The Power of Renewable Energy: A Comprehensive Analysis of Renewable Portfolio Standards and Their Strengths

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Abstract

The 2018 IPCC report is a sobering reality that the anthropogenic climate change will have vast effects on our world, the science is clear that emissions emitted by humans are responsible for the current climate crisis. In order to mitigate further damage governments must create policy that addresses human emissions which are leading to climate change.

As the U.S. federal government moves away from climate mitigation policy, including abandoning the Paris Agreement, the role of state-level policy tools such as the Renewable Portfolio Standard (RPS) take on increasing importance. RPS are the regulations, which require utilities to increase the percentage of energy they sell from renewable sources by a specified amount and date. They have been adopted in varying forms by about 35 states. For example, New York requires 50 percent of all electricity sold in 2050 to come from solar. Many states have created these standards to 1) diversify their energy resources, 2) promote domestic energy production and 3) encourage economic development. Roughly half of the growth in U.S. renewable energy generation since 2000 can be attributed to state renewable energy requirements. My analysis shows just how critical state energy laws are today, particularly as the Trump administration alters national energy policy. Regardless of the mechanisms used to promote and enact the use of renewable energies my analyses strongly suggest that the state governments are where the action is and will driving the future of our electric grid.

This thesis investigates key factors that have allowed states to implement an RPS and identifies factors that have hindered states from implementing an RPS, describes ways in which states that don't currently can find way to implement one in the future. We discuss the impact RPS's have on renewable generation in states finding that 1) Political ideology has a direct

impact on whether or not a state has adopted an RPS and the strength of that RPS 2) Resource Availability and Fiscal Health of a state do not have a direct correlation to the strength of a states RPS. An RPS is a useful policy mechanism that encourages development of renewable energy. In general, states with RPS policies have seen an increase in the amount of electricity generated from eligible renewable resources. If states aim to improve upon their RPS they can follow the metric that we have laid out. Making the RPSs mandatory, increasing the percentage (over 25%), not including non-renewables, and making the standard state-wide states.

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Preface

In order to combat climate, change it is vital that the U.S steps up to the plate and starts implementing more renewable energy into its energy mix. This thesis hopes to contribute to the understanding of state internal factors that allow states to implement a stronger RPS so that renewable energy implementation would increase due to a better understanding of factors that lead to states having a stronger RPS. This thesis would not have been possible without the help of a few very important people, I'd Like to thank my advisors Dr. Vanderheiden, Dr. Billica, and Dale Miller for their guidance. I'd like to thank my parents for all their support and guidance throughout the years. I'd like to thank Trina Hoffer and Gov. Bill Ritter and the CNEE staff for introducing me to Renewable Energy Legislation and driving my interest in RPS legislation. And I'd like to thank the members of my thesis class for fighting through with me!

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Introduction

Overview

Climate change is one of the most pressing issues facing society today as elevated levels of greenhouse gas emissions are primarily responsible for warming the planet (IPCC, 2018). "John *F. Kennedy once observed that "Our problems are man-made, therefore they may be solved by man."* It is true that for too many years, mankind has been slow to respond to or even recognize the magnitude of the climate threat (Obama, 2009). To start, for the first time in history, all nations were at the table and made commitments to reduce or slow their carbon emissions the Paris climate agreement. This means that developing countries like China and India, who have a legitimate point that developed countries pulled themselves from poverty largely by burning fossil fuels, are committed to slowing the growth of their emissions and developing cleanly. - On June 1, 2017, United States President Donald Trump announced that the U.S. would cease all participation in the 2015 Paris Agreement on climate change mitigation.

Because of the U.S federal government's refusal to address greenhouse gas emissions energy legislation has been left to the states. Among the principle state policies that have been implemented to reduce greenhouse gas emissions while increasing renewable energy, Renewable Portfolio Standards (RPS) have been some of the most impactful and important for the U.S energy sector. Simply put - RPSs are state-level policies that require a proportion of state electrical demand be supplied by specified renewable sources by a specified date. RPSs target utilities and other electricity providers, requiring that they comply with the regulatory mandate; typically including a system of renewable energy credits (RECs) in which renewable energy providers generate one REC for every MWH of renewable electricity produced.

The overarching goal of this thesis is to increase our understanding of renewable energy implementation at the state level. It does so by investigating key factors that lead to implementation of renewable energy, more specifically, Renewable Portfolio Standards (RPS). This study investigates factors such as the fiscal health of the state, political ideology and renewable potential in order to analyze the impact each of these factors has on the implementation of an RPS and the strength of that RPS. This thesis addresses two major questions involving RPS implementation.

1) Is there a correlation between a state's fiscal health, political ideology, and renewable potential on (if a state has an RPS) the strength of RPS?
2) When we know correlations between internal state factors and RPS adoption how can states without an RPS's create and strengthen RPS's?

By utilizing a regression analysis, I will test the hypothesis that; fiscal health, political ideology, and a state's renewable energy potential are strongly correlated to RPS implementation and the strength of that RPS. Over the course of this thesis we will discuss the background and history of renewable energy policies in the U.S and discuss how RPSs have fit into that policy niche. We will review the existing literature on state internal characteristics and how this impacts RPS adoption. I will also identify critical gaps in RSP research in order to fully understand the results of this research. I will outline and explain the variables we used and how they helped us evaluate RPS strengths. We will also discuss in great depth the methods that we used to both collect and analyze these data (e.g. regressions analyses).

The Results will be presented, and we will analyze and discuss how these results address our two overarching research questions.

1) What internal factors lead stronger RPS adoption? And what can states do to improve upon their RPS?

2) Then we will do a case study on two states, Texas and Hawaii in order to gain a better understanding of our internal factors on a states RPS strength.

Background

In the U.S, support for increased renewable energy capacity emerges from concerns about climate change and the other environmental impacts associated with the use of fossil fuels, the necessity for increased energy security, and desires to capitalize on the economic benefits associated with the industry (Palmer & Burtraw, 2005; Upton & Snyder, 2017). Policy makers across the nation have used these issue frames to promote the adoption of policies supportive of renewable energy; and research has demonstrated that government support is key to increased market penetration of renewable resources (Berry et al., 2015). The U.S Federal government has long ignored renewable energy policy preferring to leave it to the states, because of this U.S states have an enormous amount of power and flexibility with which to implement renewable energy policies. While states have a plethora of options like taxes, incentives, or regulatory action, many states are turning to a RPS in order to implement renewable energy. A RPSs goal is to increase the amount of renewable energy a state uses on a yearly basis. Typically, an RPS mandates that at least a subset of a state's utilities or retail electric providers supply an increasing percentage of renewable energy to their customers within a set timeframe. States have created these standards to diversify their energy resources, promote domestic energy production and encourage economic development. Roughly half of the growth in U.S. renewable energy

generation since 2000 can be attributed to state renewable energy requirements (NCSL, 2018). Iowa was the first state to establish an RPS and Hawaii has the most aggressive RPS requirement of 100% renewable by 2045. These requirements can apply only to investor-owned utilities (IOUs), but many states also include municipalities and electric cooperatives. Renewable Portfolio Standards vary drastically between states. Some states have a binding goal connected to their Renewable Portfolio Standard while other states have optional goals, the percentage goals of Renewable Portfolio Standards vary greatly. The impact of an RPS is not always to maximize renewable energy generation, however to show an intention of wanting to improve their energy portfolio.

