State-Level Renewable Electricity Policies and Reductions in Carbon Emissions

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Abstract: A wide range of renewable electricity policies has been adopted at the state level in the United States, but to date there has been no large-scale, empirical assessment of the effect of these policies on carbon emissions. We first quantitatively examine the effects of a range of policies across 39 states. While we find that the mere implementation of policies is not associated with effects on carbon emissions, as states develop experience with policies we do see significant declines in carbon emissions. The strongest effects are seen with renewable portfolio standards. We then conduct case studies of successful and unsuccessful renewable portfolio standards to identify why the success of renewable portfolio standards seems to increase over time. The policy approach that seems to have worked best at the state level is for the state to mandate an aggressive goal with an RPS, and then begin a process of experimentation with other policies such as financial and technical assistance that will help firms to meet that goal in a way that fits the local setting.

Keywords: carbon emissions; renewable electricity; state-level environmental policies

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Despite widespread appreciation across the social sciences for the role that the state plays in social change, there has not as of yet been a concerted effort to understand the role of the state in environmental policy. One reason for this may be that scholarly attention on the environment is focused on the national level, and at that level the catalogue of environmental policy in the U.S. is a relentless failure. There simply has not been much environmental policy to discuss.

But as a handful of scholars have noticed, despite the hesitant pace of environmental policy at the national level, there is a proliferation of environmental policy at the state level, where "an almost stealth-like process of policy development" (Rabe, 2004:11) has been underway for over two decades. Many state governments have determined that environmental policy is necessary and feasible, and have experimented with several different policy approaches, particularly on the question of facilitating alternative energy.

These state policies are surprising in many ways. For example, they are often driven by bipartisan coalitions, and, perhaps because of their lower visibility, they seem to have escaped the partisan wrangling that has limited national-level policy. Both George W. Bush and Christine Todd Whitman were pioneers of alternative energy policy at the state level, as governors of Texas and New Jersey respectively, before they went on to obstruct environmental policy at the federal level as president and head of the EPA (Rabe, 2004). Texas, a state that produces reliably conservative and anti-environmental contingents at the national level, is a leader in wind energy.

Environmental policy-making at the state level is pragmatic and catholic, with many different approaches being tried. Because electricity generation accounts for 41%

of all CO_2 emissions and is the largest single source of CO_2 emissions (EPA, 2011:ES-8; Carley, 2011), many states have focused their efforts on the electric power sector. One of the main sites of policy innovation has been the attempt to increase the generation of electricity from renewable sources. This represents what might be called the "innovate our way out" strategy of dealing with climate change, which focuses on providing alternatives to current fossil-fuel intensive energy sources. It is counterposed to approaches that focus on reducing energy consumption. While the two approaches are not mutually exclusive, the "innovate our way out" strategy promises that current energy-intensive lifestyles will not need to be radically altered. As consumption of energy is tied to economic development, this is a major strength of this approach, and an approach that does not require large changes in behavior may be more likely to lead to larger declines in carbon emissions.

Wind, solar, and hydropower are the most likely sources of renewable energy today. In order to boost the production of renewable electricity from such sources, states have experimented with a range of policies. One of the earliest efforts was to allow consumers to generate their own electricity from small scale renewable sources, to feed some of this small scale generation back into the electricity grid, and to charge customers only on the "net" electricity they consumed. This approach is called net metering, and is available today in forty states. Another series of laws has sought to create competition between electricity providers, in various ways: by mandating that electricity providers must disclose their fuel sources, to allow customers to understand where their electricity is coming from and switch sources if they so choose (fuel generation disclosure); by mandating outright that customers be provided choices in energy suppliers (retail choice, eleven states); and by mandating that electricity providers allow their customers the option of purchasing more expensive electricity from alternative energy sources (mandatory green power options, seven states). Another state-level law, the public benefit fund, is a kind of carbon tax, with fees on energy usage going to support environmental efforts of various kinds. Seventeen states have adopted them.

