost interacted with generation (RENEW COST*GEN) has a negative and statistically significant coefficient. A one-cent per kWh decrease in renewable energy cost leads to an increase of 0.712 MW per terawatt-hour of generation. In a state with median generation, a one cent decrease in RENEW COST leads to an increase of 36 MW. RENEW COST decreased by 1.79 cents from 1996 to 2003, which implies an increase of 65 MW for a state with median generation. This effect does not just include the technological changes in renewable energy. As mentioned in Section 4, all federal production incentives are included in the costs of

production for each renewable source, capturing the federal policy changes as well as the technological advances. The year variable coefficients, which explain the same impacts as RENEW COST, are explained in detail in Section 5.4.

The coefficient on average border state retail price interacted with generation (BORDER PRICE*GEN) is negative and marginally statistically significant only in Specification 3 of Table 3. Higher electricity prices do not appear to result in more renewable energy capacity construction. In fact, the negative coefficient implies that an increase of one cent in the price of electricity leads to a small decrease in renewable capacity by 13 MW in a state with median generation. A one standard deviation (2.07 cents) increase in price leads to a decrease of only 27 MW. It is possible that consumers in a state with high electricity prices have less of an appetite for further increases in prices through more expensive renewable generation.³⁴

The coefficient for average fuel cost interacted with generation (FUEL COST*GEN) is statistically significant. It is difficult to interpret the meaning of the coefficient, since the components of the variable may lead to opposite effects. Higher costs should make renewable energy capacity more competitive. But the variable also reflects differences in fuel type use in a state. To take one example, since natural gas is more expensive than coal, more natural gas use would lead to a higher average fossil fuel cost and make renewable energy more competitive in the market. On the other hand, natural gas results in lower emissions than using coal or oil. All else equal, a state with more natural gas capacity will have lower emissions than if a state had higher amounts of coal capacity, which lowers the need for non-emitting renewable capacity to

³⁴ High electricity prices may be one of the factors driving the enactment of state renewable energy policies. However, high prices by themselves do not appear to lead to renewable capacity deployment in a state.

meet emissions reduction goals. If this holds true, a higher average fossil fuel cost will be correlated with less renewable capacity construction.

To alleviate any concerns about FUEL COST, an additional specification is estimated replacing FUEL COST with five variables: average cost of coal, average cost of oil, average cost of natural gas, percent of non-renewable capacity comprised of coal, and percent of non-renewable capacity comprised of natural gas. Natural gas and coal capacity are treated in the same manner as hydropower and nuclear power capacity in the model. Each variable is interacted with GEN, just like the other control variables.

A higher percentage of total non-renewable capacity comprised of coal is correlated with more renewable capacity, which gives some support that states with dirtier conventional capacity use more renewable capacity. The higher the coal price, the less renewable capacity is deployed. As the price of coal increases, less renewable capacity is constructed. These two results support the idea that the emissions requirements utilities must meet are a driving force to renewable deployment, while economic competitiveness in the market does not have much of an impact. Caution is necessary in interpreting the results with the additional set of fuel variables because there are many missing observations that must be extrapolated. The dummy variables that control for missing observations for coal and natural gas are both statistically significant, which brings up concerns about the variable coefficients and any possible biases due to the missing data. The most important result from this specification is that the additional variables have no effect on the policy variable coefficients, which remain relatively unchanged relative to the original model.

The coefficient on SUGARCANE PROD CHANGE is insignificant. The missing fuel cost dummy variable interacted with generation (MISSING FUEL COST*GEN) controls for any measurement error caused by the extrapolation of the 38 missing data points and is insignificant as well.

5.2 R_{it} : Regulatory Policy Variables

Table 4 estimates the statistically significant effects from both the control variables and the policy variables based on a state with median generation levels. Clean Energy Funds, Renewables Portfolio Standards with Capacity Requirements, and Required Green Power Options have statistically significant effects on renewable capacity in the electric power industry. Renewables Portfolio Standards with Generation/Sales Requirements and State Green Power Purchasing Programs are marginally significant in Specification 1, but lose their significance once control variables are introduced into the model.

Variable	Mean	Std. Dev.	Increase Per Unit per TWh	Std. Dev. of Median Gen. State
RENEW COST (2002 ¢/kWh)	6.93	0.585	-0.725 MW	-36 MW
BORDER PRICE (2002 ¢/kWh)	7.58	2.07	-0.235 MW	-27 MW
PCT NUCLEAR	11.13	12.46	0.170 MW	107 MW
LCV SCORE (0-100)	43.06	26.51	0.025 MW	34 MW
Effect of Enacting a Policy	Mean	Std. Dev.	Per Unit Effect	Impact on Median Gen. State
PBF: CAP FUNDED	8.20	61.21	0.206 MW per 1.0 MW	20.6% of Funded Capacity
RPS: CAP REQ	14.05	78.30	1.142 MW per 1.0 MW	114% of Req. Cap.
REQ GREEN POWER OPT	0.023	0.150	3.457 MW per TWh	177 MW
Note: All other variables are statistically insignificant.				

