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# The Impact of Financial Renewable Energy Policy Incentives vs. Government Renewable Energy Regulatory Policies on CO2 Emissions and Employment in US States

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# THE IMPACT OF FINANCIAL RENEWABLE ENERGY POLICY INCENTIVES VS. GOVERNMENT RENEWABLE ENERGY REGULATORY POLICIES ON $CO_2$ EMISSIONS AND EMPLOYMENT IN US STATES

by

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# ABSTRACT

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With a clear political influence spearheading the fight against climate change, this paper investigates renewable energy policies in U.S. states from 2000 to 2018 by utilizing panel data and OLS regression analysis to pinpoint the most effective renewable energy policies. Policy data in each state comes from DSIRE, a database of state incentives for renewables & efficiency. Specific policies examined in this paper include Sales Tax Incentives, Grant Programs, Loan Programs, Renewable Portfolio Standards, Energy Standards for Public Buildings, Building Energy Codes, and Solar/Wind Access Policies. Controls for $CO_2$ emission analysis include total state GDP, transportation GDP, manufacturing GDP, utilities GDP, number of registered vehicles, and population. All GDP controls are lagged to avoid endogeneity with $CO_2$ emissions. Employment analysis includes sex and race as controls. Both dependent variables are run with state and year fixed effects. Contrary to existing literature, results vary depending upon the high-level subsamples in the analysis: High Emission Group, Low Emission Group, High Population Group, Low Population Group, Red States, and Blue States. Most policies examined have opposite effects in their subsample counterparts. For example, an RPS Policy increased emissions in Red States by 2.1% but decreased emissions by 3.4% in Blue States. However, a Grant or Loan Policy has positive impacts on employment across all subsamples. Overall, the results discussed in this paper give insight into how popular policies can be effective when implemented in the right situation. These findings indicate

that policy-makers should make decisions on a case-by-case basis to reach their desired goals.

**TABLE OF CONTENTS**

## LIST OF TABLES & FIGURES

## CHAPTER ONE

## INTRODUCTION

*A. Climate Change Overview*

This paper will take a detailed look at different types of government legislation aiming to lower $CO_2$ emission levels through the prioritization of the renewable energy industry. $CO_2$ emissions contribute to the greenhouse effect, which occurs when radiation from our atmosphere warms Earth's surface to a higher temperature than what it would be without an atmosphere. NASA's Global Climate Change division explains, "glaciers have shrunk, ice on rivers and lakes is breaking up earlier, plant and animal ranges have shifted and trees are flowering sooner" (NASA 2021). Among other impacts, NASA claims we will be subject to more droughts and heatwaves, stronger and more intense hurricanes, sea level will rise 1-8 feet by 2100, an ice-free Arctic, and changes in precipitation patterns. The economy is expected to be impacted by these environmental changes resulting from climate change. Marchant (2021) of the World Economic Forum speculates the largest impacts of climate change could wipe up to 18% of GDP off the worldwide economy by 2050 if global temperatures rise by 3.2%. Greenhouse gasses directly affect the Earth's temperature and dictate the ability to allow life on Earth. The EPA (2019) establishes that globally, carbon dioxide ($CO_2$) accounted for 80% of U.S. Greenhouse Gas Emissions in 2019. Advocates for greater reliance on renewable energy believe renewable energy helps enhance energy security through fuel diversification and lowers the risk of fuel spills while helping conserve the U.S.'s natural resources and slow climate change effects. Motivated by the prospect of large financial investments in various renewable energy policies and the need to address and combat climate change, this study aims to evaluate the effectiveness of some of the most abundant renewable energy policies available to policymakers in the US to guide future policy implementation.

*B. Legislature Background*

Coined by Pulitzer Prize-winner Thomas Friedman in 2007, the term Green New Deal has been used to describe a wide range of policy proposals that aim to make various systemic changes. Broadly, today's Green New Deal aims to reduce greenhouse gas emissions to avoid the consequences of climate change while simultaneously addressing economic inequality and racial injustice. In February 2019, Rep Alexandria Ocasio-Cortez and Senator Ed Markey released documents for their proposed Green New Deal. This proposal's goals included transitioning the U.S. to 100% renewable, zero-emission energy sources by 2050, accompanied by investment in electric cars and high-speed rail systems. This proposal also includes increasing state-sponsored jobs. During the 2020 Presidential election, climate change and the "Green New Deal" served as a prominent topic of discussion during the Presidential and Vice Presidential debates. There was considerable disagreement on whether the Green New Deal would cost $100 trillion. In reality, Biden's climate change plan, dubbed "A Clean Energy Revolution," has similar goals of a traditional Green New Deal but with goals over a longer time horizon and a lower budget in mind. Compared to the Green New Deal's goal of net-zero greenhouse gas emissions and 100% clean, renewable energy sources by 2030, the Clean Energy Revolution hopes to achieve these goals by 2050.

Additionally, D'Souza (2021) explains - the Clean Energy Revolution calls for a budget of $1.7 trillion with a private sector, state, and local investment of about $5 trillion. These goals may seem expensive, and it is. However, Biden's plan seems reasonable to its supporters compared to the Green New Deal's expected cost of $93 trillion. It is worth noting that the U.S. government currently has over $28.5 trillion in debt as of August 2021 (Duffin 2021). Given the government's balance sheet, Biden's green plan supporters believe the Clean Energy Revolution supports budget neutrality. Given the scale of investment required for such policies, the Clean Energy Revolution is one of many reasons it is important to constantly evaluate government policy implementations and their effectiveness towards their goals. In the first Presidential debate in October of 2020, Mike Pence cited concerns that the deal would abolish fossil fuels and ban fracking, costing hundreds of thousands of American jobs (Sanford 2021). To this point, this study will look to see how recent policy implementations and monetary incentives impact carbon emissions and job employment.

An argument for the implementation of policies in line with a Green New Deal's objectives claims that in the long run, the project's costs will be less expensive than if no action were to be taken. Extreme weather and fire events cost the federal government $450 billion between 2005 and 2018 (D'Souza 2021). The federal government estimates an annual economic loss of $500 billion by 2090. If net-zero targets set by the Paris Agreement are not met, and temperatures continue to rise by 3.2 degrees Celsius, D'Souza (2021) more conservatively estimates 10% of the global economy's value could be erased by 2050. Environmental concerns have been shared among the majority of scientists for years now, and the above figures show why economists should be just as concerned as the scientific community.

On the other hand, critics deem a Green New Deal too extreme and draw concerns regarding the vast government intervention required for the deal. Some critics are calling for a revenue-neutral carbon tax to decrease emissions without significantly adding to the fiscal imbalance over concerns of a slowed economy with the addition of debt and the possibility of pushing jobs overseas. While the Green New Deal is a more radical solution to the well-documented environmental concerns surrounding fossil fuels, we can look to state-level policy implementations to draw conclusions about the effectiveness of different types of government intervention before a massive investment - like the Green New Deal - comes to fruition.

### *C. The Contribution and Organization of This Paper*

Previous literature on this subject can give us some insight into different specificities of the issues surrounding Green New Deal legislature. Scholars have examined the impact of clean energy policies on net job creation in OECD countries, renewable energy policy implementation on renewable energy industry growth, and Renewable Portfolio Standards (RPS) impact on $CO_2$ emissions. Yi (2013) looks at clean energy policies on green jobs in Metropolitan areas in 2006. The study finds that both state and local clean energy policies have positive and statistically significant impacts on green jobs at the metropolitan level. While this study achieves a positive result, it is confined by the time period and by clean energy policies at large in metropolitan areas. Kilinc (2016) breaks down renewable energy policies into common renewable policy instruments: feed-in-tariffs, quotas, tenders, and tax incentives. The study looks at 27 E.U. countries and 50 U.S. states. Findings establish that feed-in-tariffs, tenders and tax incentives are effective mechanisms for stimulating the development capacity of renewable energy sources for electricity, while quotas are not. These findings leave out two evaluations of two major reasons for Green New Deal policies support - employment and emissions.

Due to the gaps in previous literature, this study focuses on renewable energy policy implementations in U.S. states from 2000 to 2018 and their effect on employment levels and $CO_2$ emissions. More specifically, this study compares renewable energy policies centered around financial incentives, such as Sales Tax Incentives, and government renewable energy regulatory policies, such as Building Energy Codes. Past studies have not explicitly looked at a robust collection of aggregate and individual policies available for the prioritization of renewable energy and their effect on both employment and carbon emissions together at the same observation level. This type of study is needed to learn more about how the U.S. should implement deals as large as have been discussed over the past presidential election.

Type of renewable energy policy will serve as the primary independent variable in this study. Other independent variables that will affect the dependent variable include total state GDP, sector GDP, number of private cars, population, sex, age, and state and year fixed effects. Dependent variables are logged $CO_2$ emissions and logged employment, as these two metrics are primary motivations behind the push for larger renewable energy government interventions - such as a Green New Deal.

State energy-related carbon dioxide emissions data in this study comes from the U.S. Energy Information Administration (EIA) for the years 2000 to 2018. Each states' employment levels over the study's time period comes from the Bureau of Economic Analysis under the U.S. Department of Commerce. Detailed data on policy implementations in each U.S. state, including the year of implementation and the type of policy, comes from DSIRE, a database of state incentives for renewables & energy efficiency.

The organization of this paper is as follows. Chapter Two provides a review of existing relevant literature regarding renewable energy, policies, emissions and employment. Chapter Three provides an overview of the data used in this paper's analysis. Chapter Five describes the econometric models used in the analysis. Chapter Six discusses the regression analysis results. Chapter Seven presents implications for policymakers, limitations of the study, and ideas for future research.

## CHAPTER TWO

## A REVIEW OF THE RENEWABLE ENERGY INDUSTRY, POLICIES, $CO_2$ EMISSIONS, AND EMPLOYMENT

Because of the disagreements surrounding ways to slow down and combat greenhouse gas emissions (GHGs) and climate change, many articles have been published examining the connection between renewable energy, emissions, and employment. Studies have examined energy policies' impact on renewables industry growth and deployment of renewable energy and renewable energy industry growth implications on employment. Additionally, studies have focused on environmental and renewable energy policies' impacts on employment. On the environmental side, articles have looked at the relationship between renewable energy deployment and $CO_2$ emissions, and environmental and renewable energy policy impacts on $CO_2$ emissions. To understand the current scope of the environmental and renewable energy policy space, we must thoroughly understand what other scholars have found in previous literature.

### *A. Energy Policies and Renewable Energy Industry Growth*

First, I review available literature discussing energy policies' impact on renewable energy industry growth and influence on the deployment of renewable energy. Lund (2008) examines the effects of energy policies on industry expansion in renewable energy. Lund (2018) finds that there are increased industrial opportunities in renewable energy by large countries, through large public resources and also smaller countries if they utilize clever policies and optimal management of the commercialization process. This study confirms that renewable energy policies do have an impact on the actual development, growth, and implementation of renewable energy sources. This finding is key to establish before we continue with further research on these policies and their effectiveness in altering $CO_2$ emission levels and influencing employment.