The most excitement in recent years has been around the renewable portfolio standard (RPS), a quota mandating that a certain proportion of energy be generated from renewable sources. RPS was first formalized in California, in an extensive statewide debate on energy policy following the deregulation of the California energy market, with the American Wind Energy Association and the Union of Concerned Scientists early advocates of the approach. A few other states had discussed the idea and some had even implemented voluntary standards, but the first formalization of the idea of a mandatory standard began in 1995, when the California Public Utilities Commission mandated a "minimum renewables purchase requirement" which required energy suppliers to either produce an amount of renewable energy on their own (defined as a percentage of their total energy production), or to purchase renewable energy from other suppliers to meet the mandate. A market in renewable energy credits would add flexibility to the arrangement and allow those suppliers most capable of turning to renewable energy to do so, while allowing those not capable of producing alternative energy on their own an alternative means of satisfying the mandate. In this picture, the role of government was to set the original standard and enforce compliance. However, the California legislature rejected the minimum renewables purchase requirement in 1996, selecting an energy tax (a "non-bypassable systems benefit charge") to fund renewables instead, and California would not take the issue up again until several years later. (Wiser, Pickle, and Goldman, 1996; Rader and Norgaard, 1996)

The idea, however, was quickly embraced by environmentalists and by other states. The major appeal of the RPS to state governments is that it does not require the government itself to spend money, and the appeal to suppliers is that the government does not dictate how the renewable energy requirement is to be fulfilled. Early adopters included Minnesota, Arizona, Massachusetts, Maine, and Nevada, and Iowa converted its existing requirements into an RPS. Texas adopted an RPS under George W. Bush in 1999, and California finally adopted it in 2002. As of today RPS has spread rapidly across the country, with 38 states having adopted them. (DSIRE 2010; Wiser, Pickle, and Goldman, 1996; Wiser and Barbose 2007; Wiser, Porter, and Grace 2005; Carley, 2011; Rader and Norgaard, 1996; Fischlein et al., 2010)

To our knowledge, there has to date been no large-scale, empirical review of the effect of state-level environmental policies in reducing CO2 emissions. Because wind energy is currently the most feasible source of clean electricity, and because RPS is the most popular policy, the most sophisticated research effort on state-level environmental policy has been focused on assessing whether RPS policies have increased the generation of electricity from wind power. Menz and Vachon (2006) use a simple OLS regression model to show that RPS does increase wind power when the number of years a policy has been in effect is taken into account. An unpublished study by Kneifel (2008) uses fixed-effects regression and finds no effect, but Yin and Powers (2010) claim that when differences in types of RPS are taken into account RPS does have an effect even in a fixed-effect model, as do Adelaja, Hailu, McKeown, and Tekle (2010). Carley (2009) finds that an RPS does increase the total availability of wind power, but does not appreciably change the overall mix of energy.

There has been much less research effort on the question of whether these policies are reducing carbon emissions in the electric power sector, however, and some critics have argued that renewable energy will not contribute to that goal. Again, the most consistent research focus has been on the RPS. Palmer and Burtraw (2005) do find that an RPS would reduce carbon emissions, but they also note that it would likely do more to reduce the use of clean but costly natural gas than cheap, dirty coal. They suggest that a simple cap on carbon emissions would be a more cost-efficient policy. Michaels (2008), in a sharp and multi-pronged critique of RPS, supports this view, noting that wind power's intermittent availability "means that [it] will largely displace gas-fired generation that can adjust output on short notice" (87). Unlike gas units, coal plants "will remain base-loaded and operating at almost all times" (87).

Hogan (2008) provides a limited empirical assessment of the issue in case studies of Colorado, Connecticut, California, and Minnesota. He finds that only Minnesota appeared to have any decline in power sector CO2 emissions after implementing an RPS (119). In accordance with the reasoning of Palmer and Burtraw as well as Michaels, Hogan notes that Minnesota was the only one of the four states where the marginal generation, which wind displaces, is predominantly coal-fired (119).

Other scholars have assessed emission effects with simulated models. For instance, Kydes (2007) shows that a 20% non-hydroelectric RPS could reduce carbon dioxide emissions by around 16.5%. Carley (2010) finds that individual state policies are only minimally effective if nearby states do not adopt similar policies. The EIA itself has conducted a simulation suggesting a national RPS of 10% would reduce carbon emissions by only 3%-7% (EIA 2002).

While the existing research is informative, there is a need to supplement this work with multivariate empirical analysis of the actual effect of state-level policies on carbon emissions. In this paper we first conduct a quantitative analysis of the effect of state-level policies on carbon emissions, and then conduct case studies of carbon emissions in five states to identify the factors that make for successful policies.

