An Assessment of the Effectiveness of Renewable Portfolio Standards in the United States

Quantitative analysis of an original data set suggests that RPS reduce state CO_2 emissions, improve state air quality levels, and increase state renewable energy production. Though far from definitive, this study is intended to get the ball rolling on much-needed examination of RPS effectiveness.

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I. Introduction

Within the last few decades, renewable portfolio standards (RPS) have become one of the most commonly adopted climate change policy tools among the states. It is for this reason that numerous scholars have begun to conduct in-depth analyses of RPS (Berry, 1994; Mintrom, 1997; Matisoff, 2008; Wiser and Barbose, 2008; Yi and Feiock, 2012; Carley and Miller, 2012; Heeter and Bird, 2013). However, because of a lack of outcome data on RPS goal completion thus far, there has been no substantial assessment of the overall effectiveness of RPS to date (Carley, 2011; Rabe, 2006, 2008; Yin and Powers, 2010). How to effectively measure the success of a relatively new policy such as RPS is a difficult task, and the research described here will attempt to partially fill this gap.

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One previous attempt at measuring the effectiveness of RPS came from Bushnell et al., who analyzed applicable climate change policies for the state of California (2007). Following their analysis they concluded that, ‘‘. . .RPS may be one of the less efficient means of achieving greenhouse gas emission reductions. . .it does not reward generation from non-renewable sources of low carbon power, and rewards energy conservation only weakly (Bushnell et al., 2007, p. 3).’’ Although Bushnell et al. do not believe that RPS can lower overall greenhouse gas (GHG) emissions, this research intends on testing this prospect to see whether this assertion has any validity. In addition to examining GHG emissions, I will also measure the effectiveness of RPS to increase state renewable energy production, and improve the quality of the air, as suggested by Matisoff (2008).

As mentioned previously, there is well-established extant research on RPS. However, this is one of the first studies to examine the specific outcomes of RPS relative to state GHG emissions, renewable energy production, and air quality. This research intends to provide an assessment of the current progress of RPS states in relation both to one another and to states that have yet to adopt a RPS. More specifically, this study aims to aid both practitioners and scholars in that it will provide a new RPS measurement that will hopefully pinpoint the utility of RPS and whether they should be considered as a viable climate change mitigation policy tool.

In the first section I will analyze the most seminal RPS research to date, with specific consideration of research that has attempted to provide a model of evaluating RPS effectiveness. The following section will present several hypotheses that will evaluate the current direction of RPS states. Next I will review the original dataset and quantitative methodologies employed in this research, and explain the purpose of applying this particular collection of data to RPS research. The fourth section will dictate whether or not state RPS, (1) effectively reduce greenhouse gas emissions, (2) have a ‘‘positive’’ impact on state air quality, and (3) increase renewable energy generation. In the final section I will explore the implications that this research has on the future of RPS adoption.

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II. Renewable Portfolio Standards

As described by Rowlands (2010, p. 184), an RPS is created to ‘‘reserve a portion of the broader electricity market for renewable resources by obliging market participants to ensure that a predetermined share of their total electricity supply is provided by renewable electricity facilities.’’ In other words, RPS are state regulations that call for electric utilities to ensure that a specific percentage of all produced electricity must come from renewable resources. The first RPS was ratified in Iowa in 1983, under a slightly different name, but with the same basic construction. The 1990s really sparked the adoption of RPS, as seven more states enacted RPS of similar variety. Currently there are 30 states, along with the District of Columbia, that have adopted some form of an RPS policy. RPS allow for ample state flexibility including a variation of different target goals and deadlines, market trading mechanisms, and renewable energy types used to comply with the RPS policy. This flexibility makes this particular policy tool especially popular, as evident by the recent exponential increase in RPS adoption. Even though the adoption of RPS is becoming rather common, this policy tool is still relatively new, with few scholarly attempts at ascertaining the results of its implementation. However, there

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has been a substantial amount of research examining RPS adoption, and some attempts to determine its effectiveness, providing a firm foundation that this particular research attempts to builds upon.