In a study that relates more to the topic of my own, Kilinc (2015) draws interesting conclusions about specific policies and their impact on renewable energy development and employment. Kilinc (2015) utilizes a 1990-2008 panel dataset to analyze the impact of feed-in-tariffs, quotas, tenders and tax incentives on renewable energy rollout in 50 US states and 27 EU countries. Interestingly, this paper uses substitution (thermal/nuclear), economic (real GDP, coal/gas price, electricity consumption), security (energy/electricity import), and environmental ($CO_2$ emission per capita) variables to examine their impact on renewable energy capacity. The initial regression analysis includes the dependent variable of the ratio of renewable electricity capacity, which is the percentage of electricity capacity from RE resources (wind, solar, geothermal, and biomass, combined into a single measure). The regression finds that feed-in-tariffs raise renewable electricity capacity by 2.815% at the highest statistically significant level, a larger impact by more than 2% compared to the other policy instruments. Feed-in-tariffs are designed to provide a guaranteed, above-market price for producers. On the other hand, quotas did not have a statistically significant impact on renewable electricity capacity. Tenders and tax both affected the dependent variable with small statistical significance and under a 1% change in renewable capacity. This result has implications for my study. Because feed-in-tariffs are technically a financial incentive, we can speculate that this type of policy will likely cause a drop in $CO_2$ emissions. We can further hypothesize that quotas and other governmental regulations may not impact $CO_2$ levels and employment rates due to quota's lack of statistical significance found by Kilinc (2015). Taken together, we can conclude that different policies have statistically significant impacts on renewable energy sector growth. Further exploration is needed to examine how specific types of policies and renewable energy development impact carbon emissions and employment.

### *B. Renewable Energy Industry Development and Employment*

I took a deeper dive into the literature based on how the findings of Kilinc (2015) and Lund (2008) may impact one of my dependent variables: employment. Given that policies influence growth in the renewable energy space, how does the promoted growth and development relate directly to jobs? As we have discussed, job growth is one main argument for the promotion of renewable energy through government intervention. Patricia et al. (2019) investigate the social impacts of renewable energy industry growth. In their study 28 EU member states are evaluated over 16 years, from 2000 to 2016. The authors examine the relationship between historical values of renewable energy power generation installed capacity and employment. The study finds that every 1% increase in RES-E capacity induces a rise of about .48% in total employment. This result is especially impactful because the study also finds that energy consumption per capita and energy dependence both have negative impacts on employment. This eliminates a possible explanation for the increase in employment from renewable energy source capacity that is due to overall energy consumption growth, which usually signifies broader economic growth, as energy consumption demand increases. This study is limited by design and data collection problems, short time-series dimension, and potential statistical problems. However, from this study, we can conclude that there may be a positive relationship between renewable energy source development and broad employment levels. Additionally, we need this type of analysis in US states for the application to assess policies being proposed under the present Biden Administration. Kilinc (2015) and Lund (2008) findings have competing viewpoints from other publications, which signifies a need for further exploration.

Contradicting Kilinc (2015) and Lund (2008), Lou et al. (2016) examine renewable energy development in China. This study uses employment and regulation as other control variables for the relationship between renewable energy generation and environmental quality. The authors adopt lagged unemployment rates to determine whether renewable energy generation is a job creator or not. The study finds that renewable energy generation is not a generator of jobs in China. Such a contradicting result from Lou et al. (2016) implies that there is more opportunity for the assessment of the relationship between renewable energy and employment.

Another study offers a different exploration of employment and RE development. Edler et al. (2012) examine renewable energy on net employment while including a major factor left of other previous literature: international market growth. Lehr et al. (2012) focuses on labor market implications of large investment into renewable energy. Positive net employment effects strongly depend on further growth of global markets and German RE exports. Compared to past literature, the authors speculate that their positive result can partly be attributed to international market developments inclusion in their study. The study notes this result contradicts other literature which finds negative economic impacts resulting from RE growth in neighboring regions, such as Spain, which only focus on domestic markets. Lehr et al. (2012) offers insight into why previous literature may find conflicting results when looking purely at renewable energy growth and net employment. Because my study looks to evaluate the effectiveness of renewable energy policies and their implications on employment and $CO_2$ emissions on a state by state basis, international market growth does not play a role in the study. It does not because international market growth is not directly impacted by state and federal level policy implementations, and therefore I do not need to control for growth happening in the overall market to get the true effect of the legislation. Other issues with the study include its limited geographical scope. Germany has historically been a leader in global renewable-energy research due to its extensive level of public funding. Their prominence already in the renewable energy landscape also takes away from the study's ability for its results to have implications on a larger scale. The results from prior literature on the relationship between renewable energy development remain convoluted.

Some literature is available on the domestic effects of clean energy policies and employment in the US. Yi (2013) evaluates the employment effects of state and local clean energy and climate policies in New York, Washington D.C., Houston, Los Angeles, Boston, Chicago, Philadelphia, San Francisco, San Diego, and Pittsburgh in 2006. The Bureau of Labor Statistics defines green jobs as jobs in businesses that produce goods or provide services that benefit the environment or conserve natural resources. The study includes a multitude of policy tools which are broken up into three categories: renewable energy, energy efficiency, and emission policies. Renewable energy policies consist of renewable portfolio standards, public benefit funds (PBF) (for renewables), net metering, interconnection standards, green power purchasing, mandatory green power option, property tax incentive, corporate tax incentive, income tax incentive, sales tax incentive, and industry support. Energy efficiency policies include energy efficiency resource standards, PBF (for efficiency), appliance/equipment standards, energy standards for public buildings, property tax incentive, corporate tax incentive, income tax incentive, and sales tax incentive. Vehicle greenhouse gas emission standards and greenhouse gas emission targets comprise the emission policies category. The study takes the state-level policies and indexes them, hypothesizing that policy incentives adopted at the state level for renewable energy and energy efficiency are positively associated with the number of green jobs in metropolitan areas. Through an OLS regression model, the study finds that with every additional state clean energy policy tool implemented, around 1.7% more green jobs are expected in the metropolitan area.

While these results are promising for my study, there remain gaps in the literature that my paper seeks to address. First, this study only includes the assessment of green jobs in 10 metropolitan areas in the U.S. The limited and specific locations leave out key markets that may have large movements in employment as clean energy policies are implemented. For example, states in the Permian Basin may see different and substantial labor market movements as a result of governmental intervention. The U.S. Energy Information Administration (EIA) cites that the Midland Basin alone (the largest portion of the Permian Basin) accounted for 15% of U.S. crude oil production in 2020 (EIA 2021). One would speculate that because of these regions' heavy involvement in oil & natural gas production in the U.S. they may experience different labor employment changes as renewable energy production and development get incentivized by the government. The U.S. Energy & Employment 2019 Report found that fuel employment (all work related to fuel extraction and mining, including petroleum refineries and firms that support coal mining, oil and gas field machinery manufacturing) grew 5% for a total of 1,122,764 jobs in 2018 (USEER 2019). Because of the large involvement of fossil fuel firms in employment levels, one of the renewable energy policy debates centers around the concern of how the fossil fuel industry will be impacted. Therefore, it is essential we consider regions where fossil fuel production dominates local economies. Additionally, Yi (2013) indexes the different policies as described above, lumping together financial incentives and government regulations all in one. This limits the ability to see which type of policies are more effective than others at influencing employment levels.

### *C. Government Intervention and Lowering $CO_2$ Emissions*

I also surveyed prior literature on the relationship between renewable energy policies and $CO_2$ emissions. To begin, I found publications that show the need for governmental intervention to help lower $CO_2$ emissions. Gan et al. (2007) finds that Malaysia's total primary energy consumption will triple by 2030, and carbon emissions will triple by 2030. The study includes projections under an alternative renewable energy (RE) scenario in which a RE strategy is an option to improve Malaysia's long-term energy security and environmental performance. Gan et al. (2007) concludes that substantial governmental involvement and support through a regulatory framework is necessary. In a similar assessment of energy markets, Li et al. (2019) examine the impact of energy price on $CO_2$ emissions in China. The study finds that energy price plays an important role in affecting energy consumption patterns and, therefore, greenhouse gas emissions caused by energy consumption. Ultimately Li et al. (2019) concludes that $CO_2$

emissions can be effectively suppressed by raising energy price. We can infer that governments can manipulate $CO_2$ emission levels by artificially raising energy prices through a carbon tax, for example. ZhiDong (2003) forecasts China's economy, energy, and environment to the year 2030. This study concludes that their speculated GDP growth of around 7% annually poses difficulties for energy security, air protection, and $CO_2$ emission reductions. The author advises that for sustainability development, improvements in energy efficiency, more rapid energy switching from coal to natural gas and renewable energy sources, imposing a carbon tax, and enforcement of air protection are necessary. Taking these three studies together, we can conclude that policy implementations are imperative for a sustainable future and lower $CO_2$ emissions.

*D. Renewable Energy Industry Development and $CO_2$ Emissions*

I built upon this preliminary literary review by looking at the relationship between renewable energy development and $CO_2$ emissions. Busu (2019) measures renewable energy efficiency and its impact on low-carbon emissions for panel data from 28 EU countries from 2010 to 2017. Busu (2019) finds that a 1% increase in renewable energy consumption would reduce the $CO_2$ emissions by .11 million tons. Although this result is statistically significant, it is worth noting that only 42.78% of the dependent variable's variation is explained by the variability of the independent variables renewable energy, energy productivity, population, urbanization, motorization, and real GDP per capita. 67.22% of the variability of the dependent variable is determined by other factors not covered in the study's analysis. Although there may be some explanation needed for the $r^2$ value, this study still provides the framework needed to establish that renewable energy growth and consumption is associated with decreasing levels of $CO_2$ emissions. Another study finds a slightly different relationship between renewable energy consumption and carbon emissions. Menyah et al. (2010) examines $CO_2$ emissions, renewable and nuclear energy consumption and real GDP for the US from 1960-2007. The econometric model suggests no causality between renewable energy consumption and $CO_2$ emissions. I speculate that these findings are a result of the data sample dating back to 1960, where renewable energy consumption was much lower than in recent years. This may explain why Busu (2019), whose study includes more recent data, finds a statistically significant negative correlation between renewable energy consumption and carbon emissions. For the purpose of my study, both of these publications provide the background needed to continue with further review of the literature surrounding renewables and emissions.

### *E. Environmental and Renewable Energy Policy Impacts on $CO_2$ Emissions*

Many publications look to evaluate renewable energy policies, as they are a staple in energy sector decarbonization efforts worldwide. Bersalli et al. (2020) utilizes a panel data set of 30 European countries and 20 Latin American countries from 1995-2015. In this study, effectiveness is defined as the policy's capacity to trigger new investment in renewable energy. The authors selected the annual increase in installed capacity (in MW/inhabitant) of renewable energy technologies as the dependent variable. Feed-in-tariffs, portfolio standards, auctions, and fiscal incentives are binary variables that indicate that type of policy is present or not. Across the 50 countries included in the study, the presence of feed-in-tariffs, portfolio standards, auctions and fiscal incentives increased the annual installed capacity of renewable energy technologies by 7.04, 16.55, 7.31, and 3.25 MW/1 million inhabitants, respectively. Fiscal incentives were the only of these variables to lack statistical significance. An annual $CO_2$ per capita increase of 1 metric ton per capita is associated with a 4.20 annual decrease in installed capacity of renewable energy tech, at the 1% significance level. Interestingly, in Europe, the presence of feed-in-tariffs, portfolio standards, auctions and fiscal incentives increased the annual installed capacity of renewable energy technologies by 12.25, 23.51, 10.95, and 8.35, respectively. Fiscal incentives remain statistically insignificant at any significance level. $CO_2$ per capita growth was associated with a 4.02 decrease in annual installed capacity of renewable energy tech. This study fails to differentiate different policies more broadly. I will specifically be looking to compare policies that involve financial changes or regulatory changes for players in the renewable energy space. Additionally, this study only observes European and Latin American countries and there is still a need for this type of analysis in the United States. Furthermore, the independent variable differs from the two used in my study. As we saw in the review of renewable energy sector growth and its impacts on $CO_2$ emissions, we cannot confidently conclude that investment in renewable tech will impact $CO_2$ emission levels significantly. Although we may be able to make some conclusions about $CO_2$ levels and their relationship with renewable energy investment, the literature still fails to assess policy impacts on carbon emission levels.