Methods and Design

In this study we examine the effect of state-level renewable electricity policies on carbon emissions by state. Our approach is to compare carbon emissions in the electric power sector over time in states that have passed renewable electricity policies to carbon emissions in states that have not done so, controlling for factors that might independently affect carbon emissions in order to isolate the effect of the policy. We construct time-series panel data and employ a fixed-effects model that allows us to control for unobserved heterogeneity between the states. Our unit of measure is the state-year, and we have data on 468 state-years.

Our main model is:

$$(1)\ CO2 = \alpha_1 + \beta_1 policy + \beta_2 GDP + \beta_3 electricitygeneration + \varepsilon$$

where *CO2* is a measure of carbon emissions, *policy* is a measure of environmental policy in the state, *GDP* is a measure of gross domestic product, and *electricitygeneration* is a per capita measure of aggregate generation of electricity from all sources.

Table 1 shows the specific definitions and sources of our variables, table 2 presents summary statistics, and tables 3a-3d present bivariate correlations for variables entered into the same model.[1]

Our independent variable for environmental policy is measured in four different ways. First we measure the effect of having any policy at all in the state, and then we measure the effect of four specific policies: net metering, retail choice, public benefit funds, and renewable portfolio standards, measured separately. We do not examine fuel generation disclosure policies or mandatory power options because their presence is highly correlated with other policies and because we see them as variations in degree on retail choice—all three of these policies (fuel generation disclosure, mandatory green power options, and retail choice) attempt to improve the competitiveness of the electricity sector by giving consumers the choice to purchase renewable electricity. The other three policies (net metering, public benefit funds, and renewable portfolio standards) represent substantially different conceptions of how to increase renewable electricity, and consequently the four variables we choose capture several different policy approaches.

We first test whether the simple presence or absence of a policy (coded as a binary) is associated with an effect on carbon emissions. We do this in two ways, first as the presence of any policy, and then as the presence of one of the four specific policies (net metering, retail choice, public benefit funds, renewable portfolio standards).

[1] While the bivariate correlation between GDP and per capita generation is relatively high (>.5), a variance inflation factor analysis does not show multicollinearity in any of the models.

However, Menz and Vachon (2006) argue that experience with a policy may also affect its success. It may be the case that as consumers become more familiar with the policy and begin to respond to it more clear effects are seen. For renewable portfolio standards in particular, years of experience with a policy may be significant because the standards are written to become gradually more stringent over time. We thus conduct separate estimations using the number of years the policy has been in effect in the state as the measure of *policy*. Again, we do this in two ways, first as a measure of aggregate experience with any policy, and second as experience with any one of the four specific policies. For the variable of experience with any policy, *anypolicyexp*, if a state had two or more policies in one year each of these policies would contribute one year of experience to the measure. For example, if a state had both net metering and public benefit funds in 1998, this would count as two years of policy experience. Our reasoning was that a state that has experience with two different policies is more experienced with environmental policy in general than a state that has experience with one policy, and a cumulative measure more appropriately reflects this experience and differentiates between states with different levels of policy effort.

This leads to four measures for the independent variable: presence of any policy; presence of one of four specific policies; number of years experience with any policy; and number of years experience one of four specific policies. To avoid multicollinearity, we do not enter any of these four ways of measuring the independent variable in the same estimation; we conduct four separate estimations.

Our dependent variable, CO2 emissions from the electric power sector, is taken from the Environmental Protection Agency's <u>Inventory of Greenhouse Gases and Sinks</u>, which is in turn derived from Energy Information Administration data. The measure of carbon emissions from the electric power sector includes carbon emissions from: "all power producers, consisting of both regulated utilities and nonutilities (e.g. independent power producers, qualifying cogenerators, and other small power producers)" (EPA 2011: 3-10). The inclusion of utilities as well as non-utilities is important, as Fischlein, Smith, and Wilson (2009) have shown that small producers account for a large minority of carbon emissions.