Policy and Renewable Energy Implementation

The study of Renewable Energy Implementation as long been linked to state policy implementation in the United States, although most countries acknowledge the relationship between the emissions from fossil fuel combustion and climate change the Trump administration has yet to do so. The use of renewable energy is of particular importance in the U.S. because it is the second biggest CO_2 emitter in the world. Electricity generation is the major source of CO_2 emissions in the U.S, accounting for more than one third (EIA) of U.S Carbon Dioxide emissions. The U.S. has long been criticized for its passive responses and efforts to address climate change because of the absence of the national level climate change action and President George W. Bush's rejection of the implementation of Kyoto Protocol. More recently, the Trump administration announced the withdrawal from the Paris Agreement on climate change mitigation, and proposed the repeal of the Clean Power Plan, initially designed for reductions in greenhouse gas emissions from electricity generation plants. Over the past decade states have taken the lead on carbon mitigation and renewable energy development. As the world calls for

solutions to climate change U.S state governments are leading the charge towards a clean energy future.

While states have a plethora of options like taxes, incentives, or regulatory action many states are turning to a Renewable Portfolio Standard (RPS) to implement renewable energy in their respective states. The goal of RPS is to increase the amount of renewable energy a state uses on a yearly basis, it does so by specifying a percentage of renewables in a state's energy mix by a specified date. Most research on RPSs find that the implementation of an RPS accomplishes an increase in renewable energy usage, but there is variability among states. For every year a state has an RPS it's percentage of renewable energy in its energy portfolio increases.

History of Renewable Portfolio Standards

The pursuit of domestic energy production started under President Nixon in the 1970's due to the OPEC embargo. The embargo was a wakeup call for the U.S to pursue energy independence in order to secure energy stability for the future. This interest in energy independence led to an increase in exploration and resulted in pollution and questions about the fossil fuel industry's environmental and climatological impacts. In 1977 President Carter created the Department of Energy (DOE) and the Federal Energy Regulatory Commission (FERC). This marked the first time the U.S government attempted to regulate energy production within the United States. It was not until the presidency of George H.W Bush that there was an increase of research pushing climate change into the U.S political spotlight pushing the Bush administration to sign and ratify the 1992 UN Framework Convention on Climate Change. Climate change mitigation was placed on the backburner through the Clinton administration and into the second Bush (G.W. Bush) administration forcing states to step in and start regulating

Chlorofluorocarbons for the first time while establishing a precedent for state lawmakers to create energy and climate mitigation legislation.

In 1983 Iowa became the first state to pass an RPS, mandating that a portion of Iowa's power must be acquired from renewable energy sources. Then in 1994 Minnesota passed the second RPS starting the trend of states implementing Renewable Energy into the grid. Between 1997 and 2014 a total of 32 states passed RPSs that were either voluntary or mandatory. Because RPSs are created on a state by state basis the attributes of these state policies vary widely. When recognizing that states pass RPS's of varying strengths it's important to not view all RPS's the same (Yin & Powers, 2010). States have varying percentage goals and varying dates from which the RPS ends, as time goes on it's important that states continue to update their RPS in order to continue the improvements that they have made with an RPS. As target dates for many RPSs start to emerge studying the continued adoption and extension of RPSs is important to understanding the landscape of renewable energy portfolios in U.S states. The passing of a RPS is only viable if states continue to extend their ability to improve their energy mix into a more modern and clean energy system continually minimizing emissions.

The Role of States

To date the U.S federal government has not enacted a national renewable energy policy. The U.S government has long ignored renewable energy policy preferring to leave it to the states, because of this, states have an enormous amount of power and flexibility with which implement renewable energy policies.("U.S. Energy Facts - Energy Explained, Your Guide To Understanding Energy - Energy Information Administration," n.d.) The ability of states to customize energy policy that fits their population and energy needs makes state legislators well suited to decide on their own energy policy, while their close relationships with utilities and

utility commissions creates a streamlined efficient policy creator when compared to the Federal Government(Berry, Laird, & Stefes, 2015). By 2015 every state in the U.S had implemented at least on state policy for the increased market penetration of renewable energy.

In the U.S, support for increased renewable energy capacity emerges from concerns about climate change and the other environmental impacts associated with the use of fossil fuels, the need for increased energy security, and desires to capitalize on the economic benefits associated with the industry (Palmer & Burtraw, 2005; Upton & Snyder, 2017). Policy makers across the U.S. have used these issues to frame and promote the adoption of policies supportive of renewable energy. Research has demonstrated that government support is key to increased market penetration of renewable resources (Berry et al., 2015). The U.S Federal government has long ignored renewable energy policy preferring to leave it to the states, because these states have an enormous amount of power and flexibility with which to implement renewable energy policies. While states have a plethora of options like carbon taxes, efficiency incentives, or regulatory action, many states are turning to a Renewable Portfolio Standard (RPS) in order to implement renewable energy. An RPS s goal is to increase the amount of renewable energy a state uses on a yearly basis. Typically, an RPS mandates that at least a subset of a state's utilities or retail electric providers supply an increasing percentage of renewable energy to their customers within a set timeframe. States have created these standards to diversify their energy resources, promote domestic energy production and encourage economic development. Roughly half of the growth in U.S. renewable energy generation since 2000 can be attributed to state renewable energy requirements (NCSL,2018). As stated earlier, Iowa was the first state to establish an RPS, however, Hawaii has the most aggressive RPS requirement of 100% renewable

by 2045. These requirements can apply only to investor-owned utilities (IOUs), but many states also include municipalities and electric cooperatives. RPSs vary drastically between states. Some states have a binding goal connected to their Renewable Portfolio Standard while other states have optional goals. In addition, the percentage goals of RPSs vary from100% (Hawaii's goal) to 2% (South Carolina's goal). The impact of an RPS is not always to maximize renewable energy generation, however to show an intention of wanting to improve

State Energy Legislation

The state governments of the United States have many options when attempting to increase renewable energy penetration into the market. Policy options range from taxes, incentives to Feed In Tariffs (FIT) which are much more common among other countries in the world. Most analysts seem to believe that price-based FIT policies are superior to quantity-based RPS approaches. This general view is shared by the European Energy Commission and many other energy commissions around the world. This conclusion is based in part on experience in the EU, where FIT regimes in, for example, Spain and Germany outperformed the RPS regime in the United Kingdom, although siting problems in the United Kingdom and the success of the RPS policy in Texas suggest that in practice the relationship between FIT and RPS policies is more complex (Schmalensee, 2012). Why then do U.S states prefer an RPS rather than FIT The answer comes down to quantity goals being more appealing than price goals, as might be suggested the constant use of quantity goals used in climate change negotiations around the world. Another possibility is the costs of RPS programs are less visible than the costs of FIT programs, (Schmalensee, 2012), this reality is sobering in the Renewable Energy field. Although

FIT programs are largely considered to be more impactful than an RPS system the benefits of an RPS are undeniable, literature is clear that Renewable Portfolio Standards (RPS) have an impact on increased renewable energy generation (Lyon & Yin, 2010).