There has been some analysis on environmental regulations and their direct impact on carbon emissions. A 2003-2017 provincial panel data study, Yang et al. (2020) finds a statistically significant, positive relationship between environmental regulation and carbon emissions in China. The findings suggest a “green paradox phenomenon” in which the response of the suppliers to environmental regulation makes energy owners speed up the exploitation and thus aggravate energy consumption, resulting in more carbon emissions. Yang et al. (2020) findings suggest an alternative narrative to what policymakers seem to push, environmental regulations may not lower carbon emissions. However, the green paradox phenomenon may only affect near-term supplier and consumer behaviors, indicating that there is a chance carbon emissions will eventually drop as a result of the regulations.

As we explore the literature on different policies aiming to affect changes in $CO_2$ emissions, we find there is extensive literature examining tax policies. One of the major strategies adopted by different governments to reduce carbon emissions targets is tax policies on the automobile industry. Vance et al. (2009) finds that a 1% increase in either circulation taxes or fuel costs indicates a greater than 1% decrease in the small, medium, luxury, sport, transporter, off-road, and van market shares. The authors then used the coefficient estimates to simulate the resulting $CO_2$ emissions in the year 2005 in a tax-free scenario and a scenario where the taxes were at actual levels. $CO_2$ emissions increased about 3.8% over the observed level in 2005, where taxes are imposed. This finding suggests that tax policies may be an effective way to lower $CO_2$ emissions. This publication offers us better insight into how government regulation and financial incentives/disincentives may be effective in lowering emissions or not. The overall consensus on effective renewable energy policies among scholars remains up for debate.

A study on carbon and energy taxation schemes in Sweden offers differing results. Speck et al. (2018) helps us better understand the true impacts of carbon and energy taxation on emissions because Sweden was one of the first countries in Europe to adopt a $CO_2$ tax. Therefore, their results will enable us to see the effects of such taxation over a greater time horizon than we can observe in other countries. The study confirms that the role of environmental taxation as a viable policy instrument in reducing $CO_2$ emissions.

Zeng et al. (2019) includes an analysis of two broad approaches to reducing air pollutant emissions. The authors broadly categorize two energy policies based on their goals: emission reduction policies, identified as throttling measures, which aim to reduce emissions from the source and renewable energy policies, which focus on the development and promotion of renewable energy. The study examines 27 Chinese provinces during the period from 2003 to 2016. A 1% increase in emission reduction policies will lead to a 0.0541% reduction in PM10 emissions and the 1% significance level. Emission reduction policies did not lead to a significant effect on PM2.5 and $SO_2$ emissions. A 1% increase in renewable energy policies will lead to a 0.0236% reduction in PM2.5 emissions and a 0.0990% reduction in $SO_2$ emissions, at the 5% and 1% significance levels, respectively. Renewable energy policies found no significant effect on PM10 emission levels. These results are all for local levels and not neighboring provinces. Zeng et al. (2019) conclude that policy decisions must be made based on the specific emission issues unique to different locations, based on the effectiveness of the two types of policies on different types of emissions. Although this study does not look at $CO_2$ emissions, we learn that some policies may be more effective and less effective based on the region of implementation.

# CHAPTER THREE

# DATA OVERVIEW

*A. State Energy-Related $CO_2$ Emissions, Employment, Population, Private Cars & GDP*

State energy-related carbon dioxide emissions data by year comes from the U.S. Energy Information Administration (EIA). The data set includes all 50 states and their yearly carbon emissions in million metric tons of energy-related carbon dioxide in each year from 2000 to 2018. Employment data comes from the Bureau of Economic Analysis under the U.S. Department of Commerce. The downloadable data files include state-level employment in the following categories: total employment, mining, quarrying and oil and gas extraction, utilities, construction, manufacturing, and transportation. For this study, I will be looking at state-level employment across all sectors. By using total employment, I will be able to pick up the net impact on the labor market as a result of the policies. Additionally from the BEA, I will be using data on GDP by industry in each state in each year. The GDP values are in millions of current dollars. I include transportation, manufacturing, and utilities GDP. GDP variables are lagged by one year to avoid endogeneity with carbon emissions. The number of registered cars in each state and year comes from the U.S. Department of Transportation Federal Highway Administration. Sex and age figures were downloaded from the US Census.

*B. Renewable Energy Policies*

Policy data comes from DSIRE, a source of information on incentives and policies that support renewable energy and energy efficiency in the United States. DSIRE is operated by the N.C. Clean Energy Technology Center. DSIRE has data on renewable energy incentives and policies in all U.S. states, the year they were enacted, the category (regulatory policy or financial incentive), and the policy/incentive type (loan program, performance-based incentive, etc.). The database includes detailed descriptions of the policies.

*C. Economic Model*

I predict that overall, the introduction of more renewable energy policies will be associated with lower levels of carbon dioxide emissions. Because the government will be supporting renewable energy growth through lowering cost of production and other means, carbon emissions will likely fall. As we saw in previous literature, growth of renewable energy capacity and consumption lowers emissions by taking away some of the market share from fossil fuels. I expect financial incentives will show a more significant effect on $CO_2$ emissions. I hypothesize this from previous literature that identified feed-in-tariffs and tax incentives as having a larger impact on emissions. I speculate this may be because direct financial repercussions may motivate large corporations more effectively due to financial implications' impact on the company's top and bottom lines. Because companies typically want to maximize value for their shareholders, direct action may be required to keep their firm hitting financial goals if financial incentives are placed on their industry.

On the other hand, government regulations will show a lesser impact on $CO_2$ emissions because this type of policy will set goals and quotas, and therefore may not have an immediate impact. However, if the cost of compliance is too high, firms will not alter their operations to adhere to agendas the government pushes onto them, such as prioritization of renewable energy and lowering carbon emissions. Based on findings in previous literature, specifically a study on clean energy policies on net job creation in OECD countries, I expect a minimal impact on employment overall. This effect may occur because job creation in green sectors will simultaneously remove jobs in industries with high environmental footprints.

# CHAPTER FOUR

# EMPIRICAL MODEL & METHODS

This chapter defines variables and describes the econometric models used in the analysis.

*A. Outcome Variables & Models*

Initial regression analysis was aimed to evaluate the effectiveness of financial incentives vs. regulatory policies broadly. To do this using an OLS framework, I utilize dummy variables for the policies in question - $Financial_{s,t}$. This variable takes on the value of one if there is a financial incentive active in state *s* at year *t* and zero otherwise. $Regulatory_{s,t}$ functions in the same way but for the presence of a regulatory policy, not a financial incentive. This type of variable is necessary in this OLS framework because there is variability of year and state. The goal of using this type of variable is to pick up similar effects as a difference-in-difference framework would. In a normal difference-in-difference estimation, we look at two different states where one state is under the experimental group after the year 2015, for example, and the other is not. However, in this study, we have states that may have the policy introduction in 2004 and another state with the policy implementation in 2007. Structuring our variable as described above is necessary to account for this variation observed in the data. A basic regression equation can be seen below.

$$Y = \beta_0 + \beta_1[Policy\ X]_{s,t} + \beta_{1+n}[Controls] + \varepsilon$$

$\beta_0$ is the constant term. $\beta_1$ the coefficient on the dummy variable $Financial_{s,t}$ (for example) indicates the true effect of a financial incentive policy on carbon emissions and employment. $\beta_{1+n}$*[Controls]* controls for variation in carbon emissions and employment that may be explained by Construction GDP (for example) in a given state and year. This variable will control for states that have large carbon emissions because of strength and prominence of polluting industries as well as other controls mentioned previously. $\varepsilon$ includes state fixed-effects and year fixed-effects. The fixed effects will control for variations in emissions and employment that may have resulted from being in a specific state or in a particular year. For example, the COVID-19 pandemic, which began in March 2020, will significantly impact carbon emissions and employment over 2020 and 2021 due to global lockdowns. Although these years are not included in this study, the COVID pandemic provides a great example as to why we need to include state and year fixed-effects. State and year fixed effects will help with these unique situations over the study's observation years and states. The error term will also account for variation in the dependent variable not picked up by the components of the regression.

Furthermore, I looked at the most abundant program types to see how effective they are. Policies in the study include Sales Tax Incentives, Grant & Loan Policies, Building/Green Policies (aggregate policy), Renewable Portfolio Standard (RPS) Policies, Energy Standards for Public Buildings, Building Energy Codes, and Solar/Wind Access Policies. Similar to the variable I created for the regulatory and financial regressions above, I coded a variable for each of these seven policies so they would take on the value of 1 if they were active in state *s* in year *t*. The regression for emissions can be seen below.

$$Y = \beta_0 + \beta_1 BEC_{s,t} + \beta_2 GDP + \beta_3 TGDP + \beta_3 MGDP + \beta_3 UGDP + \beta_3 Cars + \beta_4 Population + \varepsilon$$

The above regression was run for each of the above policies in the U.S. with the variables.[1] These coefficients on these variables will tell us how our dependent variables are affected by the respective policy being active in state *s* in year *t*. Figure 1 (p. 55) outlines the policies examined in this paper and gives detail into what the aggregated policy variables include.

The same policy variables were then regressed on log employment and with sex and race controls and state and year fixed effects. The model can be seen below:

$$Y = \beta_0 + \beta_1 BEC_{s,t} + \beta_2 Sex + \beta_3 Race + \varepsilon$$

The interpretation of $\beta_1$ remains the same, only it will tell us the effect of this policy active in state *s* in year *t* on employment. $\beta_2$ and $\beta_3$ interpretations also remain the same except they tell us the effect of sex and race on employment.

[1] *BEC* stands for Building Energy Code Policy Dummy, *GDP* is lagged total state GDP, *TGDP* is lagged transportation GDP, *MGDP* is lagged manufacturing GDP, *UGDP* is lagged utilities GDP, *Cars* is the number of registered vehicles

# CHAPTER FIVE

## SELECTION OF DIFFERENT SAMPLES FOR REGRESSION ANALYSIS

The data needed to be separated into subsamples during regression analysis and in addition to the use of propensity score matching. Matching helps eliminate a greater proportion of bias when estimating the more precise treatment effect in my data. In the regressions, I used propensity score matching for the specific outcome variable and the policy in question, matching by population. In addition to this technique, I break down the sample into subsamples.

I include six subsamples – high emission states, low emission states, high population states, low population states, Red States, and Blue States. These six groups are logical in their creation – they all capture similar observations and add value to the interpretation of the estimation results. Both emission and population subsamples were broken up high and low, determined by either over or under the mean population or emission level. Red States are states that voted Republican during the election year in question. The status of Red State was carried on until the next election year. The variable takes on 1 for Red and 0 for Blue.