Numerous scholars have examined why states choose to adopt RPS (Rabe, 2004; Huang et al., 2007; Matisoff, 2008; Wiser and Barbose, 2008; Lyon and Yin, 2010; Carley and Miller, 2012). Many plausible explanations have been suggested, including state economic development benefit (Rabe, 2004; Matisoff, 2008), regional policy diffusion (Berry, 1994; Mintrom, 1997; Stoutenborough and Beverlin, 2008; Chandler, 2009), as well as legislative and citizen ideology (Huang et al., 2007; Lyon and Yin, 2010; Carley and Miller, 2012). There have also been some attempts at determining the effectiveness of RPS (Rabe, 2006, 2008; Wiser et al., 2004, 2007; Bushnell et al., 2007; Fischer, 2010; Carley, 2011). However, much of the previous assessment has concluded that more data on RPS outcomes is necessary for an accurate measurement of RPS effectiveness. Due to this lack of data, both the policy design features and market context of the RPS have been determined to be the best predictors of success (Yin and Powers, 2010; Carley, 2011). Additionally, Fischer (2010) found that RPS can lower overall energy prices, but it varies depending on the elasticity of the electricity supply from both fossil fuel and renewable energy resources. In sum, although there have been several attempts at ascertaining the effectiveness of RPS, thus far it has yielded small successes and is in need of continued consideration. This particular research intends on providing a small but necessary contribution to this under evaluated area of RPS research.

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III. Research Hypotheses

The following hypotheses are developed and tested in order to provide a deeper understanding of RPS effectiveness. These suppositions should indicate the current direction of RPS so far, whether or not they are achieving their intended goals, and if RPS should be considered a viable climate change mitigation policy tool.

H1. States that have adopted an RPS policy will have lower CO_2 emissions than states that have not adopted an RPS policy.

This hypothesis was generated to test the earlier premise of Bushnell et al. (2007) and to establish whether or not there is obvious reduction in CO_2 emissions among RPS states. If this hypothesis is found to be true, RPS should garner further support as a climate change policy tool that can significantly contribute to curbing the human impact on the environment.

H2. Among the states that have adopted an RPS policy, from the year of RPS adoption through 2011, there will be a decrease in CO_2 emissions.

H3. States that have adopted an RPS policy will have better air quality than states that have not adopted an RPS policy.

H4. Among the states that have adopted an RPS policy, from the year of RPS adoption through 2011, there will be an increase in overall renewable energy production.

Hypotheses 2–4 are direct responses to Matisoff (2008, p. 544) who states that when it comes to RPS research, ‘‘there is the need to quantitatively assess whether these have effects on a state’s air quality, renewable electricity generation, or carbon dioxide emissions.’’ Each of these three hypotheses will address these issues head on, and attempt to further understand whether RPS are effective or simply unrelated to these environmental variables.

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IV. Methodology

A. Data

Since there is no prevailing dataset including the necessary data to conduct this research, an original dataset was developed including 49 states with the only exclusion being the state of Iowa. Iowa was omitted from this analysis because its RPS policy was enacted in 1983, more than a decade prior to any other state, giving it little relevance to this research. Also, if included, much of the longitudinal data utilized in this research would lose some of its necessary accuracy.

Moreover, the core of the data in this research is collected from both the Database of State Incentives for Renewables and Efficiency (DSIRE), funded by the U.S. Department of Energy, and the U.S. Energy Information Administration (EIA). From here I collected data on when, if at all, state RPS are adopted (DSIRE, 2013a), the amount of CO_2 emissions by each state, including commercial, industrial, residential, electric power, and transportation (EIA, 2013a), and longitudinal data regarding the amount of renewable energy generation each state produces (EIA, 2013b). Also included are data on each state's amount of coal, petroleum, and natural gas consumption and production in 2011 (EIA, 2013b). Consumption and production were combined because only using one of these measures leaves the data inaccurate. For example, South Carolina and Florida consume vast amounts of coal and petroleum respectively; however, they do not produce any of that energy in-state. Therefore, if production was the only measure calculated, a large portion of the state's energy usage would not be measured correctly. Lastly, in order to measure air quality, data was collected from the 2012 American Lung Association's *State of the Air* report.