RPS Differences

To treat all Renewable Portfolio Standards as equal is to do a disservice to many states. Literature on renewable energy implementation often lumps renewable energy policy together more specifically it treats all Renewable Portfolio Standards as one entity, even when scholars recognize thirty-five separate renewable portfolio standards. While RPS policies all share several key features, they vary dramatically in design across states (Yin & Powers, 2010). In order to be convenient, previous analyses have treated RPS policies as identical or have characterized the differences among them in an overly simplistic manner. Without properly accounting for the differences we see in RPS policies, empirical studies of their effectiveness may result in very misleading conclusions (Carley, 2009; Yin & Powers, 2010). Renewable Portfolio Standards often contain drastically different percentage goals. Hawaii has a goal of 100% while South Carolina has a goal of 10% and yet many scholars do not differentiate between these drastic disparities in strengths of Renewable Portfolio Standards. Percentages and year differential are not the only differences within Renewable Portfolio Standards. Many state-level Renewable Portfolio Standards (RPS) include preferences for solar generation, with goals of increasing the generation diversity, reducing solar costs, and encouraging local solar industries. Depending on

their policy design, these preferences can impact the RPS program costs and emissions reduction (Novacheck & Johnson, 2015). The number of objectives imbedded in an RPS are numerous and growing. Introducing solar policy variations has been one method to broaden an RPS's impact on a variety of objectives, including increasing renewable resource diversity and spurring local solar industry development (Lyon & Yin, 2010; Novacheck & Johnson, 2015).

Review of Literature

Scholars have been studying the adoption of an RPS for at least a decade. Published work has studied the RPS alongside other renewable energy-related policies or in isolation. Findings from these studies echo the findings of studies of clean energy policy adoption. Overall, this research suggests that political ideology, fiscal health and interest group activity are particularly important for explaining the adoption of an RPS. While renewable energy resource availability plays a role as well.

When discussing Renewable Portfolio Standards as a whole the literature is largely based around the effectiveness of an RPS or the lack thereof and the cost associated with implementing a Renewable Portfolio Standard. Scholars assert that an RPS increases the percentage of renewable energy resources in a state's energy mix, (Upton & Snyder, 2017). Literature is also quick to point out the downfalls of an RPS like the rise in electricity price (Palmer & Burtraw, 2005), or the impact that increased renewable penetration has on the oil and gas market in the U.S. (Kydes, 2007).

The studies undertaken to date have made it clear that particular internal state characteristics have an impact on whether or not a state has a Renewable Portfolio Standard, citizen ideology is a major impactor on Renewable Portfolio Standard implementation (Berry, Laird, Carley and Miller 2012), Political climate (Berry, Laird, and Stefes 2015; Carley and

Miller 2012), state wealth and citizen income levels (Berry, Laird, and Stefes 2015; Carley and Miller 2012), and renewable energy or environmental interest groups (Lyon and Yin 2010) are especially important for explaining the adoption of an RPS. Interestingly, in the studies that incorporated the effects of a state's renewable energy potential, typically measured through solar and/or wind potential, findings have been mixed. While some have found positive associations, others have found negative effects (Carley, Nicholson, Crotty, and Miller 2017). Most studies have not found a statistically significant effect related to fossil fuel industry presence.

For political factors associated with state policy adoption, political ideology of state legislatures and governors are often employed to explain the relationship between politics and policy adoption. Historically, blue states are more likely to be favorable to the adoption of policies that are purposed to expand social welfare (Fellowes & Rowe, 2004) or environmental actions (Carley & Miller, 2012) whereas conservative states are more amenable to economic development policy. Liberal state government ideology is expected to have positive correlations with RPS.

Another indicator for policy adoption is state fiscal health, since states with more resources can afford the costs and risks associated with the adoption of new policy. State fiscal health has been consistently positively related to the likelihood of RPS adoption (Jang, 2018). The expansion of renewable energy production is a costly decision that calls for additional investment in electricity infrastructure and bearing of short-term increase in the electricity production costs (Palmer & Burtraw, 2005). In this light, affluent states are more capable of supporting the RPS, and state citizens are more likely to afford the price tag attached to renewable energy production. This is assuming that RPS adoption increases electricity prices in the short run. States with RPS tend to experience the increase in electricity prices for expansion

of renewable energy production, literature is still unsure of the actual impact RPS adoption has on electricity price. Lyon and Yin (2010) did not find statistically significant correlation between electricity price and RPS adoption, whereas (Carley, 2009) and (Berry et al., 2015) found positive influence of electricity prices on RPS adoption. With the nature of often fluctuating energy prices and an ever-changing energy market it is hard to definitively claim what a RPS does to electricity prices.

Renewable energy availability indicates the amount of electricity that can be generated from renewable energy given the amount of wind or solar potential in each state. Studies that looked into the effect of renewable energy sources in each state focused exclusively on solar and wind energies since the majority of renewable energy sources utilized in the U.S. are solar and wind (Lyon & Yin, 2010). Although these past studies use different indicators for renewable energy potentials and exhibit differences across the types of renewable energy potentials that affect the RPS adoption, they still found in common that the potential for renewable energy substantially affect the RPS adoption (Jang, 2018) If a state has an abnormally large amount of wind or solar it is more than likely the state has adopted an RPS. Many times this RPS is less than the current renewable energy mix ("SPOT | The State Policy Opportunity Tracker (SPOT) for Clean Energy," n.d.).

Renewable Energy must be the future of the U.S energy grid in order to mitigate the effects climate change has on the environment. Scholars tend to agree that Renewable Portfolio Standards have a positive effect on renewable market penetration, although many scholars are quick to point out the pitfalls of Renewable Portfolio Standards (Barbose et al., 2016; Wiser et al., 2017). Literature is clear that many factors impact the ability of states to implement a Renewable Portfolio Standards Political Climate, Physical Geography, Resource Availability and

the Fiscal Health are correlated to states with RPS while the lack of the previous make implementing renewable energy legislation very difficult (Jang, 2018). The varying strengths of Renewable Portfolio Standards are another problem with RPS literature, and the ability to differentiate between Renewable Portfolio Standards is important and often not accounted for in literature. Literature agrees however that Renewable Portfolio Standards have a positive impact on renewable generation and the ability of the U.S to implement renewables is vital to the planet's health. So how can more states begin to implement more renewable energy legislation? And how can states without a Renewable Portfolio Standard begin to implement one?

Methodology

States have a variety of options when it comes to implementing renewable energy through the legislative process in order to add renewable energy onto the states grid. The RPS was chosen specifically for this study for a few reasons. First, an RPS provides a clear statement that a state is trying to implement renewable energy in a very public way. When an RPS sets a date and percentage of renewables for utilities it is publicly holding utilities to a higher standard when answering not only to regulatory bodies but to the public from which they sell their energy. Second, an RPS is a straightforward policy that creates change in energy production and penalizes utilities for not meeting these goals, quite frankly, RPSs work. RPSs provide basic policies that are easy to understand both for the general public and for the utilities who must implement these changes to their energy mix. Third, because an RPS is politically significant and economically viable, it represents a greater trend in the energy sector moving away from fossil fuels and into a clean energy future. Throughout the formulation of this thesis a comprehensive

analysis of states energy legislation and energy mix was compiled in order to better understand why states did or did not transition to renewable energy.

By evaluating political ideology, state fiscal health and relative renewable potential, I hope to create a better understanding of the variety of RPSs that exist across the U.S. This study aims to contribute to our understanding of the implementation of RPSs and strives to find answers as to what state internal factors lead to the implementation and strength of RPS.

In order to best understand the reasoning for implementing an RPS it is important to first look at the impacts that RPSs have on individual states. With the implementation of RPSs there were both internal and external factors that led to the passing of RPSs in individual states. The same factors came up repeatedly in the literature that I reviewed and often times led to the direct passing or or failure of an RPS implementation. By evaluating these factors, we can gain insights that lead to implementation of an RPS in states like Florida that has the potential but not a standard. Data sources used in this work included primary sources like legislative and administrative research reports and other documents, transcriptions of administrative hearings and official speeches, executive branch announcements, election campaign-related materials, and legislation. Secondary sources included news stories, interest group publications, and academic articles. Using regressions in *RStudio* I will examine correlations between these states implementing a stronger RPS.