The goal of utilizing subsamples and propensity score matching was to estimate treatment effects more precisely. Without these techniques, the estimation was susceptible to significant amounts of bias.

Summary statistics for the six subsamples can be seen in the appendix.

## CHAPTER SIX

## REGRESSION ANALYSIS RESULTS

### *A. Dependent Variable: Log Emissions*

Table 7: Regression Analysis of Log $CO_2$ Emissions

**Table 6. Regression Analysis of Log CO2 Emissions**

| | High Emission Group (1) | Low Emission Group (2) | High Population Group (3) | Low Population Group (4) | Red States (5) | Blue States (6) |
|---|---|---|---|---|---|---|
| Financial Policy Dummy | -0.038 *** | -0.019 * | - | -0.048 *** | 0.008 | -0.022 * |
| | (.009) | (.010) | - | (.008) | (.013) | (.013) |
| Regulatory Policy Dummy | 0.158 *** | - | - | -0.129 *** | -0.126 *** | - |
| | (.018) | - | - | (.009) | (.009) | - |
| Sales Tax Incentive Dummy | 0.027 *** | -0.058 *** | 0.030 *** | -0.007 | 0.022 | 0.020 * |
| | (.007) | (.016) | (.040) | (.012) | (.015) | (.010) |
| Grant/Loan Policy Dummy | -0.037 *** | 0.087 *** | -0.025 *** | 0.013 | -0.009 | 0.025 ** |
| | (.006) | (.015) | (.007) | (.011) | (.010) | (.011) |
| Grant Policy Dummy | -0.036 *** | 0.087 *** | 0.009 | -0.014 | -0.078 *** | -0.006 |
| | (.010) | (.011) | (.008) | (.013) | (.012) | (.009) |
| Building/Green Policy Dummy | -0.066 *** | 0.094 *** | -0.085 *** | 0.059 *** | 0.103 *** | 0.039 *** |
| | (.011) | (.026) | (.017) | (.018) | (.020) | (.013) |
| RPS Policy Dummy | 0.027 *** | -0.000 | -0.019 *** | -0.021 ** | 0.021 * | -0.034 *** |
| | (.008) | (.013) | (.008) | (.010) | (.011) | (.009) |
| Energy Standards for Public Buildings Dummy | -0.025 *** | -0.007 | 0.005 | -0.028 *** | -0.002 | -0.009 |
| | (.006) | (.013) | (.007) | (.008) | (.008) | (.008) |
| Building Energy Code Policy Dummy | -0.096 *** | 0.094 ** | 0.182 *** | 0.080 *** | 0.148 *** | -0.172 *** |
| | (.032) | (.040) | (.019) | (.028) | (.027) | (.014) |
| Solar Wind Access Policy Dummy | 0.032 *** | 0.028 *** | -0.063 *** | 0.002 | -0.017 ** | 0.068 *** |
| | (.007) | (.011) | (.009) | (.009) | (.008) | (.009) |
| **Controls** | | | | | | |
| Total State GDP | Yes | Yes | Yes | Yes | Yes | Yes |
| Transportation GDP | Yes | Yes | Yes | Yes | Yes | Yes |
| Manufacturing GDP | Yes | Yes | Yes | Yes | Yes | Yes |
| Utilities GDP | Yes | Yes | Yes | Yes | Yes | Yes |
| # of Cars | Yes | Yes | Yes | Yes | Yes | Yes |
| Population | Yes | Yes | Yes | Yes | Yes | Yes |
| State Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |

*t* statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

*note:* the dash (-) indicates that when using propensity score matching and specific grouping, there is not enough observations for significant regression analysis

To put the results discussed in the following sections into context, a discussion of percentage changes in carbon emissions is necessary. In a study conducted by the Organization for Economic Co-operation and Development (OECD), findings indicate that in the first year with a 5% $CO_2$ emission reduction, premature deaths and cases of chronic bronchitis both decreased by 4.52% (Garbaccio et al., nd). According the CDC, nearly 900,000 Americans die prematurely from the five leading causes of death (CDC 2014). The reduction in premature deaths of 4.52% in the OECD study equates to 40,680 fewer deaths. Extend this finding to the first year with a 10% $CO_2$ emission reduction, and we would expect to see a 9.04% reduction in premature deaths - about 81,360 fewer deaths. The following sections will utilize this 5% to 4.52% proportion to connect percentage changes in $CO_2$ emissions to the health of humans.

### *a. High Emissions Group vs. Low Emissions Group: Emission Regression Results & Comparison*

This section will highlight statistically significant results in both the high and low emissions groups.

Both groups saw a statistically significant effect of a Financial Incentive Policy in state *s* in year *t*. Implementing this type of policy drops emissions by 3.5% in high emissions states and 1.9% in low emissions states. Using the CDC's baseline of 900,000 premature deaths nationwide and the reported relationship between carbon emission reductions and premature deaths, this emission reduction may equate to 28,440 fewer premature deaths across the United States and 15,480 fewer premature deaths, respectively.

Alternatively, a Grant or Loan Policy appears to have opposite impacts on carbon emissions depending on which group implements the policy. A Grant or Loan Policy active in a high emission state drops emissions by 3.7% (30,060 deaths). Still, the analysis indicates an 8.7% increase in emissions in the low emissions group - a possible 70,740 increase in premature deaths. These results suggest that a Grant or Loan Policy that supports renewable energy and carbon emission reduction does more harm than good in states that need not be regulated (already have low levels of $CO_2$ emissions).

A similar juxtaposition of impacts can be observed with the presence of a Building/Green policy and a Building Energy Code Policy.[2] A Building/Green Policy decreases emissions by 6.6% (53,730 fewer premature deaths) in high emission states while increasing emissions by 9.4% (76,500 more premature deaths) in low emission states. A Building Energy Code Policy has almost exactly opposite effects in the two groups. In the high emissions group, emissions are lowered by 9.6% (78,120 fewer premature deaths) but are increased by 9.4% (76,500 more premature deaths) in the low emissions group. Previous literature may offer an explanation for why we see such a stark difference in emission reactions to a Building Energy Code between the two subsamples. Lou et al. (2021) found that improving lighting efficiency and equipment efficiency have less impact on emission reduction in cold climates than in hot climates. Improving lighting efficiency and equipment efficiency are both agendas of Building Energy Codes and Building/Green Policies. The low emission group has a colder average temperature

[2] *Building/Green Policies* (Group) – can include one of these four policies: Building Energy Code, Energy Standards for Public Buildings, Green Building Incentives and/or Green Power Purchasing. The following are definitions and examples of the type of policy:
*Building Energy Code* (Regulatory) - Building Energy Codes Program: consists of an integrated portfolio of activities to increase energy efficiency in buildings - DOE participates in the development of model energy codes and standards maintained by the International Code Council and the American Society of Heating, Refrigerating and Air-Conditioning Engineers.
*Energy Standards for Public Buildings* (Regulatory) - standards for buildings that range in requirements: example - all new municipal buildings larger than 10,000 square feet must be constructed to meet U.S. Green Building Council Leadership in Energy and Environmental Design (LEED) Silver Certification Standards; proposed projects must use 15% less energy than the minimum provisions of Chapter *X* of the *State* Energy Conservation Code
*Green Building Incentive* (Financial Incentive) - incentives can range from technical assistance, monthly educational lecture, free promotional materials, and rebates. Ex: Rebates issued to buildings/new buildings that achieve different levels of compensation based on the amount of points given by LEED (certification level)
*Green Power Purchasing* (Regulatory Policy) - committing to some level of purchasing of green/renewable power. ex: City of Chicago agreed to purchase 20% of its electricity from clean, renewable resources

than the high emission group by about 5 degrees Fahrenheit, which may help explain why the low emission group saw a much different effect than the high emission group.[3]

A Sales Tax Incentive increases emissions by 2.7% (21,960 more premature deaths) in the high emissions group. Still, it decreases emissions by 5.8% (47,160 fewer premature deaths) in the low emissions group (net decrease of 25,200 premature deaths across groups).[4] The positive result observed in the high emissions group may indicate that the Sales Tax Incentive implemented was not successful in changing the energy output landscape of the given state. Therefore, the positive effect being picked up could be the natural growth in emissions from inaction. The negative impact observed in low emission states may indicate that low emissions states are already more willing to shift to alternative green energy sources and thus, do not need as much of an incentive to commit to emission-reducing actions.

A Solar/Wind Access Policy increases emissions in both groups – 3.2% (26,010 more premature deaths) in the high emission group and 2.8% (22,770 more premature deaths) in the low emission group. Although pollution related to solar energy systems is less than other energy sources, transportation and installation of solar systems have been associated with GHG emissions. These associated pollutants could have been picked up in the regression, causing us to see the percentage increase in $CO_2$ emissions mentioned above. Additionally, because solar energy is weather-dependent, other energy sources are likely used in conjunction with solar systems. This dependency, combined with transportation and installation pollutants, may have caused us to observe a positive

[3] Data comes from USA.com's U.S. Average Temperature State Ranking
[4] *Sales Tax Incentive* (Financial Incentive) - exemption from state sales and use tax when promoting renewable/green energy options. Example: zero-emission transit buses are exempt from state sales and use taxes when sold to public agencies eligible for the Low Emission Truck and Bus Purchase Vouchers.

relationship between the policy implementation and emissions.[5] Protecting solar and wind access also may not significantly impact the usage of nonrenewable sources.

An RPS Policy and an Energy Standard for Public Buildings Policy are only significant in the high emissions group.[6] An RPS Policy increases carbon emissions by 2.7% (21,960 more premature deaths). The positive result may indicate the RPS Policy is ineffective in reducing emissions, and the 2.7% increase showed normal growth observed in $CO_2$ emissions. The Energy Policy Institute at the University of Chicago (2019) discusses the costs of integrating a highly-complex electricity grid due to RPS Policies. The integration of a highly-complex electricity grid may involve construction and transportation-related emissions, changing the impact of RPS policies on emissions negatively in the near term. Improvements to emission levels may not have been realized yet.

Like the reduction in emissions resulting from a Building Energy Code Policy in high emission states, an Energy Standard for Public Buildings Policy decreases carbon emissions by 2.5% (20,340 fewer premature deaths). The analysis suggests that green building initiatives are effective in reducing carbon emissions in high emission states. This conclusion confirms findings from UC Berkeley (2014) that found that building to LEED standards, often a benchmark included in green building policies, contributes 50% fewer GHGs than conventionally constructed buildings due to water consumption, 48% fewer GHGs due to solid waste, and 5% fewer GHGs due to transportation.[7] The

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5 Solar energy information provided by GreenMatch

6 *RPS Policy* (Regulatory Policy) - RPS set a minimum requirement for the share of electricity supply that comes from designated renewable energy resources (wind, solar, geothermal, biomass, hydroelectricity, landfill gas, municipal solid waste, ocean energy, etc.) by a certain date or year.

7 Study analysis provided by U.S. Green Building Council in the 2021 article "How green buildings can help fight climate change"

insignificant results observed in the low emissions group may indicate the lack of construction activity. In the high emission group, the construction employment mean is 303,188 people. Alternatively, the mean construction employment is 75,038 people in the low emission group. On average, 288,150 more people work in construction in high emission states than low emission states in a given year. With more minor construction activities in low emission states, green building initiatives may not significantly impact $CO_2$ emissions. Fewer new green buildings are being constructed in low emissions states, causing insignificant regression results.