CEF: CAP FUNDED, which measures the amount of capacity that the fund has agreed to help finance, has a marginally statistically significant coefficient. This includes capacity that has been agreed upon, but has not yet been built, either because

the project has not been finished or the project is later cancelled. For each megawatt of capacity that the Clean Energy Fund has funded or agreed to fund in the near future, approximately 0.206 MW has been constructed. This is not significantly different than the fraction of capacity that has actually been constructed as of 2003, which was 0.33 MW per 1 MW. Even though actual renewable capacity is probably not constructed linearly over the lifetime of the policy, the estimates from the linear interpolation seem to be representative of actual capacity construction due to the Clean Energy Funds.

The coefficient on RPS: CAP REQ is positive and significant, and about the same size as would be expected. For each megawatt of capacity required by the Renewables Portfolio Standard, approximately 1.14 MW is constructed. The coefficient is not significantly different than one. Similar to CEF: CAP FUNDED, the linear interpolation approach taken in designing RPS: CAP REQ is effective at capturing the policy effects by allowing variation in the timing of capacity construction.

The most interesting result from the model is the effect that Required Green Power Options have on renewable capacity. The coefficient for REQ GREEN POWER OPT*GEN has a positive and statistically significant coefficient and has some of the largest effects on renewable capacity of any variable, where enactment leads to renewable capacity increasing by 3.46 MW per terawatt-hour of generation. A state with a median generation level (51.15 TWh) that enacts a Required Green Power Option would have an increase of 177 MW. Washington has the largest electricity market of states that have enacted a Required Green Power Option (100.1 TWh), which would lead to an increase in renewable capacity of 346 MW. To give some perspective on these results, the estimated impacts in total renewable capacity can be expressed in

terms of a percentage of total capacity in a state. Depending on the state, a Required Green Power Option leads to an increase of about 1.2-1.6%.³⁵ The statistically and economically significant increase implies that Required Green Power Options, which create a niche market for green power by requiring states to offer renewable-based electricity to their consumers at a premium, are very useful in increasing the amount of renewable energy capacity in a state.³⁶

The coefficients for both STATE PURCHASING: PCT REQ*GEN and RPS: SALES REQ*GEN are marginally statistically significant in Specification 1. However, once control variables are included in the regressions, the coefficients are no longer statistically significant. Initial state government purchase levels are minimal and account for a relatively small portion of the electricity market in a state. The low demand can still be met by current renewable generation in a state. Given the size and statistical significance of the coefficient in Specification 3, it is unlikely that state government purchases of renewable energy will result in any significant increase in renewable capacity in a state.

There are multiple reasons for the insignificance of RPS: SALES REQ*GEN. First, most Renewables Portfolio Standards with sales requirements have been enacted fairly recently and currently have low requirements. Power suppliers may be able to meet their low initial requirements by using current renewable capacity. Second, some of the states implementing these policies have available hydropower capacity already in place that is considered eligible to meet a portion of these currently low mandates,

³⁵ These estimates are made by taking the estimated effect of a Required Green Power Option in a state on total renewable capacity in 2003, and then dividing that value by total capacity in the state for 2003. The resulting impact is a measure of the change in renewable capacity in percentage terms of total capacity.

³⁶ This estimation is in the range of the average participation rate for all local green power programs of 1.4% (Wiser and Olson, 2004).

which decreases the policies' effectiveness in encouraging new non-hydro renewable capacity deployment in a state. Third, some states allow the purchase of Renewable Energy Credits (RECs), which are certificates that represent the environmental rights of renewable electricity, instead of actual generation. Many of these same states allow power producers/retailers to purchase RECs from out-of-state power producers to meet their in-state requirements. All three of these factors will decrease the policy's impacts on in-state renewable capacity deployment. A few more years of data should result in RPS: SALES REQ*GEN to have statistically significant impacts on renewable capacity in its state. This can be supported by a one-tailed t-test that shows the regression coefficient to be marginally statistically significant.

Neither net metering nor interconnection standards appear to have an impact on renewable capacity. The coefficients on NET METERING and INTERCON STANDARDS are statistically insignificant.