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B. Variables

The two dependent variables analyzed include CO_2 emissions and an ordinal measure of each state's air quality. CO_2 emissions were measured for all 49 states in this study. For states that have adopted an RPS policy CO_2 emission data is calculated from the year of RPS adoption through 2011, the final year of data availability, in order to determine changes in CO_2 emissions. Conversely, for non-RPS states data was calculated from 1997, the first year any state in this research adopted an RPS, through 2011. Then, the mean average of CO_2 emissions over each state's particular time period was calculated and subsequently utilized as the first dependent variable. The possible concern with this variable is the imbalance between how RPS states and non-RPS states are measured. If all the RPS states, like the non-RPS states, were measured equally from 1997 to 2011 there might be some changes in the results, however, if this variable is modified to measure RPS and non-RPS states in the same way, it becomes impossible to gauge whether the actual adoption of an RPS policy has an effect on CO_2 emissions. Utilizing the mean average of the CO_2 emissions should help offset some of the possible skewness concerns this variable could theoretically have.

The air quality dependent variable, as stated previously, came from the 2012 American Lung Association's *State of the Air* report. This report included all 50 states with measurements of particulate pollution by county in each state graded on a scale of A through F. Although there were several states that had some missing county data, this is one of the most concise and easily accessible air quality measurements available, and it is completed by an organization that has been collecting air quality data since 2000. The A through F scale was recoded as a 5 to 1 ordinal scale, with 5 being the best possible air

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quality and 1 being the worst possible air quality. I then was able to calculate each counties corresponding number, find the sum, and lastly determine the mean average of each state's air quality using the same scale.

The independent variables analyzed include whether or not a state adopts an RPS policy, the consumption and production of coal, natural gas, petroleum, and nuclear energy, as well as renewable energy production, measured the same way as CO_2 emissions. The CO_2 emissions dependent variable is also used as an independent variable in one of the regression equations.

C. Analysis

This research employs three separate variations of quantitative analysis: (1) ordinary least squares regression, (2) ordered logistic regression, and (3) quantitative comparison. Using these three types of analysis will provide conclusions that are empirical in nature and offer the opportunity for generalizable findings in the future. Since this analysis is only attempting to determine the statistical outcomes of RPS policies, qualitative analysis is unnecessary for this particular study. Ordinary least squares regression is utilized to determine whether or not the adoption of an RPS policy affects the amount of state GHG emissions, or more specifically CO_2 emissions. Secondly, the ordinal logistic regression is employed to ascertain whether or not the adoption of an RPS policy affects each state's air quality. Lastly, the quantitative comparison component is used to further examine the impacts of RPS adoption on CO_2 emissions and determine if the adoption of an RPS policy in turn prompts an increase in state renewable energy production.

Two other independent variables that were found to be positive predictors of CO_2 emissions are the consumption and production of coal and petroleum.

V. Results

The quantitative findings are represented through both regression and quantitative comparison tables. The four hypotheses presented previously are tested below in the order they were introduced. The outcome of this hypothesis testing will provide strong evidence for or against state RPS adoption, and more specifically, help in determining if RPS adoption is an effective climate change mitigation policy tool that should continue to be implemented in the future.

A. CO_2 emissions

To begin, Hypothesis 1, which posits that states with RPS are likely to have lower CO_2 emission than states without RPS, is tested using ordinary least squares regression. The results of this regression analysis are displayed in **Table 1**. This regression equation supports the premise that states that adopt an RPS policy are more likely to have lower CO_2 emissions than states that do not adopt an RPS policy. However, the *p*-value of RPS adoption is only significant at the 0.1 level and does not reach the 95 percent certainty mark. Despite this result, this regression equation does indicate that CO_2 emissions are at the very least marginally affected by the adoption of an RPS policy. Two other independent variables that were found to be positive predictors of CO_2 emissions are the consumption and production of coal and petroleum. This particular result is expected since coal and petroleum are known to be the largest CO_2 emission producers of most all energy types.