The regressions all included controls for Total State GDP, Transportation GDP, Manufacturing GDP, Utilities Sector GDP, the Number of Cars Registered, State Population, and state and year fixed effects.

### *b. High Population Group vs. Low Population Group: Emission Regression Results & Comparison*

This section will highlight statistically significant results in both the high population group and the low population group.

The low population group observed significant and negative impacts on carbon emissions when a Financial Incentive Policy or a Regulatory Policy was active. A Financial Incentive Policy decreased $CO_2$ emissions by 4.8% (39,060 lives), and a Regulatory Policy reduced $CO_2$ emissions by 12.9% (105,300 lives). Because financial incentives are offered monetary benefits to help encourage action or inaction to reach a goal, and regulatory policies tend to require compliance (eliminating the optional participation present in many financial incentives), it makes sense that regulatory policies have a larger percentage impact on carbon emissions. When using propensity score matching and subsample grouping in the high population group, there were not enough observations for significant regression analysis for either a Financial Incentive Policy or a Regulatory Policy.

A Sales Tax Incentive increased emissions in the high population group by 3.0% (24,390 lives) and was insignificant in the low population group. Similar to the effect observed in the high emission group, this effect may indicate the policy's inability to significantly change current energy-related operations in the high population state - leading the result to show the impacts of ongoing carbon-emitting activity.

Similar to the effect observed in the high emission group, a Grant or Loan Policy decreased emissions in the high population group by 2.5% (20,340 lives) and was insignificant in the low population group. In a high population state, grants or loans are available to more people or businesses. The mean population in the high population group is 12.9 million, compared to a mean population of 2.8 million in the low population group. This difference in mean population could result in more pro-renewable energy action in total, explaining the significant effect in the high population and insignificant findings in the low population group. Additionally, the funding provided by renewable energy grants and loans may go to R&D in low emission states, given their lack of need to immediately reduce their own in-state emission levels (OECD 2018).

A Building/Green Policy reduced emissions in the high population group by 8.5% (69,120 lives). Alternatively, the same policy variable increased emissions by 5.9% (47,970 lives) in the low population group. 70% of the top 10 states for LEED Green Buildings are in high population states. In 2020, Massachusetts, Washington, Illinois, Colorado, New York, Maryland, California, Virginia, Texas, and Nevada led the country in certified green square footage, in that order (Benjamin 2021). These figures may explain why a Building/Green Policy significantly reduced emissions in the high population group but did not in the low population group.

An Energy Standards for Public Buildings Policy was insignificant in the high population group. Alternatively, implementing this policy lowered emissions by 2.8% (22,770 lives) in the low population subsample. Because we saw the aggregate policy dummy, Building/Green Policy, increase emissions in the low population group, this result suggests that Energy Standards for Public Buildings are effective, but the effect may get negated by other ineffective green building policies included in the aggregate variable.

Interestingly, a Building Energy Code Policy increased emissions in both subsamples, 18.2% and 8.0% (148,050 and 65,070 lives), respectively. I speculate that the increase in emissions may result from higher construction activities - which may raise emissions even though the end product (the building) will operate to help lower emissions. I conducted an entire sample analysis (all 50 states together) of construction activity, using construction GDP levels to examine this explanation further. The mean year in the entire sample for Building Energy Code implementation is 2011. The average growth rate in construction GDP in each state is 2.82% before 2011. The average growth rate post-2011 is 5.12% - supporting my possible explanation for the increased emissions resulting from a Building Energy Code above. The high population group saw a much starker growth rate pre and post 2011. Construction GDP had a 1.85% annual growth rate pre-2011 and a 6.51% annual growth rate post-2011. Low population states saw a less significant growth rate difference. Construction GDP annual growth rate increased from

3.23% pre-2011 to 4.58% post-2011. These growth rate differences help explain why the high population group's coefficient for a Building Energy Code is much larger than the low population group's coefficient.

Unlike the relationship in the emissions groups, both the high and low population groups experienced a decrease in emissions by implementing an RPS Policy, 1.9% and 2.1% (15,480 and 17,010 lives), respectively. This result confirms findings in previous literature (Prasad et al. 2012) that renewable portfolio standards show a significant negative effect on carbon emissions.

A Solar/Wind Access Policy dropped emissions by 6.3% (51,210 lives) in the high population group and was insignificant in the low population group. In this instance - a higher population influences the number of buildings that can take advantage of protected access to solar and wind energy. With this in mind, ensuring access to solar/wind energy for more buildings decreases emissions at a greater rate and larger magnitude than a lower population state, causing the discrepancy in effects between high population states vs. low population states observed here.

### *c. Red States vs. Blue States: Emission Regression Results & Comparison*

This section will discuss results in both the Red States group and the Blue States group.

Red States saw an insignificant impact on emissions when implementing a Financial Incentive Policy, while Blue States saw a decrease in emissions of 2.2% (17,910 lives), significant at the 10% level. Blue States have been recorded as leading the push for renewable energy consumption( Plumer 2019). Given that financial incentive policies are typically "nudges," the decrease in emissions in Blue States and the insignificant findings in Red States could result from state ideology - making this type of policy effective in progressive states and not effective in conservative states.[8] Red States observed a reduction in emissions of 12.6% (102,510 lives) with the introduction of a Regulatory Policy. Blue States lacked enough observations when using pscore matching and subsample grouping for significant regression analysis for a Regulatory Policy. As stated above, regulatory policies demand action in the form of compliance. Red States, which tend to have a larger proportion of their state GDP coming from industries that emit carbon emissions, are forced to take action under regulatory policies.[9] These synergies may explain why Red States see a significant and large reduction in $CO_2$ emissions and Blue States see an insignificant result.

Blue States experienced an increase in emissions by implementing a Grant or Loan Policy and a Sales Tax Incentive Policy, increasing emissions by 2% and 2.5% (16,290 and 20,340 lives), respectively. I speculate that the magnitude of the impact many loans and grant programs have is minimal. For example, the Energize Delaware Home Energy Loan Program provides eligible homeowners $1,000 to $30,000 at a 5.99% fixed interest rate of term length up to 10 years. While this low-interest loan program may provide support to sustainable energy usage, I do not believe that a program like this would significantly impact state-level emissions, given its reliance on individuals to seek out this financial incentive. As a result, Blue States saw a relatively normal increase in carbon emissions, even when implementing a Grant or Loan Policy. Other financial

[8] In Behavioral Economic Theory, a “nudge” is essentially a means of encouraging or guiding behavior, but without mandating or instructing

[9] Mining, Oil & Gas Extraction GDP as % of total state GDP means: 4.4% in Red States, 0.7% in Blue States
Transportation GDP as % of Total State GDP means: 3.9% in Red States, 2.6% in Blue States
Manufacturing GDP as % of Total State GDP means: 13.3% in Red States, 11.6% in Blue States

incentives included in the Financial Policy variable may have caused the reduction in emissions seen in the above paragraph for Blue States, leading me to believe Grant and Loan Policies are not key catalysts for changes in emission levels in this subsample of states.

Furthermore, Sales Tax Incentives for renewable energy typically come in the form of state sales tax or sales tax and use exemption for the purchase of a solar (or other renewable) energy system. This type of policy helps reduce the upfront costs of a solar (or other renewable energy) installation (Solar Energy Industries Association, n.d.). Although upfront costs may be cut for the installation, $CO_2$ pollutants still emit from the process of installation and transportation of the system. This fact may help explain why both Red and Blue states observe either no effect (insignificant results) or an increase in $CO_2$ emissions when implementing a Sales Tax Incentive.

A Building/Green Policy increased Red and Blue States emissions by 10.3% and 3.9% (83,790 and 31,770 lives), respectively. Some of the policies included in the aggregated variable counter any reduction in emissions caused by an individual policy in the group. An Energy Standards for Public Buildings Policy was insignificant in both subsamples.

A Building Energy Code Policy had opposite effects in the two groups, increasing emissions by 14.8% (120,420 lives) in Red States but decreasing emissions by 17.2% (139,950 lives) in Blue States. A possible explanation for these results involves the newness of this type of policy in Red States vs. Blue States. In many Democratic-leaning states, residential International Efficiency Conservation Code (IECC) building codes have been frequently updated to the leading standards (See Figure 2 in the Appendix)

(Smith 2021). Alternatively, Red States have lagged in adopting up-to-date standards, losing out on possible improved effectiveness in energy efficiency, thus losing potential $CO_2$ emission reduction. As seen in Figure 3 (p. 53), the adoption of up-to-date American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) codes is better across all states. However, right-leaning states again tend to lag in comparison to left-leaning states. The difference in adoption of more modern codes could offer an explanation for why Building Energy Code Policies only reduce emissions in Blue States.

An RPS Policy implementation has conflicting results between Red and Blue States. Red States see a growth of 2.1% $CO_2$ emissions, significant at 10%, while Blue States see a 3.4% reduction in $CO_2$ emissions, significant at 1%. Public support for RPS Policies can give insight into these results. Figure 4 (p. 55) depicts the following figures. The majority of Red States have the least public support for RPS – ranging from 30% to 60% (Stuaffer 2017). In most of these states, the current policy has no target or has voluntary targets. Because most of these states have no target or a voluntary target, the positive result may indicate that energy operations are not experiencing change, and the RPS Policy is ineffective in reducing emissions. Alternatively, the majority of Blue States public support for RPS ranges from around 55% to 85%. Most of these states currently have a binding, committing to less than 25% clean energy of retail electricity sales, or binding, committing to 25%, RPS Policy in place. Therefore, the nature of the binding commitment – confirmed dedication of a certain percentage of the electricity mix to come from renewable sources by a given date – justifies the decrease in emissions seen in my regression analysis.

Solar/Wind Access Policy implementation also had opposite effects. The policy decreased emissions by 1.7% (13,860 lives) in Red States but increased emissions by 6.8% (55,350 lives) in Blue States. The discrepancy in results observed in Red and Blue states could be explained by the geographical characteristics of states that lean Republican. A stronger positive Installed Wind Capacity (WC)/Wind Energy Penetration (WP) correlation with Republican-leaning states has been observed in previous literature (Schumacher et al. 2018), which in large parts could be explained with the Republican Party's dominance in rural states, most notably in the Midwest and the Great Plains areas, where most of WPT (Wind Potential) is located.[10] Given that right-leaning states tend to have higher WC & WP, the reduced emissions in Red States due to a Solar/Wind Access Policy, and not in Blue States, is justified.