We included carbon emissions in the state itself, as well as carbon emissions in neighboring states, in the measure of the dependent variable. This is necessary because electricity generation is sold across state lines (Jiusto, 2006). Thus, a state could pass a policy that increases renewable electricity production, and then find all of that renewable electricity sold to other states. In this scenario the policy might not reduce emissions in the state itself, but might have important effects on carbon emissions in neighboring states. Since we are interested in the overall effect of the policy, not on its local effect, it is necessary to take this out-of-state leakage into account. However, there are currently no data on state-to-state energy flows[2], and common methods to account for the size of these flows for individual states (e.g. Jiusto, 2006) cannot address the question we are attempting to address here of the overall effect of policies. Thus, we estimate their effect by summing a state's own carbon emissions and the carbon emissions of its neighboring states. Neighboring states are defined as states sharing a border with the target state (taken from Holmes, 1998).

[2] Personal communication, Energy Information Administration. We are grateful to two anonymous reviewers for pointing out the importance of interstate electricity flows.

As for our control variables, the scholarly literature has produced a wide range of findings on the factors that influence emissions, from the structure and size of the economy to the shape of politics and civil society to the design of home appliances to preferences for housing size (e.g. Roberts and Grimes, 1997; York, Rosa, and Dietz, 2003; Grimes and Kentor, 2003; Shandra, London, Whooley, and Williamson, 2004; Jorgenson, 2006). It is not possible to include controls for every factor, and moreover, there is high correlation between many of the factors that have been identified as relevant, such as population and GDP. Therefore our strategy was to control for two big factors: GDP and per capita electricity generation. These two factors should capture the structural, political, economic, and cultural influences that may independently affect carbon emissions, because most of these effects will happen *through* increases in electricity generation. For example, a factor such as the smaller size of home appliances—if it were having an effect—would be picked up in the measure of electricity generation, since smaller appliances would require less energy. The GDP control should capture the effect of other demographic or structural changes that are not captured in the electricity generation measure.

It should be noted that, because we control for electricity generation, we are measuring the degree to which clean energy policies have succeeded in *decoupling* electricity production from carbon emissions—whether they are replacing dirtier energy sources with cleaner energy sources, which would result in lower carbon intensity of the economy even if electricity production in the aggregate is increasing. We are not analyzing whether electricity generation in general is declining, as we would not expect renewable energy to lead to less overall electricity generation. Indeed, the promise of this approach is precisely that current lifestyles and energy expenditure levels can continue. In the presence of renewable electricity a similar amount of electricity generation should yield relatively lower carbon emissions, and therefore we show not whether carbon emissions are going down in absolute terms, but whether they are going down *compared to what they would have been* without the renewable electricity policies.

The controls are also aggregates for the state as well as neighboring states.

Because wind energy has been the main focus of the state-level alternative energy movement, we restricted our attention to the 39 states with significant wind energy potential. Our reasoning was that, given currently available technologies, these are the states that can reasonably be expected to have lowered carbon emissions.

Augmented Dickey-Fuller tests were conducted to test for unit roots in the dependent variable and the null hypothesis of the presence of a unit root was rejected, suggesting that the series is stationary and pooled time series analysis is appropriate. However, inspection of the slopes of the residuals for individual states revealed greater variation between the states than within them even after accounting for the control variables. Because of this unit heterogeneity we use a fixed effects model, which allows us to account for unobserved heterogeneity between states. We modeled the auto-correlation on the independent variable as an AR(1) process, after an examination of the partial autocorrelation plot. To test for outliers we repeated all of our estimations 39 times, dropping one state at a time.

All data and calculations, including for all of the alternative ways of measuring the variables and running the model, are available from the authors.[3]

[3] We have submitted the data and calculations in an annex, and we plan to make all data and calculations available on our website.

Table 1: Variables and Sources

Variable	Definition	Source
totco2	Carbon emissions from electric utilities, million metric tons, for state and neighboring states	Environmental Protection Agency, www.epa.gov
Totgdp	Gross domestic product for state and neighboring states	Bureau of Economic Analysis
Totpcgen	Per capita net generation (in MWh) of total electric power industry for state and neighboring states	Energy Information Administration, www.eia.doe.gov
Netm	Net metering, 1=yes, 0=no	Database of State Incentives for Renewables and Efficiency (DSIRE)
Netmexp	Years of experience with net metering	DSIRE
Rc	Retail choice (1=yes, 0=no)	DSIRE
Rcexp	Years of experience with retail choice	DSIRE
Pbf	Public benefit funds (1=yes, 0=no)	DSIRE
Pbfexp	Years of experience with public benefit funds	DSIRE
Rps	Renewable portfolio standard (1=yes, 0=no)	DSIRE
Rpsexp	Years of experience with RPS (excluding early experience with RPS)	DSIRE
Anypolicy	1 if state has any of the four policies (netm, rc, pbf, rps), 0 otherwise	Calculated from above
Anypolicyexp	Number of years of experience with any policy, 1997-2008	Calculated from above