In order to provide more specificity to this initial finding, quantitative comparison of RPS and non-RPS states' actual output of CO_2 emissions is examined. **Table 2** summarizes those findings, and a state-by-state analysis is available in the appendices. As shown in Table 2, there is a wide variation between RPS states and non-RPS states

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Table 1: Ordinary Least Squares Determinants of State CO_2 Emissions

Independent Variables	Coefficient	Sig.
RPS Adoption**	−.10 (.006)	.090
Coal*	.018 (.002)	.000
Petroleum*	.027 (.002)	.000
Natural Gas	.003 (.062)	.956
Nuclear Energy	.005 (.030)	.184

Note: Standard errors are in parentheses. The dependent variable is coded as million metric tons of CO_2.
* $p \leq .05$.
** $p \leq .10$; $X^2 = .000$; $R^2 = .906$; adjusted $R^2 = .896$.

Table 2: Percent Change of CO_2 Emissions and Renewable Energy Production

	Percent Change	
	CO_2 Emissions	Renewable Energy Production
RPS States	−69.6	666.6
Non-RPS States	113.9	128.5

Note: RPS states CO_2 emissions and renewable energy production calculated from year of RPS adoption through 2011. Non-RPS states CO_2 emissions and renewable energy production calculated from 1997 through 2011. Percent change was calculated for each state beginning with the first year of data and mean average of all the years.

relative to CO_2 emissions. States that have adopted an RPS policy display a combined percent decrease of 69.6 percent since the first year of RPS adoption through 2011. This result further strengthens the finding in the regression analysis that revealed the significance of RPS adoption at lowering CO_2 emissions and confirms Hypothesis 2. Conversely, non-RPS states displayed a starkly different CO_2 emission change. Specifically, non-RPS states exhibit a CO_2 emission increase of 113.9 percent from 1997 through 2011. This quantitative comparison demonstrates the effect that RPS states can have on state CO_2 emissions, and furthermore calls into question the premise put forth by Bushnell et al. (2007) that stated that RPS policies were unlikely to affect the level of GHG emissions.

However, a causal relationship between RPS and CO_2 cannot be made in this research due to the vast amount of policy tools at the municipal, state, and federal government level that could play a role in CO_2 emissions reduction. These programs could include the federal Renewable Electricity Production Tax Credit (PTC) that ran from 1992 through 2013 (DSIRE, 2013b), state-level programs such as carbon cap-and-trade policies or demand-side management (DSM) programs. Even municipal policies such as net metering could play an important role in CO_2 reduction. Although direct causality cannot be made regarding RPS and CO_2 emissions, what can be said is that under certain conditions RPS do contribute to reduced CO_2 emissions.

B. State air quality

Using the data collected from the 2012 American Lung Association's *State of the Air* report and ordinal logistic regression, I test Hypothesis 3, which asserts that states with RPS will have better air quality than states without RPS. The results of the ordinal logistic regression are shown in **Table 3**. Of the seven independent variables analyzed in this regression equation, the only variable that meets the 95 percent certainty marker was RPS adoption. In other words, states that have adopted an RPS policy are more likely to have better air quality levels than states that have not adopted an RPS policy. Two other variables were significant at the 90 percent level as predictors of bad air quality. Not surprisingly, they include state coal production and consumption and state CO_2 emissions, both scientifically proven and well known to have a negative impact on air quality levels.

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Table 3: Ordinal Logistic Regression Analysis of Factors Impacting State Air Quality

Independent Variables	Coefficient	Wald Statistic	Sig.
CO_2 Emissions**	−.023 (.014)	2.964	.085
Renewable Energy Production	.032 (.020)	2.550	.110
RPS Adoption*	1.090 (.551)	3.914	.048
Coal**	−.010 (.008)	3.315	.069
Petroleum	−.009 (.006)	2.358	.125
Natural Gas	−.019 (.003)	2.235	.121
Nuclear Energy	−.005 (.045)	2.286	.118

Note: Standard errors in parentheses. The dependent variable is coded from ''1'' to ''5'' with ''1'' being the worst air quality and ''5'' being the best air quality.
* $p \leq .05$.
** $p \leq .10$; $X^2 = .000$; pseudo $R^2 = .27$.