*B. Dependent Variable: Log Employment*

[10] Wind Potential [Potential installed capacity (MW) ≥ 35% GCF 110m hub height, 2014 turbine technology (MW)]

Table 8: Regression Analysis of Log Employment

**Table 7. Regression Analysis of Log Employment**

| | High Emission Group | Low Emission Group | High Population Group | Low Population Group | Red States | Blue States |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Financial Policy Dummy | 0.007 *** | 0.014 *** | - | 0.008 *** | 0.007 *** | -0.006 * |
| | (.001) | (.004) | - | (.003) | (.002) | (.003) |
| Regulatory Policy Dummy | 0.059 *** | 0.039 | - | -0.074 *** | -0.074 *** | - |
| | (.001) | 0.139 | - | (.002) | (.002) | - |
| Sales Tax Incentive Dummy | 0.003 | -0.023 *** | 0.005 | -0.018 *** | -0.012 ** | -0.011 *** |
| | (.003) | (.005) | (.004) | (.004) | (.005) | (.003) |
| Grant/Loan Policy Dummy | 0.019 *** | 0.011 *** | 0.011 ** | 0.019 *** | 0.019 *** | 0.014 *** |
| | (.003) | (.005) | (.004) | (.003) | (.004) | (.004) |
| Grant Policy Dummy | -0.020 *** | 0.014 *** | 0.011 *** | 0.002 | -0.020 *** | -0.005 *** |
| | (.004) | (.004) | (.003) | (.003) | (.005) | (.002) |
| Building/Green Policy Dummy | -0.041 *** | 0.027 *** | -0.021 *** | 0.015 * | 0.042 *** | -0.001 |
| | (.005) | (.011) | (.007) | (.009) | (.012) | (.006) |
| RPS Policy Dummy | -0.016 *** | 0.017 *** | -0.012 *** | 0.009 * | 0.009 | -0.005 |
| | (.003) | (.006) | (.003) | (.005) | (.006) | (.003) |
| Energy Standards for Public Buildings Dummy | -0.026 *** | 0.015 | -0.014 *** | 0.006 | -0.006 | -0.010 *** |
| | (.004) | (.005) | (.003) | (.004) | (.005) | (.004) |
| Building Energy Code Policy Dummy | -0.070 *** | 0.054 *** | 0.078 *** | 0.018 | 0.101 *** | 0.114 *** |
| | (.018) | (.019) | (.008) | (.014) | (.019) | (.005) |
| Solar Wind Access Policy Dummy | -0.006 ** | 0.025 *** | 0.013 *** | 0.012 *** | -0.013 *** | 0.015 *** |
| | (.003) | (.003) | (.003) | (.003) | (.004) | (.002) |
| **Controls** | | | | | | |
| Race | Yes | Yes | Yes | Yes | Yes | Yes |
| Sex | Yes | Yes | Yes | Yes | Yes | Yes |
| State Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |

*t* statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

*note:* the dash (-) indicates that when using propensity score matching and specific grouping, there is not enough observations for significant regression analysis

For this section - any significant results below a 1% threshold will be considered a significant zero effect on employment.

### *a. High Emissions Group vs. Low Emissions Group: Employment Regression Results & Comparison*

A Financial Policy was associated with an increase in total state employment in the low emission group by 1.4%. The high emission group experienced a significant zero effect with just a 0.7% increase in state employment. Implementation of a Regulatory Policy increased employment by 5.9% in the high emission group, while having an insignificant effect in the low emission group. These results refute arguments that pushing renewable energy initiatives will hurt total employment. There is either a positive impact on employment in these two aggregated policy categories or no impact.

In these two aggregated policy categories, there is either a positive impact on employment, or no effect (Mundaca et al. 2015).

A Sales Tax Incentive Policy introduction had an insignificant impact on employment in the high emissions group but decreased employment by 2.3% in the low emission group. Taking this result with the findings of Yi (2013) (which includes Sales Tax Incentives in the analysis), we can see that although Sales Tax Incentives may increase the number of green jobs, the net impact of the policy on employment is still negative.

A Grant or Loan Policy increased employment in both groups - a 1.9% increase in the high emission group and 1.1% in the low emission group. This result confirms findings from prior research which found the ARRA program, which provided $2.3 billion for renewable energy generation, energy storage, advanced transmission, energy conservation, renewable fuel refining or blending, plug-in vehicles, and carbon capture, created 192,900 direct and indirect jobs from clean energy spending.[11]

A Building/Green Policy implementation reduces employment in the high emissions group by 4.1%. Alternatively, the low emissions group experiences increased employment by 2.7%. It is possible that the high emission group sees more long-term impacts of such green building projects on employment. The average year in the high emission group with a Building/Green Policy in place is 1.3 years earlier than the low emission group. Due to the youth of the policies in low emission states may not realize the eventual drop in total employment caused by a Building/Green Policy.

[11] The American Recovery and Reinvestment Act of 2009 (ARRA) provided billions of dollars in financing to homeowners, businesses, and local governments to invest in energy-efficiency and renewable-energy technology through the Department of Energy’s State Energy Program

An Energy Standard for Public Buildings decreases employment in the high emission states by 2.6%. The same type of policy implementation has an insignificant effect on employment in low emission states. This finding is consistent with the results discussed in the above section on the aggregate policy variable for green building initiatives.

A Building Energy Code has differing effects in the two groups as well. The policy reduces employment in the high emissions group by 7.0%, but increases employment by 5.4% in the low emission group. This finding is consistent with the aggregated green building variable results and the Energy Standards for Public Buildings results. It makes sense that this policy sees a relatively high percentage increase in employment in low emission states. This result, working in conjunction with the insignificant findings in the energy standards for public buildings, allows for a logical explanation for the slight percentage increase in employment seen from the Building/Green Policy variable.

An RPS Policy provides almost exactly opposite effects in the two groups. The high emissions group experiences a 1.6% reduction in employment, while the low emissions group sees a 1.7% increase in employment. I speculate that the reduction in employment in high emission states results from net job impact. Because high emission states tend to have significant employment in high emission producing industries, this job loss outweighs the job growth in green job creation observed as a result of an RPS Policy (Friedrich et al. 2017). Alternatively, low emission states can observe the green job growth without taking as much of a job market hit in pollution heavy industries.

The high emission group sees a significant zero effect when a Solar/Wind Access Policy is implemented. The low emission group sees a 2.5% increase in employment with the same policy implementation. This result confirms prior literature (Patricia et al. 2019) that claims increased RES-E capacity induced a rise in employment.[12]

### *b. High Population Group vs. Low Population Group: Employment Regression Results & Comparison*

With pscore matching and subsample grouping, there are not enough observations for significant regression analysis in the high population group on a Financial Incentive Policy. A significant zero effect is observed in the low population group for a Financial Incentive Policy.

Again, there were insufficient observations for significant regression analysis in the high population group for a Regulatory Policy. However, a Regulatory Policy implementation lowered employment by 7.4% in the low population group. Forced compliance to renewable energy initiatives may have hit the manufacturing industry hard in low population states. Vermont, for example, has one of the highest employment rates. However, some business owners in the state claim they lack qualified, skilled workers for their companies, specifically the manufacturing industry (World Population Review, n.d.). Highly skilled workers are needed for the R&D and manufacturing of renewable energy sources and highly-complex electricity grids. As a result, this subsample may accrue layoffs, explaining the result above.

A Sales Tax Incentive had an insignificant effect on employment in the high population group. Alternatively, the same policy implementation dropped employment by

[12] RES-E: Electricity from Renewable Energy Sources

1.8% in the low population group. Low population states may not have the infrastructure in place to capitalize on the prospective employment benefits that may result from higher demand in renewable energy sources that result from a Sales Tax Incentive. As seen in Table 3 (p. 55), 52.63% of the states in the low population group that have a Sales Tax Incentive in place have Renewables Utility-Scale Net Electricity Generation (share of total) 10% or more below the national average (EIA 2022). Job stability may occur in other states that have stronger renewable energy infrastructure. The low population states will only see a decrease in employment resulting from outsourcing energy generation.

A Grant or Loan Policy had significant impacts on employment in both the high and the low population groups - increasing employment by 1.1% and 1.9%, respectively. This observation is in line with the high and low emission subsamples, indicating this policy may be effective in increasing employment in many states with varying characteristics.

Opposite effects were observed from regressing a Building/Green Policy on employment in the groups. A 2.1% reduction was observed in the high population group, while a 1.5% increase in employment was observed in the low population group.

An Energy Standards for Public Buildings Policy dropped employment by 1.4% in the high population group but saw insignificant effects in the low population group.

A Building Energy Code Policy increases employment in high population states by 7.8%. Again, in the low population group, insignificant effects were observed.

An RPS policy dropped employment by 1.2% in the high population group while having a significant zero effect in the low population group. Renewable energy policy adversaries argue that pushing these policies will hurt the job market. The results above confirm this for implementation of an RPS Policy in high population states only. The Smart Grid sector supported 25,000 jobs in 2017 compared to 5,255 in 2016 (McGinn & Schneer 2019). Although this growth figure is strong, in the overall state job market, this gain in green jobs is likely outweighed by other job market movers.

The introduction of the Solar/Wind Access Policy had positive impacts on employment in both high and low population states - 1.3% and 1.2%, respectively. These results indicate that Solar/Wind Access Policies create jobs. As solar and wind power access increases as a result of this policy, firms will need to increase headcount to keep up with growing manufacturing, transportation, and installation demands.

### *c. Red States vs. Blue States: Employment Regression Results & Comparison*

A Financial Policy in both Red States and Blue States has a significant zero effect on employment. A Regulatory Policy hurts employment in Red States, dropping total state employment by 7.4%. An average of 4.5% of Red States' GDP comes from mining, quarrying, and oil & gas extraction, compared to just 0.72% in Blue States. Because RE Regulatory Policies mandate action to comply with the proposed goal or target, these major industries in Red States will be under pressure. As a result, employment falls as companies are forced to downsize operations, as observed in the above result. In Blue States - there were not enough observations for significant regression analysis.

A Sales Tax Incentive has the same effect on employment in both Red and Blue States, reducing employment by 1.2% and 1.1%, respectively. A Grant or Loan Policy also positively influences employment in both Red and Blue States, increasing employment by 1.9% and 1.4%, respectively. It is worth noting that this positive effect is observed across all six subsamples. It is the only policy that does not adversely affect employment in any state groupings.

A Building/Green Policy raises employment by 4.2% in Red States. Alternatively, there are insignificant impacts on employment in Blue States resulting from a Building/Green Policy implementation. Building green structures likely has no impact on the major industries in Red States, allowing for new green building jobs to accrue over the years of the study.

An RPS Policy has insignificant implications for employment in both Red and Blue States. This insignificant result confirms findings from Zhao et al. (2016) that renewable energy generation is not a job creator.

Introducing an Energy Standards for Public Buildings Policy had no significant effect on employment in Red States but it reduced employment in Blue States by 1.0%. Alternatively, both Red and Blue States saw an increase in employment from a Building Energy Code Policy - by 10.1% and 11.4%, respectively. Building Energy Codes increase employment in every subsample except the low population and high emission groups.

A Solar/Wind Access Policy has differing impacts on employment in Red vs. Blue States. Red States saw a reduction of 1.3%, while Blue States saw an increase of 1.5%. Similar to the impact seen when the dependent variable is log emissions, the geographical characteristics of Red States make them ideal candidates for large-scale solar and wind power production. Because of this, I speculate the demand for the labor needed to install such systems is higher than in Blue States. However, the added pressure to implement this type of energy source may cause companies in the fossil fuel industry to reduce headcount slightly to cut overhead costs, as they anticipate a downward trend in fossil fuel usage. Blue States may be able to capitalize on the solar and wind power shift, adding jobs without significant job loss in the fossil fuel industry (as its involvement in the sector is lower than in Red States), explaining the percentage increase in employment in Blue States.