Table 2: Means and Standard Deviations

Variable	Obs	Mean	Std.Dev.	Min	Max
co2	468	43.905	42.914	.005	220.569
totco2	468	223.486	129.538	6.6	528.48
Totpcgdp	468	38.680	6.322	24.38	57.63
Totpcgen	468	13887.03	4263.226	7207.13	32382.96
Netm	468	.596	.491	0	1
Netmexp	468	2.724	3.381	0	11
Rc	468	.147	.355	0	1
Rcexp	468	.380	1.182	0	7
Pbf	468	.295	.456	0	1
Pbfexp	468	1.329	2.650	0	11
Rps	468	.280	.449	0	1
Rpsexp	468	.829	1.993	0	11
Anypolicy	468	.506	.500	0	1
Anypolicyexp	468	5.263	6.934	0	32
Incrqmtshare	156	68443.59	556456.7	-2.93	5353573

Table 3: Bivariate Correlations among Independent and Control Variables

(a)

	totgdp	totpcgen	anypolicy
totgdp	1.0000		
totpcgen	-0.503	1.0000	
anypolicy	0.306	-0.154	1.0000

(b)

	totgdp	totpcgen	netm	rc	pbf	rps
totgdp	1.000					
totpcgen	-0.503	1.000				
netm	.171	-0.224	1.000			
rc	.038	-0.118	0.158	1.000		
pbf	.174	-0.191	0.360	0.154	1.000	
rps	.285	-0.191	0.368	0.305	0.254	1.000

(c)

	totgdp	totpcgen	anypolicyexp
Totgdp	1.000		
Totpcgen	-0.503	1.000	
Anypolicyexp	0.286	-0.156	1.000

(d)

	totgdp	totpcgen	netmexp	rcexp	pbfexp	rpsexp
totgdp	1.000					
totpcgen	-0.503	1.000				
netmexp	0.253	-0.178	1.000			
rcexp	0..057	-0.104	0.301	1.000		
pbfexp	0.215	-0.112	0.502	0.205	1.000	
rpsexp	0.247	-0.156	0.500	0.299	0.324	1.000

Findings

Table 4 shows the results.

Model 1 shows the effect of the presence of any policy. This estimation finds no effect.

Model 2a shows the effects of the presence of specific policies. While public benefit funds are near significance (p<.1), this effect does not remain if any one of the following states are removed from the estimation: California, Colorado, Connecticut, Delaware, Iowa, Indiana, Maryland, Montana, New Jersey, Ohio, Oregon, Texas, Virginia, Vermont, West Virginia, or Wyoming. For example, Model 2b shows the same estimation excluding Oregon, and shows no effect.

Model 3 shows the effect of years of experience with any policy. This estimation shows a strong and significant effect, with one additional year of policy experience associated with a .462 million metric ton reduction in carbon emissions. This effect remains significant (p<.05) in the 39 additional estimations we conducted testing for outlier states.

Model 4 shows the effect of years of experience with specific policies. Net metering, retail choice, and public benefit funds do not show an effect, but renewable portfolio standards show a strong and significant effect, with one additional year of policy experience associated with a 1.266 million metric ton reduction in carbon emissions. This effect remains significant or near significant (p<.1) in the 39 additional estimations we conducted testing for outlier states.[4]

[4] Recently, Yin and Powers (2010) have suggested that specific features of RPS can have very different effects on the success of the policy. They create detailed distinctions among RPS designs, specifically on how the RPS treats different types of utilities, how existing renewable resource capacity is counted against the mandate, how freely the state allows utilities to meet the mandate by purchasing credits from out of