This result provides early support for the adoption of an RPS policy, if in fact the end goal is curbing the negative impacts of human behavior on the environment. As it was with CO_2 emissions, direct causality cannot be asserted due to the wide variety of municipal, state, and federal programs that could also play a role in improved air quality. Nevertheless, as it pertains to this research, for the adoption of an RPS policy to be the only significant variable at the 0.05 level when the other predictor variables included in the analysis were strong GHG-emitting energy sources displays a meaningful relationship between RPS adoption and state air quality that cannot be completely ignored. At the very least, this finding demonstrates that adoption of an RPS policy does has an effect on state air quality levels, even if in future research that effect is revealed to be small.

C. Renewable energy production

Another RPS consideration that has little scholarly attention is whether or not RPS adoption equates a growth in renewable energy production. This conceptual relationship is usually assumed to exist because the essence of a RPS policy is renewable energy production; however, it is important to analyze this relationship and see if our assumptions are indeed accurate. Yin and Powers (2010) found that RPS policies do significantly increase state renewable energy production. This quantitative comparison is only a small extension of their analytically rigorous study, but is still noteworthy and important to consider further.

Looking back at Table 2, it first becomes obvious that states that have adopted an RPS policy, as well as those that have not, both show substantial increases in renewable energy production over the time period examined. However, RPS states have displayed a percent increase of 666.6 percent while non-RPS states have exhibited a combined increase of 128.5 percent. Since the investment in renewable energy has substantially increased over the past few decades all across the United States these results are not surprising. However, the difference between RPS states and non-RPS states is very telling. RPS states have increased their renewable energy production 538.1 percent more than states that have not adopted an RPS policy. This quantitative comparison confirms Hypothesis 4 and the findings of Yin and Powers (2010), albeit through a much less rigorous statistical analysis. A state-by-state analysis of these increases in renewable energy production is available in the appendices.

VI. Concluding Implications and Discussion

Despite ample research regarding RPS policies as a whole, little progress has been made regarding the effectiveness of

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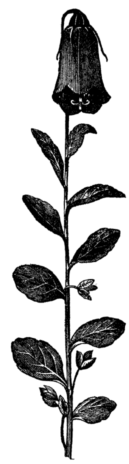
RPS. This research attempted to partially fill in this obvious gap by examining the effectiveness of RPS policies at curbing state CO_2 emissions, improving the quality of air, and increasing state renewable energy production. The quantitative analysis in this research confirmed each of these assertions, and furthermore provided evidence that RPS are a contributor to climate change mitigation. Although this research alone cannot assert that the results found here are generalizable as of yet, future research using similar criteria and analyses could make this ambition become a realization.

Specifically, future research can consider similar longitudinal data with other forms of statistical analysis. Time series regression analysis being the most likely option as more data becomes available and the RPS policies continue forward toward their target dates. Future analyses can also continue to develop and search for other variables that may prove to impact the effectiveness of RPS policies, such as the size of the state electricity market or available funds for RPS implementation. Furthermore, research in the future could attempt to compare RPS policies to other policy tools such as those mentioned previously (e.g. renewable electricity production tax credit, state DSM policies, etc.) to see whether some may have a larger impact on climate change mitigation than others. Although the difficulty of conducting this research is obvious, it would without a doubt be a noteworthy endeavor.



Moreover, since the data examined in this research are ever changing, one cannot assume that the results of this analysis are absolute. Similar research in the future very well might produce starkly different findings compared to the conclusions drawn here. However, the outcomes of this analysis do provide a step, arguably modest, toward further understanding of RPS effectiveness. Continued analysis will undoubtedly aid in broadening our grasp of this still relatively new policy phenomenon.

Since this research is rather original and unique to extant RPS research it cannot provide the broad generalizations that are necessary for this particular policy tool. However, this study does begin the much-neglected examination of RPS effectiveness and progression and hopefully initiates some of this necessary research and discussion. Future research using even more complex statistical analysis should either accept or reject many of these early findings from this study; however, as this research suggests, RPS adoption is a contributor to climate change mitigation, at least more so than what current research and scholarship suggests.