# CHAPTER SEVEN

# CONCLUSION

*A. Summary & Policy Implications*

Exemplified by the analysis in this paper, the question of whether or not the Green New Deal will be good or bad for the economy, employment, emissions, etc., is far too simplistic. The most high-level takeaway presented in this paper is that a nuanced approach to green policy implementation is imperative for their success. The results in this paper show how even with broad subsample groupings, the impact of a policy can change dramatically. 21 regression estimates are contradictory between comparative groups. Furthermore, many policies that achieve emission reduction goals negatively impact employment, and many policies that reduce emissions also reduce employment. This paper explores possible explanations for why some of these interactions are occurring, and policy-makers must carefully consider what other factors may contribute to the outcome of the policy in question. All context should be considered in order for policies to be successful. Underlying factors need to be considered on a case-by-case basis to help policy-makers decide which type of policy to implement. For example, are there loopholes in the legislation of Solar/Wind Access Policies that high emission states are taking advantage of - causing the policy to be ineffective in reducing emissions?

At the time of this paper, crude oil prices are skyrocketing as a result of the Russia-Ukrainian conflict overseas. Now more than ever, lawmakers are in a unique situation to shift their focus to renewable energy alternatives and decrease dependence on oil and natural gas imports. Findings of this paper are imperative to the future of energy in the United States.

*a. Emissions*

Financial incentives have the most consistent negative impact on $CO_2$ emissions across all subsamples. Renewable Portfolio Standards lower $CO_2$ emissions in the majority of subsamples (66% of subsamples).

*b. Employment*

Solar/Wind Access Policies positively impact employment in 66% of subsamples and do not induce a drop in employment in 83% of subsamples.

Policy-makers need to be careful with the influence of policies on employment in high emission states, as 60% of the policies included in this study reduced total employment.

*c. Across Dependent Variables*

Democratic states should highly consider implementing a Building Energy Code if they do not have one in place already, as they positively impact employment and reduce carbon emissions.

High population states should highly consider Solar/Wind Access Policies, as they also are effective in reducing emissions while positively impacting employment levels. Additionally, high population states should consider implementing Grant or Loan Programs as they reduce emissions and positively influence employment.

RPS Policies reduce emissions in low population states and have no impact on employment - they should also be considered an option.

Policy-makers should also be aware that Grant or Loan Programs also reduce emissions and increase employment in high emission states.

*d. Green New Deal Implications*

Figure 5 below outlines a few goals and projects of the Green New Deal, tying the goals with applicable policies discussed in this paper and where the policy may be effective. Bolded subsamples are effective in reducing carbon emissions and increasing employment. "Entire Sample" refers to when the regressions were run with all 50 states together – without any sampling.

Figure 5:

| Green New Deal Goal | Applicable Policy | CO2 Effective | Employment Effective |
|---|---|---|---|
| Meeting 100 percent of the power demand in the United States through clean, renewable, and zero-emission energy sources, including—<br>(i) by dramatically expanding and upgrading renewable power sources; and<br>(ii) by deploying new capacity | Sales Tax Incentive, Solar/Wind Access Policy, RPS Policy | **Low Emission States**, **High Population States**, **Low Population States**, Red States, **Blue States** | **Low Emission States**, **High Population States**, **Low Population States**, **Blue States** |
| Building or upgrading to energy-efficient, distributed, and ''smart'' power grids, and ensuring affordable access to electricity | RPS Policy | High Population States, Low Population States, Blue States | Low Emission States |
| Upgrading all existing buildings in the United States and building new buildings to achieve maximum energy efficiency, water efficiency, safety, affordability, comfort, and durability, including through electrification | Building Energy Code, Energy Standards for Public Buildings | Entire Sample, High Emission States, Low Population States, **Blue States** | Low Emission States, High Population States, Red States, **Blue States** |
| Spurring massive growth in clean manufacturing in the United States and removing pollution and greenhouse gas emissions from manufacturing and industry as much as is technologically feasible, including by expanding renewable energy manufacturing and investing in existing manufacturing and industry | Grant/Loan Policies, Sales Tax Incentives | **High Emission States**, **Low Emission States**, **High Population States** | Entire Sample, **High Emission States**, **Low Emission States**, **High Population States**, Low Population States, Red States, Blue States |
| Overhauling transportation systems in the United States to remove pollution and greenhouse gas emissions from the transportation sector as much as is technologically feasible, including through investment in—<br>(i) zero-emission vehicle infrastructure and manufacturing;<br>(ii) clean, affordable, and accessible public transit; and<br>(iii) high-speed rail | Grant/Loan Policies, Sales Tax Incentives | **High Emission States**, **Low Emission States**, **High Population States** | Entire Sample, **High Emission States**, **Low Emission States**, **High Population States**, Low Population States, Red States, Blue States |

*B. Limitations*

A primary limitation of this study comes from the outcome variables. The high level of aggregation that comes with state-level outcome variables causes concealment of differences between and among important subgroup categories. Although I tried to address this issue by leveraging the six subsamples, many more local-level effects are not appropriately observed.

Because the observations are at the state level, I cannot control for time varying-state characteristics. We miss out on controlling for certain characteristics or events that occur in year *t* in state *s*. Our analysis can only control for observations being in state *s*, and year *t* individually. With time varying-state characteristics missing in the analysis, we could lose some accuracy.

### *C. Further Research*

While the results of this study provide critical insight into the effectiveness of specific policies in certain locations and socioeconomic and geopolitical settings in the US, further research is needed. This study emphasizes the need for a more granular assessment of these policies to develop an exhaustive understanding of how they function in unique geopolitical and socioeconomic settings. A granular study, perhaps at the county level across the United States, would allow for a more accurate and complete analysis of renewable energy policies and give policy-makers a full picture of the renewable energy landscape in the US.

## APPENDIX

### Table 1: Descriptive Statistics - High Emission Group

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Building/Green Dummy | 520 | .762 | .427 | 0 | 1 |
| Grant/Loan Dummy | 520 | .644 | .479 | 0 | 1 |
| Renewable Portfolio Standard Dummy | 520 | .546 | .498 | 0 | 1 |
| Emissions (Million Metric Tons) | 520 | 170.678 | 116.343 | 74.47 | 684 |
| Log Emissions | 520 | 4.991 | .504 | 4.31 | 6.528 |
| Total State Employment | 520 | 5429581.3 | 4295521.1 | 868331 | 24078517 |
| Mining, Quarrying, Oil & Gas Extraction Employment | 517 | 34588.17 | 72702.39 | 2340 | 552397 |
| Construction Employment | 520 | 303187.93 | 239209.86 | 43573 | 1283262 |
| Manufacturing Employment | 520 | 437236.71 | 308002.41 | 49438 | 2035437 |
| Transportation, Utilities, & Warehousing Employment | 520 | 210196.53 | 170393.39 | 29820 | 1183490 |
| Total State GDP | 520 | 436196.76 | 414928.3 | 41714.301 | 2730974 |
| Mining, Quarrying, Oil & Gas Extraction GDP | 520 | 7641.442 | 23044.924 | 119.8 | 205168 |
| Transportation & Warehousing GDP | 520 | 12919.66 | 11237.532 | 1393.7 | 71855 |
| Manufacturing GDP | 520 | 56380.063 | 48098.374 | 5392.6 | 314935.59 |
| Utilities GDP | 520 | 7360.491 | 6316.301 | 1118.1 | 37746.398 |
| Population | 520 | 9402320.6 | 7567632.9 | 1798582 | 39557045 |
| Red/Blue State | 520 | .562 | .497 | 0 | 1 |
| # of Cars (Registered) | 520 | 7583545 | 5913992 | 1351746 | 34433206 |
| Population Density | 520 | 210.81 | 232.854 | 32.91 | 1200.771 |
| Minimum Wage | 438 | 6.433 | 1.524 | 2.65 | 11.5 |
| Educational Attainment | 520 | 5.797 | .282 | 5.058 | 6.599 |
| Race | 520 | 1.572 | .321 | 1.124 | 2.858 |
| Age | 520 | 39.72 | 1.815 | 35.479 | 45.088 |
| Sex | 520 | 1.515 | .007 | 1.493 | 1.533 |
| Regulatory Policy Dummy | 520 | .96 | .197 | 0 | 1 |
| Financial Incentive Dummy | 520 | .927 | .261 | 0 | 1 |
| Building Energy Code Dummy | 520 | .673 | .47 | 0 | 1 |
| Solar/Wind Access Policy Dummy | 520 | .725 | .447 | 0 | 1 |
| Sales Tax Incentive Dummy | 520 | .531 | .5 | 0 | 1 |
| Energy Standard for Public Buildings Dummy | 520 | .648 | .478 | 0 | 1 |

### Table 2: Descriptive Statistics - Low Emission Group

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Building/Green Dummy | 430 | .707 | .456 | 0 | 1 |
| Grant/Loan Dummy | 430 | .721 | .449 | 0 | 1 |
| Renewable Portfolio Standard Dummy | 430 | .558 | .497 | 0 | 1 |
| Emissions (Million Metric Tons) | 430 | 39.893 | 21.35 | 5.4 | 74.2 |
| Log Emissions | 430 | 3.487 | .696 | 1.692 | 4.307 |
| Total State Employment | 430 | 1277867.7 | 947517.07 | 324653 | 4854672 |
| Mining, Quarrying, Oil & Gas Extraction Employment | 396 | 9772.646 | 10250.989 | 185 | 48555 |
| Construction Employment | 426 | 75038.676 | 51592.261 | 20678 | 261037 |
| Manufacturing Employment | 428 | 93391.671 | 77696.559 | 10441 | 311711 |
| Transportation, Utilities, & Warehousing Employment | 426 | 46136.014 | 33069.094 | 10574 | 190279 |
| Total State GDP | 430 | 99851.604 | 94377.497 | 15679.7 | 532354.31 |
| Mining, Quarrying, Oil & Gas Extraction GDP | 430 | 1929.887 | 3431.898 | .1 | 20392.301 |
| Transportation & Warehousing GDP | 430 | 3070.453 | 2351.671 | 376.8 | 12027.1 |

| | | | | | |
|---|---|---|---|---|---|
| Manufacturing GDP | 430 | 10969.857 | 11843.6 | 802.3 | 62816.199 |
| Utilities GDP | 430 | 1757.391 | 1473.412 | 365.8 | 7291 |
| Population | 430 | 2116563.1 | 1585934.9 | 492982 | 7163543 |
| Red/Blue State | 430 | .526 | .5 | 0 | 1 |
| # of Cars (Registered) | 430 | 1796766.6 | 1228181 | 507706 | 6725467 |
| Population Density | 430 | 171.321 | 281.984 | 1.1 | 1036.271 |
| Minimum Wage | 404 | 6.842 | 1.521 | 1.6 | 11 |
| Educational Attainment | 430 | 5.877 | .351 | 5.105 | 6.801 |
| Race | 430 | 1.692 | .777 | 1.123 | 5.169 |
| Age | 430 | 39.809 | 2.499 | 32.005 | 45.774 |
| Sex | 430 | 1.51 | .011 | 1.467 | 1.534 |
| Regulatory Policy Dummy | 430 | .967 | .178 | 0 | 1 |
| Financial Incentive Dummy | 430 | .923 | .266 | 0 | 1 |
| Building Energy Code Dummy | 430 | .651 | .477 | 0 | 1 |
| Solar/Wind Access Policy Dummy | 430 | .695 | .461 | 0 | 1 |
| Sales Tax Incentive Dummy | 430 | .347 | .476 | 0 | 1 |
| Energy Standard for Public Buildings Dummy | 430 | .479 | .5 | 0 | 1 |