Table 4: Effect of State-Level Policies on Carbon Emissions

	Model 1	*Model 2a*	*Model 2b*	*Model 3*	*Model 4*
totgdp	0.000***	.000***	.000***	.000***	.000***
	(.000)	.000	(.000)	(.000)	(.000)
totpcgen	0.005***	.005***	.006***	.005***	.005***
	(.001)	(.001)	(.001)	(.001)	(.001)
anypolicy	0.845	--	--	--	--
	1.507				
NETM	--	2.317	2.255	--	--
		(1.627)	(1.639)		
RC	--	-.327	1.010	--	--
		(1.910)	(1.942)		
PBF	--	-3.998†	-1.502	--	--
		(2.382)	(2.501)		
RPS	--	-.735	-1.145	--	--
		(1.385)	(1.386)		
anypolicyexp	--	--	--	-.462*	--
				(.180)	
NETMexp	--	--	--	--	-.298
					(4.66)
RCexp	--	--	--	--	.710
					(.651)
PBFexp	--	--	--	--	-.646
					(.499)
RPSexp	--	--	--	--	-1.266*
					(.600)
R-squared	**.25**	**.27**	**.39**	**.42**	**.41**

†<.1 *p<.05 **p<.01 ***p<.001

Dependent variable: carbon emissions in the electric power sector, million metric tons. Standard errors in parentheses. 1997-2008. Model 2b excludes Montana.

state utilities, and the penalties associated with non-compliance (1143). Yin and Powers were not willing to make their data and measures available, so we recreated their measure of specific design features of RPS, and attempted to repeat our tests using this measure. However, problems of multicollinearity prevented this estimation from being used in our models. These results are not presented here, but are available in the supplement to this article.

Embedding RPS

We conclude that RPS can help to increase wind power capacity, but that simply implementing the policy is not enough. Policy experience matters, and states must learn how to make it work. But if states learn, what do they learn?

To answer this question, we conducted case studies of RPS in five states, three of which have been successful in using RPS to increase wind power capacity, and two of which have been less successful in doing so.

Successful Cases

Iowa. Iowa's approach to wind development has been comprehensive and coordinated, marked by an early (1983) policy impetus that was reinforced by a supportive Utilities Board and legislature. Politicians including popular former Governor Tom Vilsack have backed wind power as a means of supporting farmers, spurring rural development, and positioning the state as a national leader in renewable energy. Wind development in Iowa has also been helped by the state's access to other green energy markets, in Wisconsin and Chicago. Wisconsin utilities have also bought wind projects in Iowa as a cost-effective means of complying with their own state's RPS (EUW 2006). Wind power developers benefit from a number of tax exemptions (DSIRE, 2009) and in 2005 state agencies were required to obtain 10% of energy from renewables by executive order, and to replace state vehicles with more energy efficient models. These mandatory programs are complemented by a set of voluntary programs, including research grants and "awareness and incentive programs" such as energy efficiency in public buildings. The Iowa Energy Bank offers technical assistance, including "energy audit," engineering assessment, and financing aid. Wind power may also be popular in that it does not compete directly with other resource industries in the state. In short, the Iowa RPS's success is only one piece of a state-wide effort to increase wind power through financial incentives, technical assistance, and environmental factors such as proximity to large markets.

Washington. Washington State has had great success developing wind power in part because such projects are easily integrated into its existing electricity generation system. Hydroelectric plants produce much of the state's power. These plants are a perfect complement to wind installations in that their output can be very easily adjusted to pick up the production slack during periods of intermittent winds or peak demand (Harden 2007). Additionally, fortuitously, many of the state's best wind resources are found near hydro sites in its rural, eastern regions (Harden 2007). This means that wind projects can be easily linked to high capacity transmission lines that run to population centers in the western part of the state (Harden 2007). Thus, there are "no fundamental technical barriers" to large scale wind power integration according to the region's Bonneville Power Administration (Harden 2007). The remote, eastern siting also means that there are fewer challenges to wind project development on aesthetic or environmental grounds (Harden 2007). Several regional electricity market factors helped encourage wind power development at the start of this century. Drought reduced hydroelectric power production and further stressed regional electricity markets that were already weakened by the ongoing California deregulation crisis (Bird et al. 2003). Also, wind power became more economically attractive at this time as natural gas prices went up (Bird et al. 2003). Under the 2001 law, only "fish-friendly" hydropower qualified as "renewable," a provision that effectively included new development (DSIRE, 2009). Some California municipal utilities also turned to Northwest power producers to support their own green pricing programs (Bird et al. 2003). In 2006, Washington became only the second state to approve a RPS by popular ballot initiative (DSIRE, 2009). Nearly 53% of voters supported the initiative that required large electric utilities, providers of about 84% of the state's load, to have 15% renewable power production by 2020 (DSIRE, 2009). The new law was notable in that, like the 2001 mandatory green power option legislation, it did not consider most hydropower "renewable," and thus required utilities to pursue other forms of production (Riner 2006). As with Iowa, RPS in Washington State seems to have been once piece of a broader environmental effort, and to have benefited from certain contextual factors, such as the proximity to large California markets, that may not be replicable in other states.