Appendix A. RPS States and CO_2 Emissions

State ID	RPS Adoption Year	Initial CO_2 Emissions	2011 CO_2 Emissions	Mean CO_2 Emissions	Percent Change
Arizona	2001	87.9	91.8	94.1	7.0
California	2002	380.3	345.8	375.3	−1.3
Colorado	2004	92.5	91.2	94.6	2.3
Connecticut	1999	40.3	33.1	38.9	−3.5
Delaware	2005	16.5	11.8	13.9	−15.8
Hawaii	2004	22.5	19.3	21.2	−5.8

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Appendix A (*Continued*)

State ID	RPS Adoption Year	Initial CO_2 Emissions	2011 CO_2 Emissions	Mean CO_2 Emissions	Percent Change
Illinois	2005	240.1	225.3	232.4	−3.2
Kansas	2009	75.1	73.2	74.5	−.8
Maine	1999	20.4	17.2	20.9	2.5
Maryland	2004	81.4	63.7	74.3	−8.7
Massachusetts	1997	84.3	65.8	77.9	−7.6
Michigan	2008	173.2	157.4	164.1	−5.3
Minnesota	1997	91.4	91.3	95.9	4.9
Missouri	2008	135.7	132.9	132.9	−2.1
Montana	2005	35.5	31.7	34.9	−1.7
Nevada	1997	37.9	33.3	41.6	9.8
New Hampshire	2007	18.9	15.9	17.4	−7.9
New Jersey	2001	117.8	110.2	118.4	.5
New Mexico	2002	55.2	56.5	57.4	4.0
New York	2004	209.8	158.2	177.6	−15.3
North Carolina	2007	150.3	122.8	137.2	−8.7
Ohio	2008	260.6	233.4	244.1	−6.3
Oregon	2007	43.3	36.3	40.4	−6.7
Pennsylvania	2004	274.5	244.7	263.3	−4.1
Rhode Island	2004	10.7	10.7	10.8	.9
Texas	1999	698.9	655.5	688.6	−1.5
Washington	2006	75.8	68.9	75.7	−.1
West Virginia	2009	88.8	95.9	94.6	6.5
Wisconsin	1999	104.9	96.2	103.2	−1.6
Total		3724.5	3390	3616.1	−69.6

Note: Initial CO_2 emissions from RPS adoption year and mean CO_2 emissions include all data from RPS adoption year to 2011. Percent change is calculated using the mean and initial CO_2 emissions. CO_2 emissions are measured in million metric tons.

Appendix B. Non-RPS States and CO_2 Emissions

State ID	1997 CO_2 Emissions	2011 CO_2 Emissions	Mean CO_2 Emissions	Percent Change
Alabama	133.2	128.7	135.9	2.0
Alaska	41.9	38.2	42.8	2.1
Arkansas	59.1	66.7	62.2	5.2
Florida	217.8	226.9	239.4	9.9
Georgia	155.8	153.8	166.9	7.1
Idaho	13.7	15.5	15.1	10.2
Indiana	214.9	206.9	224.5	4.5
Kentucky	141.4	147.6	148.2	4.8
Louisiana	237.9	222.7	226.9	−4.6
Mississippi	55.3	59.9	62.6	13.2

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Appendix B (*Continued*)

State ID	1997 CO_2 Emissions	2011 CO_2 Emissions	Mean CO_2 Emissions	Percent Change
Nebraska	40.6	51.7	44.1	8.6
North Dakota	47.1	53.6	50.9	8.1
Oklahoma	98.7	107.1	103.5	4.9
South Carolina	70.2	77.8	80.8	15.1
South Dakota	13.1	14.4	13.7	4.6
Tennessee	120.7	102.8	119.5	−.9
Utah	60.8	63.9	64.5	6.1
Vermont	6.4	5.6	6.3	−1.6
Virginia	108.9	97.3	115.9	6.4
Wyoming	58.6	63.8	63.4	8.2
Total	1896.1	1904.9	1987.1	113.9

Note: Mean CO_2 emissions include all data from 1997 to 2011. Percent change is calculated using the mean and 1997 CO_2 emissions. CO_2 emissions are measured in million metric tons.