Key Variables Used

Political Ideology

Legislators, on the state and federal levels, are elected to act in the best interests of their citizens when making decisions. While this thesis recognizes interest group activity often plays a role in the legislature process the majority of citizens do not make significant contributions to campaigns, a citizen's primary in the legislative process is through voting. Because voting citizens have such a large impact when looking at political variables that cause the adoption of policy, it is important to examine the influence that voting citizens have over policy decisions. Politicians must answer to the interests of the people or they will not become re-elected. This means that when the public takes a strong stance on an issue, lawmakers generally vote accordingly. This implies that when public opinion shifts towards greater support for increasing renewable energy in a state, like through a RPS, it is expected that the state will respond and adopt this type of policy (Fellowes & Rowe, 2004). It is thought that states with a more liberal ideology pertaining to renewable energy will most likely have an RPS while states that are considered more of a red state will be less likely to adopt an RPS.

Fiscal Health of a State

Renewable energy implementation is often linked to a significant investment for the first few years of implementation, often with gains to be made many years down the time line. Often when implementing renewable energy there is a period of job transition between fossil fuel industries and renewable energy industries. The initial investment into a long-term process of renewable energy development is seen as too great a risk for states whose job market is based on fossil fuels. A thriving job market and low unemployment is an indicator of a state's fiscal health and is often a calling card for legislatures looking to flaunt their abilities when campaigning. Because of this, the job market is a driving force behind many policy decisions that state

legislatures make. Adoption of an RPS is often viewed as a risk for the job market, there are two possible scenarios when a state implements an RPS. The first one is a state adds a significant amount of jobs due to jobs being created in the renewable energy field (Young & Bistline, 2018) Contrary to the former, if a state has a significant amount of jobs in the fossil fuel industry, they might be less likely to implement an RPS due to the loss in jobs that might occur. This makes unemployment and there for the fiscal health of a state an important indicator of whether or not a state will pass an RPS.

Renewable Energy Potential

Regardless of political ideology or the fiscal health of a state the likelihood a state adopts a stronger RPS should be a function of the amount of renewable energy a state has within its borders. The three largest renewable energy resources around the U.S are solar power, wind power, and hydroelectric power these three titans of renewable energy were responsible for fifty two percent of the total U.S renewable energy mix in 2017 while forty five percent of that was different biofuels in which we are not investigating in this thesis. Agencies like the National Renewable Energy Laboratory and the U.S Energy Information Administration keep records on the both the quantity of renewables in each state while also quantifying the possibilities states have for implementing renewables. Insight tells us that states with a larger amount of renewable energy potential would be more likely to implement renewables into the electric grid while passing more legislation related to renewable energy implementation leading to a positive correlation with a strong RPS.

Statistical Analysis

I used basic linear regressions to identify state internal factors that have a significant effect on the strength of a states RPS. In addition, in order to analyze these affects I first need to find a way from which to rank and quantify RPS strengths. The RPS strength is vitally important when analyzing the implementation of an RPS due to the drastic discrepancies between different states RPSs. In this thesis I will run multiple regressions under the three umbrellas of states fiscal health, political ideology, and renewable energy potential. In the past other researchers have studied used these variables (factors) in relation to RPS adoption on a binary of either the state did or did not implement an RPS with varying success and results. In order to create these regressions, I had to come up with a way to numerically categorize RPS legislation and to give each RPS a numerical value based off the strength of the legislation. I was then be able to run regressions that were not simply binary but had multiple layers to the strength of each RPS giving us a more accurate idea of the affect fiscal health, political ideology, and renewable potential had on the strength of an RPS.

Assigning Strength Categories

The first thing I did when assigning strengths of an RPS was to identify which factors in an RPS make the legislation a more powerful standard. The goal was to find discrepancies in RPS legislation and decide which side of these discrepancies created a stronger vs. weaker RPS while setting baselines along the way. Throughout the process of searching through RPS legislation I was able to identify five major stepping stones in RPS legislation that created a stronger RPS. The Center of the New Energy Economy (2018) identifies the same five metrics to rank RPS strengths with some minor differences. The five metrics that were used to judge an RPSs strength are as follows: 1) presence or absence of an RPS, 2) is it a mandatory RPS, 3) is it over 25% , 4) does it exclude non renewables, and 5) is it state wide.

. By utilizing a detailed ranking system, we are able to judge state internal factors in much greater detail than was previously done. The first metric seems obvious as to whether a state has an RPS or not (presence vs absence). The second metric we used when ranking RPS legislation was if the RPS was mandatory or not mandatory. A non-mandatory RPS is a suggestion that utilities in the state aim for a percentage goal by a certain date a mandatory RPS is largely considered to be a much stronger statement of renewable implementation than a non-mandatory RPS. Our ranking system awards a point to states that have a mandatory RPS instead of an optional one. If a state does not have a mandatory RPS they can still be ranked higher if they fulfill the requirements for other categories like greater than 25% or excluding non-renewables. The third metric that we are testing is if the state has an RPS of over 25%. States with an RPS over 25% often have very lofty goals for the future of their energy mix like Hawaii who is aiming for 100%, while states under the 25% often are drastically under the mark and many times have optional portfolio standards. The 25% mark was chosen because it lies in the middle of the averages for RPS legislation, the Center for the New Energy Economy cuts the metric off at 20%. . The fourth metric I used in my ranking system was if the RPS legislation excluded non renewables from the RPS. A states RPS is often a sign that the state is trying to move towards a cleaner energy future however some like Indiana include energy resources like "clean coal" in their renewable standards. We do not consider "clean coal" to be a renewable energy so for this metric they will get a zero while states with only renewables in their standard will get a one. The fifth metric for analyzing the strength of a states RPS Is if the standard is state wide. It is common it RPS legislation to omit certain utilities from having to follow the standard, or not including certain counties in the RPS adoption. For our metric system we will award a

point to a state that has a state wide RPS and give a zero to a state that does not require all utilities to participate in the program.

Table 1. Metric used to rank strength of RPS (CNEE, 2018)

Ranking Metric	**Yes**	**No**
Does the state have an RPS?	1	0
Is the RPS Mandatory?	1	0
Is the RPS > 25%?	1	0
Does the RPS exclude non-renewables?	1	0
Is the RPS state wide?	1	0

Results

Political Ideology

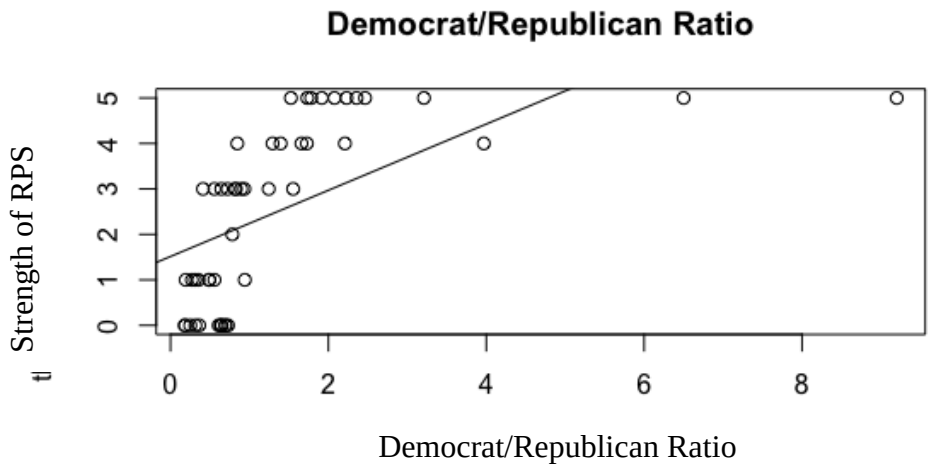

Figure 2. Regression analysis RPS strength versus ratio of democrats to republicans per state.