5.3 S_{it} : State Fixed-Effects Variables

Forty-nine state fixed-effects variables are included in Specification 3 in Table 3 to control for state interpretation of federal policies enacted prior to 1996 as well as any time-invariant differences across states.³⁷ Time-constant variation across states includes the availability of renewable energy resources and the initial level of a state's preferences for renewable energy use. The coefficients should be highly correlated to the amount of renewable capacity that existed in 1996. The correlation between a state's initial renewable capacity and its state-fixed effect coefficient is 0.978. The state fixed-

³⁷ One state must be dropped from the model to remove multicollinearity of the fixed-effects variables.

effects seem to effectively control for the impact of existing regulation and the market environment prior to 1996.

5.4 T_{it} : Year Variables

The third specification replaces the national renewable energy cost trend variable (RENEW COST) with year variables interacted with GEN. The coefficients are statistically insignificant for all years except for 2003, where the impact is 0.530 MW per terawatt-hour of generation in a state. A state with median generation has an increase of 27 MW from 1996 to 2003. These year variables measure the impact of renewable energy becoming more economically viable as well as federal policy implemented to encourage renewable energy use. The federal Renewable Energy Production Tax Credit (PTC) and federal Renewable Energy Production Incentive (REPI) were enacted in 1992. The federal PTC was renewed in both 1999 and 2001, while the funding for the REPI changes from year to year based on congressional appropriations. Each year coefficient controls for the impact of these policies on each state as funding for these production incentives change as well as the improvements in the technology behind renewable energy.

6. CONCLUSIONS

States have enacted many policies to increase the deployment of non-hydro renewable capacity into the electric power industry in that state. The literature evaluating the effectiveness of these programs consists of case studies and one statistical study, which explains the use of wind power. My statistical study utilizes a larger panel,

more policies, and more control variables to explain the deployment of total renewable capacity in a state.

Three regulatory policies appear to be effective at increasing renewable capacity deployment in a state. The significant results from these regulatory policies confirm many of the findings from prior research. Comparing the findings to that of Menz and Vachon, more policies are found to be effective at increasing renewable capacity. Not only do Renewables Portfolio Standards with Capacity Requirements and Mandatory Green Power Options increase renewable capacity in a state, but Clean Energy Funds increase capacity deployment in a state as well.

Menz and Vachon found Public Benefits Funds, which include any Clean Energy Fund in a state, to be insignificant in their model. My paper finds that Clean Energy Funds with utility-scale projects increase the deployment of renewable capacity in a state. By using System Benefits Charges (SBCs) a state can effectively make consumers pay for cleaner energy without creating a different market for renewable energy demand. Similar to the case study findings by Bolinger et al. (2001, 2004, 2005), larger utility-scale projects make Clean Energy Funds more effective at increasing renewable capacity deployment in a state. However, only about 20.6% of the obligated capacity has typically finished construction. Some of this capacity will be finished in the near future, while other projects will be cancelled for financial reasons.

Menz and Vachon found that, in general, Renewables Portfolio Standards increase renewable capacity in a state. This paper finds that different types of Renewables Portfolio Standards have different effects on renewable capacity. Each megawatt of capacity mandated by Renewables Portfolio Standards with Capacity

Requirements results in the deployment of one megawatt of additional renewable capacity in a state. But recent Renewables Portfolio Standards that mandate generation or sales levels appear not to have statistically significant effects. Given time, these policies may, and likely will be shown to increase renewable capacity in a state in the near future once current levels of renewable energy capacity cannot cover the generation/sales requirements. These results mirror Petersik's case study in that only Renewables Portfolio Standards with Capacity Requirements have increased renewable capacity, but expand on the case study by finding evidence on the size of the policy effect holding other policies fixed.

Statewide Required Green Power Options appear to have been as effective as any other policy. Forcing utilities to offer customers the option to purchase renewable-based electricity at a "reasonable" premium rate drastically increases renewable capacity in a state. The policy has a greater impact in larger electricity markets and appears to be effective regardless of a state's political environment.

There are major renewable policy implications if these results hold when additional years are eventually included in the model. Only five states have currently implemented Required Green Power Options even though creating a statewide "green power" market appears to be as effective at increasing renewable energy capacity in a state as a command-and-control scheme of a Renewables Portfolio Standards or tax-and-subsidy scheme of a Clean Energy Fund. State government purchasing agreements of renewable energy appear to be no more than "window dressing" for politicians to show their support to the environmental community, and additional funding to renewable power producers.

The important policy implications that arise from the results indicate policymakers have a wide array of tools at their disposal to promote renewable energy deployment in a state to meet environmental and energy security policy goals. The array of policy mechanisms will become even more useful to state governments if the prospect of U.S. climate change/carbon emissions policy becomes a reality.

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