Oregon. Oregon's power production system shares many of the characteristics that made Washington's so amenable to wind development. The state's extensive hydropower production network complements new wind installations (Harden 2007). Also, some of Oregon's best wind resources are located in the eastern part of the state where transmission lines are easily accessible and new projects face fewer community challenges (Harden 2007). Oregon experienced market conditions similar to Washington's that made wind power more economically attractive in the early 2000s. At the time, the market was stressed by California deregulation and regional drought (Bird et al. 2003). The Bonneville Power Administration pursued wind development, noting that such projects were easily sited and expanded, had few environmental impacts, were attractive to customers, was economically competitive, and could come online quickly

(Bird et al. 2003). A number of financial incentives are available to wind developers, such as “enterprise zones” where property tax can be abated for three to five years (Bird et al. 2003).

Unsuccessful Cases

Maine. In contrast to Iowa, Washington, and Oregon, Maine’s first attempt at an RPS was, by many accounts, tragically flawed. Taking effect in 2000, Maine’s RPS required all energy providers in the state to use 30% renewable energy (DSIRE, 2009). This was the most aggressive RPS standard by percentage (Wiser et al. 2005). However, the regulation allowed the state’s existing, prevalent conventional hydroelectric plants and cogeneration systems to count toward the goal (Petersik 2004; Wiser et al. 2005). Consequently, the “eligible supply far exceeds demand,” and the policy did not encourage the development of any new renewable production (Wiser et al. 2005). After many calls for revision, the legislature adopted a goal of 10% new renewable energy by 2017 (DSIRE, 2009). While the new goal did include some environmentally-friendly hydropower systems, it did not account for cogeneration or municipal solid waste systems (DSIRE, 2009). In 2007, the legislature changed this goal to a standard (DSIRE, 2009). Unfortunately, this policy also faced some criticism as wind developers deemed it too vague on price caps, the definition of “renewable,” and expiration (GPR 2007). The next year, the legislature laid out more specific goals and guidelines for the wind power industry by calling for at least 2,000 MW installed wind power capacity in 2015, and at least 3,000 MW by 2020 (DSIRE; Riner 2008). Maine’s wind power could be in high demand in Massachusetts and other New England states where a lack of land for big projects complicates compliance with state renewable portfolio standards (Wood 2008). However, there are not currently adequate transmission lines to connect the northern producers to the more southern consumers. This fact has complicated progress in the development of at least one large scale wind project in Maine (Wood 2008). While wind development stakeholders recognize the problem, there is regional disagreement on who—Massachusetts or Maine—should finance improvements in the transmission network (Wood 2008a; Wood 2009). In recent years, wind development proposals in Maine have faced strong public opposition. A 2005 report by the Maine Public Utilities Commission identified public opinion as one of the "two largest obstacles" to wind power development in the state (Berry et al. 2005). Various groups in the environmental lobby have led successful opposition efforts. For instance, in early 2007, the Maine Land Use Regulation Commission rejected a 90 MW wind project because of Maine Audubon's and other groups' concerns over the project's proximity to the rustic Appalachian Trail as well as its effects on local bird populations (Wood 2007). Other citizen groups have concerns in part because large scale wind projects are largely foreign to, and thus misunderstood in, the state (Berry et al. 2005). Additionally, the approval process for new projects is often challenged because of the state's inconsistent siting guidelines and complicated rezoning processes (Berry et al. 2005; Wood 2008a). According to Berry et al. (2005), wind power in Maine is "extremely capital-intensive hindering its cost competition with current sources" (33). However, in 2003, Maine was one of only two states that were not offering some kind of financial incentive for the production of renewable energy (Menz 2005). Incentives have only slightly improved in the years since. For instance, the state now offers a 100% sales tax refund for “community” (i.e. < 10 MW) wind projects (DSIRE, 2009). Also, as of 2008, the state offers nominal rebates for 500-2000 MW wind energy systems (DSIRE, 2009). These incentives still pale in comparison to those commonly offered in the Midwest and Northwest.