Table 2

	Estimate	Std. Error	T Value	P Value
Intercept	1.5141	0.2945	5.142	5.2e-06***
Ratio of D/R	0.7279	0.1404	5.184	4.5e-06 ***

Renewable Potential

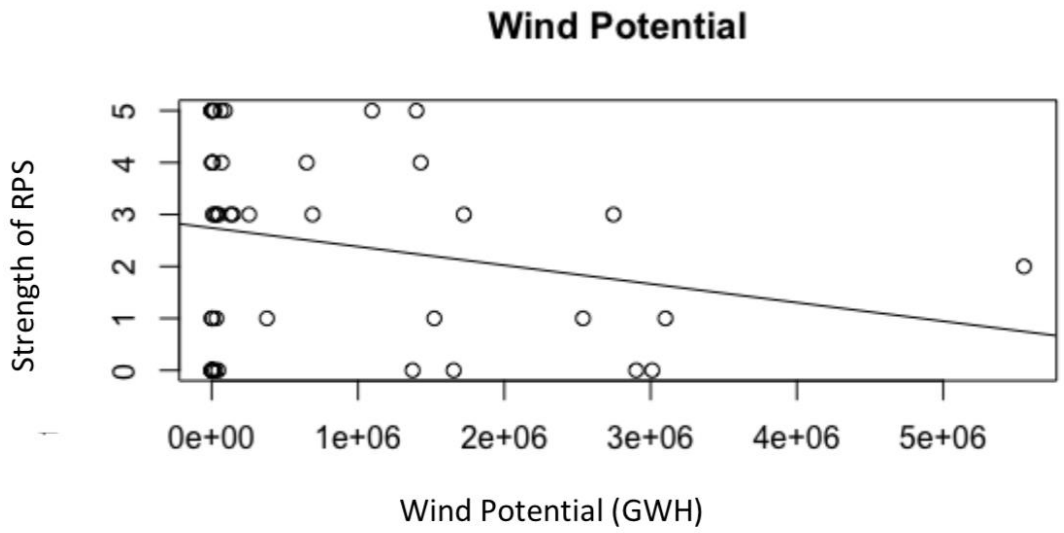

Figure 3. Regression analysis RPS strength versus wind potential of each state.

Table 3

	Estimate	Std. Error	T Value	P Value
Intercept	2.741	3.111e-1	8.811	1.13e-11***
Wind Potential	-3.599e-07	2.366e-07	-1.521	0.135

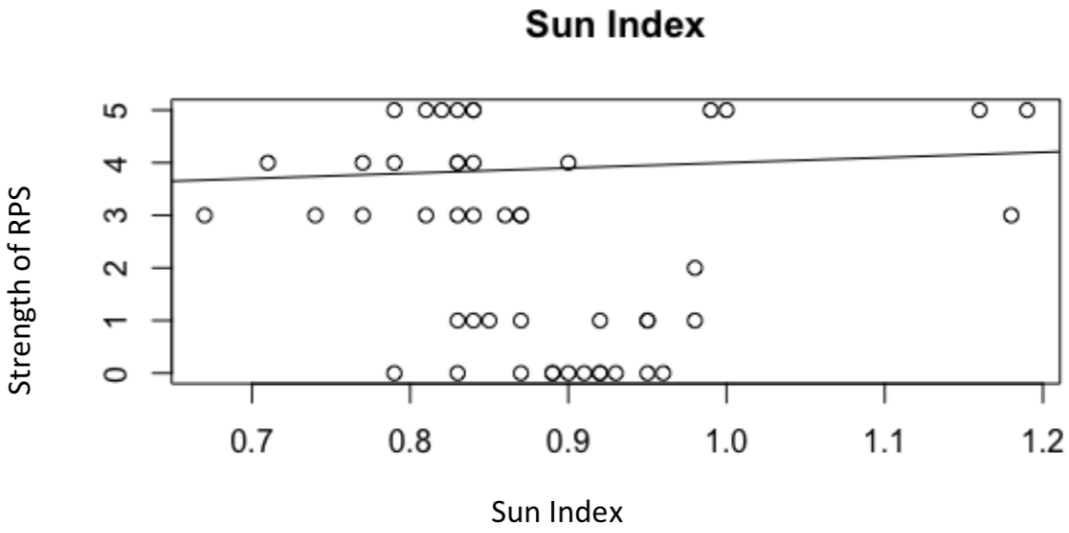

Figure 4. Regression analysis RPS strength versus the Sun Index of each state.

Table 4

	Estimate	Std. Error	T Value	P Value
Intercept	3.000	1.786	1.769	0.106
Sun Index	1.000	02.526	0.396	0.696

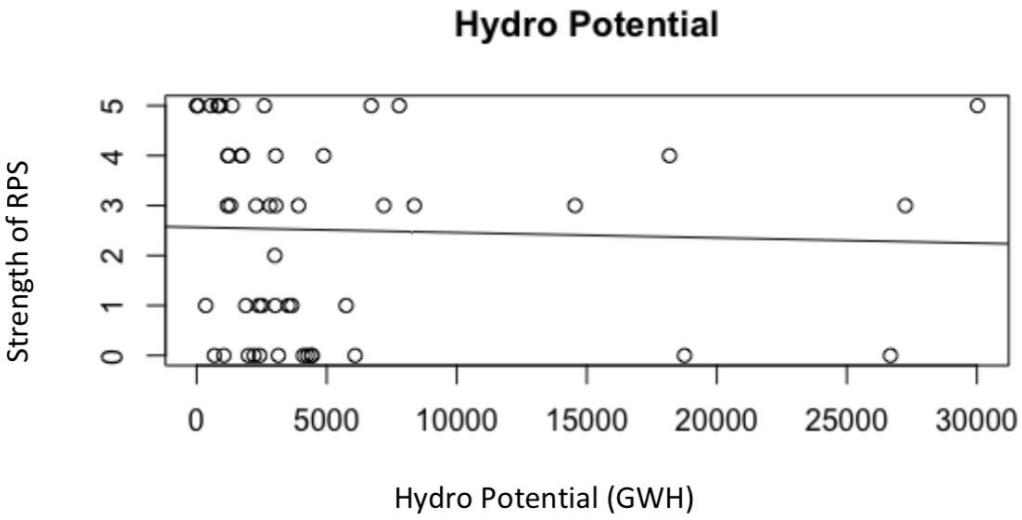

Figure 5. Regression analysis RPS strength versus hydro potential of each state.