Appendix C. RPS States and Renewable Energy Production

State ID	RPS Adoption Year	Initial Renewable Production	2011 Renewable Production	Mean Renewable Production	Percent Change
Arizona	2001	90.7	115.2	87.9	−3.1
California	2002	676.3	837.8	708.5	4.8
Colorado	2004	22.5	101.7	61.5	63.4
Connecticut	1999	49.9	29.9	29.5	−40.9
Delaware	2005	.9	3.8	2.4	166.7
Hawaii	2004	13.9	19.1	15.7	12.9%
Illinois	2005	137.2	276.3	203.5	48.3%
Kansas	2009	91.6	105.1	99.9	9.1%
Maine	1999	159.2	154.3	152.5	−4.2%
Maryland	2004	53.4	56.9	47.4	−11.2%
Massachusetts	1997	72.3	47.8	51.9	−28.2%
Michigan	2008	145.5	144.5	140.5	−3.4%
Minnesota	1997	83.5	303.5	157.7	88.9%
Missouri	2008	81.9	91.7	90.4	10.4%
Montana	2005	113.9	140.1	120.6	5.9%
Nevada	1997	48.3	51.4	42.8	−11.4%
New Hampshire	2007	34.8	42.5	40.9	17.5%
New Jersey	2001	28.9	35.1	26.8	−7.3%
New Mexico	2002	8.7	36.7	25.3	197.6%
New York	2004	358.9	392.3	373.7	4.1%
North Carolina	2007	112.7	144.8	139.7	24.0%
Ohio	2008	107.1	121.7	109.6	2.3%
Oregon	2007	397.2	513.7	426.9	7.5%

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Appendix C (*Continued*)

State ID	RPS Adoption Year	Initial Renewable Production	2011 Renewable Production	Mean Renewable Production	Percent Change
Pennsylvania	2004	110.4	154.9	121.2	9.8%
Rhode Island	2004	3.8	3.4	2.9	−23.7%
Texas	1999	93.9	431.7	195.4	108.1%
Washington	2006	928.3	1051.6	897.6	−3.3%
West Virginia	2009	45.1	44.8	43.9	−2.7%
Wisconsin	1999	114.2	197.1	142.4	24.7%
Total		4185	5649.4	4559	666.6

Note: Initial renewable production from year of RPS adoption and mean renewable production include all data from RPS adoption year to 2011. Percent change is calculated using the mean and initial renewable production. Renewable production is measured in trillion BTUs.

Appendix D. Non-RPS States and Renewable Energy Production

State ID	1997 Renewable Energy Production	2011 Renewable Energy Production	Mean Renewable Energy Production	Percent Change
Alabama	299.7	245.3	266.5	−11.1
Alaska	14.9	15.7	15.2	2.0
Arkansas	124.1	113.5	112.9	−9.0
Florida	232.4	266.7	205.1	−13.3
Georgia	262.5	206.3	220.4	−16.0
Idaho	179.3	180.4	137.5	−23.3
Indiana	45.8	201.7	81.8	78.6
Kentucky	47.9	68.8	57.5	20.0
Louisiana	149.6	109.7	138.9	−7.2
Mississippi	84.3	62.9	61.2	−27.4
Nebraska	62.4	307.5	122.3	96.0
North Dakota	38.5	132.9	46.3	20.3
Oklahoma	55.2	95.6	62.5	13.2
South Carolina	131.9	108.1	100.8	−23.6
South Dakota	95.9	237.8	109.8	14.5
Tennessee	164.1	179.1	155.8	−5.1
Utah	20.4	24.4	15.2	−25.5
Vermont	19.9	30.5	23.9	20.0
Virginia	123.6	102.5	111.2	−10.0
Wyoming	16.4	59.9	22.2	35.4
Total	2169.1	2749.5	2067.1	128.5

Note: Mean renewable energy emissions include all data from 1997 to 2011. Percent change is calculated using the mean and 1997 renewable energy production. Renewable energy production emissions are measured in trillion BTUs.■

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References

Berry, F., 1994. Sizing up state policy innovation research. Policy Stud. J. 22 (3) 442–456.