Nevada. Nevada has great potential to harness its solar and geothermal resources. This may detract from wind development in complying with RPS and other renewable energy policies (Wiser et al 2005). Indeed, geothermal is now the most market competitive of the three options as it offers a steady, constant source of power (GPR 2006). Also, under the state’s RPS, 5% of the portfolio is required to be from solar power (DSIRE, 2009). During the early 2000s, Nevada’s main two utilities had such poor credit ratings that they could not secure financing for new renewable energy projects to comply with the state RPS (Wiser et al. 2005). Lenders feared that the utilities would succumb to bankruptcy. The governor’s office, Public Utilities Commission, utilities, and developers eventually worked to enable building in spite of the credit challenges in 2004 (EUW 2004a). However, this was not before the problem led to the cancellation or delay of 270 MW of renewable projects (EUW 2004a). Like other western states, Nevada faces challenges in transmitting its wind power to populated markets. The state has apparently been slow to act on this concern. Nevada’s Renewable Energy Transmission Access Advisory Committee only issued its first report in January 2008 (Howland 2008). In its recommendations, the task force called for the creation of special renewable development zones that have at least moderate renewable resources but close proximity to transmission lines (Howland 2008). The group also advocates the construction of two new transmission lines from Nevada to California (Howland 2008).

Discussion and Limitations

Existing research on the effects of state-level environmental policy has focused on the question of whether these policies are increasing the amount of clean electricity generated. We argue that an equally important research question is whether these policies are reducing carbon emissions. In this paper we have measured the effect of policies on carbon emissions in the electric power sector. To our knowledge, this is the first paper to conduct a multivariate test of the effect of state-level policies on carbon emissions.

We do not find that the mere presence of a policy leads to reductions in carbon emissions. However, we do find that years of experience with a policy, and particularly with renewable portfolio standards, are associated with significant and robust reductions in carbon emissions.

To examine why states might become more successful with RPS over time we then conducted case studies of RPS in five states. We found several common difficulties, such as making the RPS standard too low in the early years, or problems with the electricity transmission system. We also found that what successful states do over time is implement other policies that aid firms in making the switch to alternative energy, such as technical and financial assistance to firms. The policy approach that seems to have worked best at the state level is for the state to mandate a goal, and then begin a process of experimentation with other policies that will allow firms to meet that goal in a way that fits the local setting.

Our study has several limitations. First, although it is clear that interstate flows of electricity are substantial, no data exist on the size of these flows. Thus, we have only been able to conduct an estimation of their effects by including carbon emissions in neighboring states in our models. However, electricity sales may go beyond directly neighboring states, and they will vary in size among states, suggesting that our findings can only be taken as a first approximation. There is a clear need for good data on the size of interstate electricity flows, and further research along these lines may alter our findings.

Second, we have not formally considered the possibility of reverse causation in our model. It is possible that our finding of an association between policy and carbon emissions is the result of a mechanism by which carbon emissions affect policy, rather than vice versa. However, we consider this theoretically improbable, as it envisions a scenario in which a state passes a policy because its carbon emissions are declining. We consider it more likely that states pass renewable electricity policies because their carbon emissions are rising, which means that a technical control for endogeneity in our model should strengthen our results.

Renewable electricity may have benefits other than reduced carbon emissions. For example, renewable electricity may contribute to energy security, rural development, or employment in the environmental sector. These are outcomes that we have not considered. Nevertheless, we argue that it is worth tracking the effect of renewable electricity policies on carbon emissions, as the outcome of controlling carbon emissions is a major goal of the environmental movement. Although our findings have limitations, with this paper we hope to move the attention of the research community onto the question of whether existing environmental policies are actually reducing carbon emissions.

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