Table 5

	Estimate	Std. Error	T Value	P Value
Intercept	2.56	3.452e-1	7.427	1.45e-9***
Sun Index	-1.062e-5	3.999e-5	0.265	0.792

Fiscal Health

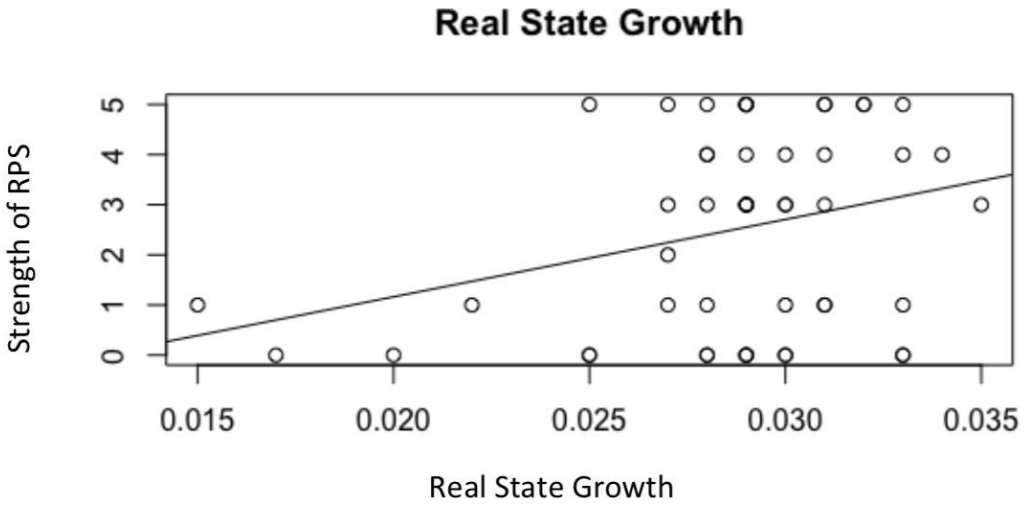

Figure 6. Regression analysis RPS strength vs. real state growth of each state.

Table 6

	Estimate	Std. Error	T Value	P Value
Intercept	-1.926	2.034	-0.947	0.3484
Sun Index	154.426	70.216	2.199	0.0326*

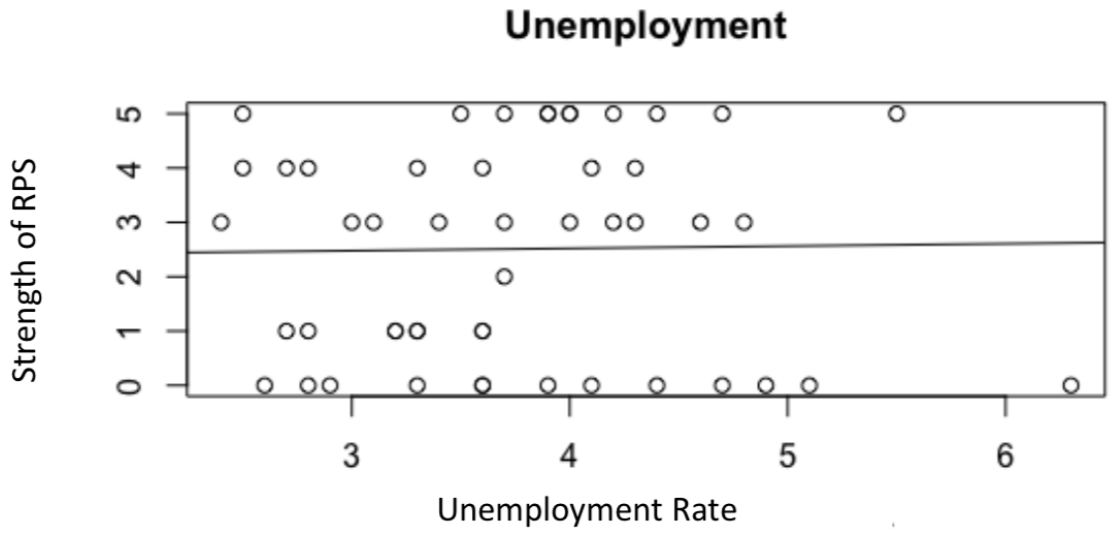

Figure 7. Regression analysis RPS strength versus unemployment rate of each state.

Table 7

	Estimate	Std. Error	T Value	P Value
Intercept	2.34925	1.3136	1.788	0.0799
Sun Index	0.04296	0.34354	0.125	0.9010

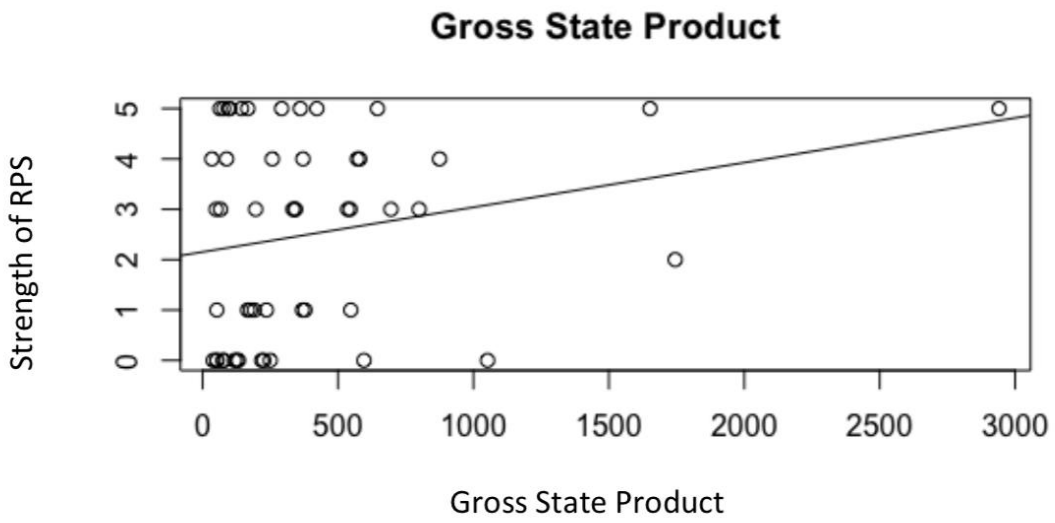

Figure 8. Regression analysis RPS strength versus gross state product.

Table 8

	Estimate	Std. Error	T Value	P Value
Intercept	2.15279	0.344297	6.253	9.53e-08***
Sun Index	0.0008847	0.0005307	1.672	0.101

Analysis and Discussion

Political Ideology

To test the hypothesis that a state's political ideology would have a significant impact on the strength of a states I utilized RPS data that was collected by the National Conference of State Legislators. To test political Ideology at the state level we created a ratio of democrats over republicans from the number of representatives in each states house. The ratio allows us to standardize the variable without regard to the variability in the numbers of legislatures per state. Many states had a number of independent legislators whom we omitted when creating the ratio of democrats over republicans, independents have an impact on the voting of RPS legislation; however, due to the nature of political ideology as a variable in our experiment it simpler to ignore them in this analysis.

The tests that were run show strong support for the hypothesis that political ideology is an indicator of strength of a states RPS. The independent variable in this case is the political ideology while the dependent variable is the strength of each states RPS. These data indicate that the higher ratio of democrats to republicans were more strongly correlated to a stronger RPS. The ratio of democrats to republicans was found to have a strong significance with a P value of 5.2e-06 (table 2). Our regression outputs explain the for every unit increase in the ratio between democrats and republicans we would expect to see a 0.72 increase in the strength of a states RPS, the P value of 5.2e06 means there is a high certainty of direct correlation between democratic political ideology and a stronger RPS score.

Renewable Potential

Our prediction that renewable energy potential was correlated with a stronger RPS was based on the assumption that it would be easier for states with a greater renewable potential to adapt to a stronger RPS as opposed to than a state with less renewable potential. We assumed and it seemed reasonable that a larger renewable energy potential would be compatible with a stronger RPS, however, our regressions analysis found just the opposite. When looking at the potential energy for Solar (sun index), Wind , and Hydroelectric the regressions that we conducted did not support our initial hypothesis that states with a greater potential for renewable energy would have in general a stronger RPS score. We found that all three variables (e.g. hydropotential, wind and solar) were not statistically significant.