Bushnell, J., Peterman, C.J., Wolfram, D., 2007. California's Greenhouse Gas Policies: Local Solutions to a Growing Problem? University of California Energy Institute, Berkeley.

Carley, S., Miller, C., 2012. Regulatory stringency and policy drivers: a reassessment of renewable portfolio standards. Policy Stud. J. 40 (4) 730–756.

Carley, S., 2011. The era of state energy policy innovation: a review of policy instruments. Rev. Policy Res. 28 (3) 265–294.

Chandler, J., 2009. Trendy solutions: why do states adopt sustainable energy portfolio standards? Energy Policy 37 (8) 3274–3281.

EIA, 2013a. State CO_2 Emissions, http://www.eai.gov/evironment/emissions/state/state_emis (accessed 15.10.13).

EIA, 2013b. State Profiles and Energy Estimates, http://www.eia.gov/state/ (accessed 20.10.13).

DSIRE, 2013a. Current RPS Data, http://www.dsireusa.org/rpsdata/index.cfm (accessed 04.10.13).

DSIRE, 2013b. Renewable Electricity Production Tax Credit (PTC), http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=US13F (accessed 06.06.14).

Fischer, C., 2010. Renewable portfolio standards: when do they lower energy prices? Energy J. 31 (1) 101–119.

Heeter, J., Bird, L., 2013. Including alternative resources in state renewable portfolio standards: current design and implementation experience. Energy Policy 61, 1388–1399.

Huang, M.-Y., Alavalapati, J.R.R., Carter, D.R., Langholtz, M.H., 2007. Is the choice of renewable portfolio standards random? Energy Policy 35 (11) 5571–5575.

Lyon, T., Yin, H., 2010. Why do states adopt renewable portfolio standards? An empirical investigation. Energy J. 31 (3) 133–157.

Matisoff, D., 2008. The adoption of state climate change policies and renewable portfolio standards: regional diffusion or internal determinants? Rev. Policy Res. 25 (6) 527–546.

Mintrom, M., 1997. Policy entrepreneurs and the diffusion of innovation. Am. J. Polit. Sci. 41 (3) 737–770.

Rabe, B., 2004. Statehouse and Greenhouse: The Emerging Role of U.S. State Renewable Portfolio Standards. The Brookings Institute, Washington, DC.

Rabe, B., 2006. Race to the Top: The Expanding Role of U.S. State Renewable Portfolio Standards. Pew Center on Global Climate Change, Arlington, VA.

Rabe, B., 2008. States on steroids: the intergovernmental odyssey of American climate policy. Rev. Policy Res. 25 (2) 105–128.

Rowlands, I., 2010. Encouraging renewable electricity to promote climate change mitigation. In: Rabe, B. (Ed.), Greenhouse Governance: Addressing Climate Change in America. The Brookings Institute, Washington, DC, pp. 181–203.

Stoutenborough, J., Beverlin, M., 2008. Encouraging pollution-free energy: the diffusion of state net metering polices. Soc. Sci. Quart. 89 (5) 1230–1251.

Wiser, R., Namovicz, C., Gielecki, M., Smith, R., 2007. The experience with renewable portfolio standards in the United States. Electr. J. 20 (4) 8–20.

Wiser, R., Barbose, G., 2008. Renewable Portfolio Standards in the United States: A Status Report with Data through 2007. Lawrence Berkeley National Laboratory, Berkeley, CA.

Wiser, R., Porter, K., Grace, R., 2004. Evaluating Experience with Renewable Portfolio Standards in the United States. Lawrence Berkeley National Laboratory, Berkeley, CA.

Yin, Haitao, Powers, N., 2010. Do state renewable portfolio standards promote in-state renewable generation? Energy Policy 38 (2) 1140–1149.

Yi, H., Feiock, R., 2012. Policy tool interactions and the adoption of state renewable portfolio standards. Rev. 29 (2) 193–206.

This flexibility makes this particular policy tool especially popular.

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