In order to best test the effect renewable potential had on the strength of an RPS I was able to gather all of my data involving renewable potential through the National Renewable Energy Laboratory (NREL). NREL has extensive resources for the amount of renewable potential unique to each state.

The sun index is the amount of direct sunlight received in each state and accounts for latitude and cloud cover of each state, the sun index sets California as the baseline with a numerical value of one and continues up or down respectively from that baseline. With the sun index as our independent variable and the strength of a states RPS as the dependent variable we find that a state's solar potential has no correlation to the strength of a states RPS. Our regression indicates that there is a slight positive correlation between a high solar potential and a stronger RPS. The sun index ranges from 0.7 to 1.79 and the slope our best fit line calculates to a one-

point increase in the RPS score for everyone unit counted in the solar index. Because the range of the solar index is so small our P score of 0.69 is not significant. Basically, the slope of our graph is not informative in our regression analysis and we may suggest that that solar potential in the U.S does not strongly impact the strength of a states RPS.

The National Renewable Energy Laboratory calculates the amount of total estimated technical potential for hydropower by state, they do so utilizing GIS data collection calculating the Giga Watt Hours (GWH) of potential energy that each state possesses. The data collected from NREL for potential hydro power has a range from less than 1GWH to 27,249GWH the regression produces a P value that is not significant. The graph of our regression has a slope of -0.000001062, this decrease in RPS strength per MWH of hydropotential is a small and insignificant change which does not show a correlation between RPS strength and hydropotential.

The final variable under renewable potential is wind potential, NREL keeps track of both offshore and onshore wind potential for all states and separates them into independent categories. Because offshore wind is not applicable for all U.S states and is considered a completely different entity than the wind power sector of the U.S we omitted the offshore wind data from our regressions. Similar to the hydrothermal data collected by NREL the wind potential is calculated in GWH and has a range of 0 GWH to 5.5 million GWH. The regression results show a negative correlation between Giga Watt Hours and RPS strength, the value of -3.599e-07 is significant however the P value is not significant, so we reject this regressions results.

Fiscal Health

Renewable energy adoption by states comes with a large investment form the state and its utilities followed by an extended period of savings after the initial investment. Our hypothesis predicts that because of this initial investment states that are fiscally healthier will be more likely to have a stronger RPS. In other words, there will be a positive relationship between RPS strength and state fiscal health. Because there are no existing consistent rankings for state fiscal health, we chose three indicators of fiscal health and gathered data these indicators were real state growth, gross state product, and the unemployment rate of each state. Our hypothesis asserts that states with a greater state growth, gross state product, and a lower unemployment would have a higher RPS score than their counter parts. Our regressions showed that this was the case for real state growth and gross state product. We found a value of no significance when testing for unemployment.

Data for real state growth was obtained from the Bureau of Economic Analysis out of the U.S department of Commerce. Real state growth indicates the percentage rate at which GDP of a state grows in a ten-year period, for this data set it's from 2009-2019. Our hypothesis states that states with a higher real state growth will due to ability to invest in new technology will have a higher RPS score than that of states with a smaller or negative growth rate. Our testing supports our hypothesis in this instance with a positive correlation, however our P value is not significant

meaning that we cannot reject our null hypothesis that real state growth has no impact on RPS strength

Our second variable to measure state fiscal health is gross state product our data was obtained again from the Bureau of Economic Analysis. The gross state product is identical to the gross domestic product of a state, which is a measure of the market value of goods and services produced by the state in a year time period. Our hypothesis states that a higher gross state product would lead to a higher RPS score which is exactly what the slope of our line indicates. However again like real state growth the P value of 0.1 is an indicator of no confidence and therefor again we cannot reject the null hypothesis.

The final variable we looked at in order to test fiscal health as an indicator of RPS strength is the unemployment percent of each state our test considered a lower unemployment number to a state was more fiscally healthy. Our hypothesis stated that because renewable energy is a risk for many states when it comes to a job market that is dependent on fossil fuels that states with low unemployment would be less likely to implement renewable energies even though renewables could help them in the long run. Our regressions showed that there was no correlation between RPS strength and the unemployment rate of a state. These results are insignificant because they show no correlation between RPS strength and unemployment of a state.

Conclusion

Future Implications

Our study tests the hypothesis that political ideology, state fiscal health, and a renewable potential have a direct correlation on the strength of a states RPS. We tested one variable for political ideology, three variables for fiscal health, and three variables for renewable potential. After testing seven variables total the only one that came back significant was the political ideology variable that took the ration of democrats to republicans in the house or representatives of each state. The positive correlation between a higher ratio of democrats to republicans and a stronger RPS show that the political ideology portion of our hypothesis was correct. Fiscal health and renewable potential were identified as not significant over the course of our study. This answers our first research question; what state internal factors correlate to a stronger RPS? Knowing the results of our first research question we can then begin to analyze our second research question. When we know correlations between internal state factors and RPS adoption how can states without an RPS's create and strengthen RPS's? By creating a metric to rank RPS strengths we have also created a blueprint for states to improve upon their RPS. If states aim to improve upon their RPS they can follow the metric that we have laid out in figure one. By making RPSs mandatory, increasing the percentage (over 25%), not including non-renewables, and making the standard state wide. Every state could improve upon these actions and create a stronger RPS and a better renewable energy economy in their state.

Given the strong evidence that RPS strength is correlated to a democratic political ideology by looking at legislatures that have a high ratio of D/R we can start to identify states that should could a stronger RPS in the future. Virginia is an outlier in our data set with D/R

ratios that are more conducive to a stronger RPS score. Virginia has a D/R ratio of 0.94 which is close to the average D/R ratio of 1.3, however Virginia has an RPS score of one which is well under the average of 2.5. Our findings would assert that is reasonable to see an increase in the RPS of Virginia in the near future. Another outlier that we found within our data was West Virginia, however as of 2015 they repealed their RPS meaning the improvement we could see in Virginias RPS may not be feasible for West Virginia.

Limitations

This study was as thorough and accurate as possible given the time and resources provided. The data collected for fiscal health and renewable potential were as reliable as could be due to the obtaining the data from federal entities. Political ideology on the other hand is difficult to measure perfectly because there is not a magical number that tells the whole story for every person in each state. Ideally this study would have been more significant if we would have had the ability to give a survey involving political ideology in each state that was in our data set. This way Nebraska who has a non-partisan legislator would have been included in our regressions for political ideology. Instead the study used legislators in the house of representatives for each state. While people elect these representatives, their actions do not perfectly align with the beliefs of all their constituents. This strategy also excludes the influence the Governor, has on policy decisions and voting in a state like Maine that has been trying to pass RPS legislation for many years now with no success due to the Governor continually vetoing renewable legislation. Given more time and resources this study could have tested many more independent variables and created better data for political ideology, however this experiment is still successful in testing the

variables that it tested with the most accuracy possible. The results of this study should still be considered valid within the scope of the experiment.

Final thoughts

Government action on climate change began in the 1970s under the Carter administration however it wasn't until the early 1990's that state governments started to pass legislation relating to climate change mitigation. While states have continued to pass legislation limiting carbon emissions and attempting to mitigate our globe warming one of the most important tools has been the RPS. An RPS is a requirement for a set percentage of a state's energy portfolio to be produced from renewable sources by a specified date. There is debate over the relative effectiveness of these standards however there is little debate as to the positive impact these standards have. An RPSs impact is well past that of regulation it represents; the increasing concern and action being taken at the state level to overcome federal inaction in addressing climate change. States from all over the country are adopting these standards of varying strength despite political and economic obstacles. This study attempted to find what state internal factors affect the relative strength of each states RPS. Among the variables tested in this study, the only one that was correlated to adoption of a stronger RPS was political ideology. The other factors tested, renewable energy potential, and a state's fiscal health did not corelate to the strength of a states RPS. Thirty-five states and the District of Columbia have RPS legislation however there is still much more to be done in the future to both improve existing policies and to see more states adopt RPS legislation. Climate change is an issue that affects everyone; this study shows that climate

change mitigation is very much a partisan issue and in order for improvement to be made this needs to change.

Appendix

R Code

```
thesis_data <- read_excel("Desktop/Thesis/RPS Data Thesis .xlsx")

plot(thesis_data$`Real State Growth`,thesis_data$`RPS Strength`)
abline(lm(thesis_data$`RPS Strength`~thesis_data$`Real State Growth`))
title(main = "Real State Growth ")


reg1<-lm(thesis_data$`RPS Strength`~thesis_data$`Real State Growth`)
summary(reg1)
```

Regression Statistics

Political Ideology
Ratio of D/R
Call:

lm(formula = thesis_data$`RPS Strength` ~ thesis_data$`Ratio D/R`)

Residuals:
```
   Min     1Q Median     3Q    Max
-3.211 -1.645  0.355  1.229  2.376
```

Coefficients:
```
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)           1.5141     0.2945   5.142  5.2e-06 ***
thesis_data$`Ratio D/R`   0.7279     0.1404   5.184  4.5e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Renewable Potential

Wind Potential
Figure 3- Wind Potential
Call:
lm(formula = thesis_data$`RPS Strength` ~ thesis_data$`Wind Potential (GWH)`)

Residuals:
```
   Min     1Q  Median     3Q     Max
-2.7411 -1.7402  0.3053  1.6328  2.7624
```

Coefficients:
```
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                  2.741e+00  3.111e-01   8.811 1.13e-11 ***
thesis_data$`Wind Potential (GWH)` -3.599e-07  2.366e-07  -1.521    0.135
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Sun Index

all:
lm(formula = thesis_data$`RPS Strength` ~ thesis_data$`Sun Index`)

Residuals:
```
   Min     1Q  Median     3Q     Max
-3.3333 -0.4167  0.0000  0.8333  2.1667
```

Coefficients:
```
                    Estimate Std. Error t value Pr(>|t|)
```

(Intercept)	3.000e+00	1.786e+00	1.679	0.106
thesis_data$`Sun Index`0.71	**1.000e+00**	**2.526e+00**	**0.396**	**0.696**
thesis_data$`Sun Index`0.74	3.196e-15	2.526e+00	0.000	1.000
thesis_data$`Sun Index`0.77	5.000e-01	2.188e+00	0.229	0.821
thesis_data$`Sun Index`0.79	2.178e-15	2.063e+00	0.000	1.000
thesis_data$`Sun Index`0.81	1.000e+00	2.188e+00	0.457	0.652
thesis_data$`Sun Index`0.82	2.000e+00	2.526e+00	0.792	0.436
thesis_data$`Sun Index`0.83	-1.667e-01	1.930e+00	-0.086	0.932
thesis_data$`Sun Index`0.84	6.000e-01	1.957e+00	0.307	0.762
thesis_data$`Sun Index`0.85	-2.000e+00	2.526e+00	-0.792	0.436
thesis_data$`Sun Index`0.86	3.700e-15	2.526e+00	0.000	1.000
thesis_data$`Sun Index`0.87	-1.250e+00	1.997e+00	-0.626	0.537
thesis_data$`Sun Index`0.89	-3.000e+00	2.188e+00	-1.371	0.183
thesis_data$`Sun Index`0.9	-1.000e+00	2.188e+00	-0.457	0.652
thesis_data$`Sun Index`0.91	-3.000e+00	2.526e+00	-1.187	0.246
thesis_data$`Sun Index`0.92	-2.667e+00	2.063e+00	-1.293	0.208
thesis_data$`Sun Index`0.93	-3.000e+00	2.526e+00	-1.187	0.246
thesis_data$`Sun Index`0.95	-2.333e+00	2.063e+00	-1.131	0.269
thesis_data$`Sun Index`0.96	-3.000e+00	2.526e+00	-1.187	0.246
thesis_data$`Sun Index`0.98	-1.500e+00	2.188e+00	-0.686	0.499
thesis_data$`Sun Index`0.99	2.000e+00	2.526e+00	0.792	0.436
thesis_data$`Sun Index`1	2.000e+00	2.526e+00	0.792	0.436
thesis_data$`Sun Index`1.159	2.000e+00	2.526e+00	0.792	0.436
thesis_data$`Sun Index`1.18	3.405e-15	2.526e+00	0.000	1.000
thesis_data$`Sun Index`1.19	2.000e+00	2.526e+00	0.792	0.436
thesis_data$`Sun Index`N/A	3.333e-01	2.063e+00	0.162	0.873

Hydro Potential

Call:
lm(formula = thesis_data$`RPS Strength` ~ thesis_data$`Hydero Potential GWH`)

Residuals:
```
    Min      1Q  Median      3Q     Max
-2.5571 -1.9209  0.4656  1.5581  2.7544
```

Coefficients:
```
                                Estimate Std. Error t value Pr(>|t|)
(Intercept)                     2.564e+00  3.453e-01   7.427 1.45e-09 ***
thesis_data$`Hydero Potential GWH` -1.062e-05  3.999e-05  -0.265    0.792
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
Residual standard error: 1.982 on 49 degrees of freedom
Multiple R-squared:  0.001436,         Adjusted R-squared:  -0.01894
F-statistic: 0.07047 on 1 and 49 DF,  p-value: 0.7918
```

Fiscal Health

Real State Growth

```
Call:
lm(formula = thesis_data$`RPS Strength` ~ thesis_data$`Real State Growth`)

Residuals:
   Min     1Q  Median     3Q    Max
-3.1699 -1.8610  0.4478  1.6022  3.0655

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                   -1.926      2.034  -0.947   0.3484
thesis_data$`Real State Growth`  154.426     70.216   2.199   0.0326 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.892 on 49 degrees of freedom
Multiple R-squared:  0.08984,         Adjusted R-squared:  0.07127
F-statistic: 4.837 on 1 and 49 DF,  p-value: 0.03261
```

Unemployment

```
Call:
lm(formula = thesis_data$`RPS Strength` ~ thesis_data$`Unemployment Rate`)

Residuals:
   Min     1Q  Median     3Q    Max
-2.6199 -1.9824  0.4703  1.5391  2.5434

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                  2.34925    1.31358   1.788   0.0799 .
thesis_data$`Unemployment Rate`  0.04296    0.34354   0.125   0.9010
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.983 on 49 degrees of freedom
Multiple R-squared:  0.000319,         Adjusted R-squared:  -0.02008
F-statistic: 0.01564 on 1 and 49 DF, p-value: 0.901
```

Gross State Product
Call:
lm(formula = thesis_data$`RPS Strength` ~ thesis_data$`Gross State Product`)

Residuals:
    Min   1Q Median   3Q   Max
-3.0865 -1.9444 0.3638 1.5687 2.7904

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)
(Intercept)   2.1527919 0.3442977   6.253 9.53e-08 ***
thesis_data$`Gross State Product` 0.0008874 0.0005307   1.672   0.101

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.929 on 49 degrees of freedom
Multiple R-squared: 0.05399,	Adjusted R-squared: 0.03469
F-statistic: 2.797 on 1 and 49 DF, p-value: 0.1008

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