**Table 3: Descriptive Statistics - High Population Group**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Building/Green Dummy | 308 | .812 | .392 | 0 | 1 |
| Grant/Loan Dummy | 308 | .692 | .463 | 0 | 1 |
| Renewable Portfolio Standard Dummy | 308 | .662 | .474 | 0 | 1 |
| Emissions (Million Metric Tons) | 308 | 207.025 | 137.276 | 62.69 | 684 |
| Log Emissions | 308 | 5.166 | .56 | 4.138 | 6.528 |
| Total State Employment | 308 | 7433538.9 | 4583602.6 | 3181571 | 24078517 |
| Mining, Quarrying, Oil & Gas Extraction Employment | 301 | 39615.12 | 91502.085 | 2340 | 552397 |
| Construction Employment | 308 | 406465.43 | 262096.62 | 159458 | 1283262 |
| Manufacturing Employment | 308 | 568877.01 | 326519.17 | 158837 | 2035437 |
| Transportation, Utilities, & Warehousing Employment | 308 | 286826.12 | 183979.58 | 99752 | 1183490 |
| Total State GDP | 308 | 624073.58 | 452037.45 | 203801.09 | 2730974 |
| Mining, Quarrying, Oil & Gas Extraction GDP | 308 | 9238.771 | 29291.542 | 119.8 | 205168 |
| Transportation & Warehousing GDP | 308 | 17872.205 | 12207.484 | 4722.9 | 71855 |
| Manufacturing GDP | 308 | 77382.749 | 52303.377 | 20584.5 | 314935.59 |
| Utilities GDP | 308 | 10180.699 | 6858.827 | 1532.6 | 37746.398 |
| Population | 308 | 12940552 | 8080706.1 | 6108612 | 39557045 |
| Red/Blue State | 308 | .422 | .495 | 0 | 1 |
| # of Cars (Registered) | 308 | 10223606 | 6419220.7 | 4182332 | 34433206 |
| Population Density | 308 | 310.416 | 282.202 | 54.488 | 1200.771 |
| Minimum Wage | 289 | 6.848 | 1.547 | 3.25 | 11.5 |
| Educational Attainment | 308 | 5.898 | .288 | 5.275 | 6.801 |
| Race | 308 | 1.685 | .335 | 1.258 | 2.858 |
| Age | 308 | 39.731 | 1.826 | 35.479 | 45.088 |
| Sex | 308 | 1.515 | .005 | 1.504 | 1.532 |
| Regulatory Policy Dummy | 308 | 1 | 0 | 1 | 1 |
| Financial Incentive Dummy | 308 | .964 | .186 | 0 | 1 |
| Building Energy Code Dummy | 308 | .721 | .449 | 0 | 1 |
| Solar/Wind Access Policy Dummy | 308 | .753 | .432 | 0 | 1 |
| Sales Tax Incentive Dummy | 308 | .617 | .487 | 0 | 1 |
| Energy Standard for Public Buildings Dummy | 308 | .714 | .452 | 0 | 1 |

**Table 4: Descriptive Statistics - Low Population Group**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Building/Green Dummy | 642 | .701 | .458 | 0 | 1 |
| Grant/Loan Dummy | 642 | .673 | .47 | 0 | 1 |
| Renewable Portfolio Standard Dummy | 642 | .498 | .5 | 0 | 1 |
| Emissions (Million Metric Tons) | 642 | 65.643 | 45.043 | 5.4 | 237.87 |
| Log Emissions | 642 | 3.9 | .83 | 1.692 | 5.472 |
| Total State Employment | 642 | 1687438.3 | 1042145.5 | 324653 | 3857800 |
| Mining, Quarrying, Oil & Gas Extraction Employment | 612 | 16058.662 | 21530.475 | 185 | 139586 |
| Construction Employment | 638 | 100991.92 | 63212.83 | 20678 | 273970 |
| Manufacturing Employment | 640 | 143938.45 | 120585.91 | 10441 | 696031 |
| Transportation, Utilities, & Warehousing Employment | 638 | 63657.824 | 41541.628 | 10574 | 211129 |
| Total State GDP | 642 | 120784.8 | 82355.334 | 15679.7 | 400406 |
| Mining, Quarrying, Oil & Gas Extraction GDP | 642 | 3049.626 | 5146.545 | .1 | 35003.199 |
| Transportation & Warehousing GDP | 642 | 3946.851 | 2688.499 | 376.8 | 12161.7 |
| Manufacturing GDP | 642 | 15889.072 | 13641.194 | 802.3 | 58874.102 |
| Utilities GDP | 642 | 2254.639 | 1533.858 | 365.8 | 7291 |
| Population | 642 | 2824982.7 | 1744583.5 | 492982 | 6091649 |
| Red/Blue State | 642 | .604 | .489 | 0 | 1 |
| # of Cars (Registered) | 642 | 2441094.2 | 1490460.3 | 507706 | 5820656 |
| Population Density | 642 | 136.575 | 223.015 | 1.1 | 1036.271 |
| Minimum Wage | 553 | 6.515 | 1.518 | 1.6 | 10.75 |
| Educational Attainment | 642 | 5.802 | .326 | 5.058 | 6.712 |
| Race | 642 | 1.598 | .661 | 1.123 | 5.169 |
| Age | 642 | 39.775 | 2.292 | 32.005 | 45.774 |
| Sex | 642 | 1.511 | .01 | 1.467 | 1.534 |
| Regulatory Policy Dummy | 642 | .945 | .227 | 0 | 1 |
| Financial Incentive Dummy | 642 | .907 | .291 | 0 | 1 |
| Building Energy Code Dummy | 642 | .636 | .482 | 0 | 1 |
| Solar/Wind Access Policy Dummy | 642 | .692 | .462 | 0 | 1 |
| Sales Tax Incentive Dummy | 642 | .366 | .482 | 0 | 1 |
| Energy Standard for Public Buildings Dummy | 642 | .503 | .5 | 0 | 1 |

## Table 5: Descriptive Statistics - Red States

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Building/Green Dummy | 518 | .674 | .469 | 0 | 1 |
| Grant/Loan Dummy | 518 | .656 | .475 | 0 | 1 |
| Renewable Portfolio Standard Dummy | 518 | .353 | .478 | 0 | 1 |
| Emissions (Million Metric Tons) | 518 | 118.908 | 119.844 | 13.3 | 684 |
| Log Emissions | 518 | 4.451 | .806 | 2.59 | 6.528 |
| Total State Employment | 518 | 2900783.7 | 3010271.7 | 324653 | 17606363 |
| Mining, Quarrying, Oil & Gas Extraction Employment | 516 | 32028.864 | 72825.795 | 711 | 552397 |
| Construction Employment | 517 | 179847.19 | 199126.86 | 20678 | 1207229 |
| Manufacturing Employment | 516 | 243925.78 | 231737.42 | 10441 | 1129114 |
| Transportation, Utilities, & Warehousing Employment | 516 | 118125.73 | 128507.44 | 13855 | 877812 |
| Total State GDP | 518 | 210399.78 | 249344.46 | 15679.7 | 1677110.9 |
| Mining, Quarrying, Oil & Gas Extraction GDP | 518 | 7597.015 | 23027.229 | 25 | 205168 |
| Transportation & Warehousing GDP | 518 | 7365.514 | 8573.185 | 525.8 | 61303 |
| Manufacturing GDP | 518 | 30144.2 | 36075.406 | 829.9 | 224691.8 |
| Utilities GDP | 518 | 3940.369 | 4578.126 | 365.8 | 28070.199 |
| Population | 518 | 5009794.1 | 5202787.5 | 492982 | 28701845 |
| Red/Blue State | 518 | 1 | 0 | 1 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| # of Cars (Registered) | 518 | 4186333 | 4062417.2 | 572623 | 22186241 |
| Population Density | 518 | 84.195 | 75.768 | 1.1 | 394.454 |
| Minimum Wage | 410 | 6.029 | 1.493 | 1.6 | 10.5 |
| Educational Attainment | 518 | 5.67 | .246 | 5.058 | 6.407 |
| Race | 518 | 1.505 | .273 | 1.124 | 2.57 |
| Age | 518 | 39.294 | 2.324 | 32.005 | 45.088 |
| Sex | 518 | 1.512 | .01 | 1.467 | 1.534 |
| Regulatory Policy Dummy | 518 | .932 | .251 | 0 | 1 |
| Financial Incentive Dummy | 518 | .903 | .296 | 0 | 1 |
| Building Energy Code Dummy | 518 | .635 | .482 | 0 | 1 |
| Solar/Wind Access Policy Dummy | 518 | .668 | .471 | 0 | 1 |
| Sales Tax Incentive Dummy | 518 | .34 | .474 | 0 | 1 |
| Energy Standard for Public Buildings Dummy | 518 | .483 | .5 | 0 | 1 |

**Table 6: Descriptive Statistics - Blue States**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Building/Green Dummy | 432 | .813 | .391 | 0 | 1 |
| Grant/Loan Dummy | 432 | .706 | .456 | 0 | 1 |
| Renewable Portfolio Standard Dummy | 432 | .789 | .408 | 0 | 1 |
| Emissions (Million Metric Tons) | 432 | 102.574 | 93.379 | 5.4 | 397.2 |
| Log Emissions | 432 | 4.141 | 1.091 | 1.692 | 5.984 |
| Total State Employment | 432 | 4329304.1 | 4532137.6 | 400963 | 24078517 |
| Mining, Quarrying, Oil & Gas Extraction Employment | 397 | 13161.607 | 15550.806 | 185 | 69887 |
| Construction Employment | 429 | 225275.53 | 227100.15 | 26104 | 1283262 |
| Manufacturing Employment | 432 | 327474.59 | 341524.29 | 16474 | 2035437 |
| Transportation, Utilities, & Warehousing Employment | 430 | 158147.12 | 173780.42 | 10574 | 1183490 |
| Total State GDP | 432 | 372156.06 | 434838.07 | 17176.9 | 2730974 |
| Mining, Quarrying, Oil & Gas Extraction GDP | 432 | 2009.6 | 3989.751 | .1 | 25746.9 |
| Transportation & Warehousing GDP | 432 | 9775.883 | 10918.122 | 376.8 | 71855 |
| Manufacturing GDP | 432 | 42638.832 | 49041.704 | 802.3 | 314935.59 |
| Utilities GDP | 432 | 5884.311 | 6335.633 | 420.1 | 37746.398 |
| Population | 432 | 7417258 | 8050830 | 609903 | 39557045 |
| Red/Blue State | 432 | 0 | 0 | 0 | 0 |
| # of Cars (Registered) | 432 | 5897066 | 6364688.1 | 507706 | 34433206 |
| Population Density | 432 | 323.325 | 327.339 | 15.003 | 1200.771 |
| Minimum Wage | 432 | 7.199 | 1.348 | 4.25 | 11.5 |
| Educational Attainment | 432 | 6.028 | .281 | 5.308 | 6.801 |
| Race | 432 | 1.771 | .778 | 1.123 | 5.169 |
| Age | 432 | 40.32 | 1.771 | 36.251 | 45.774 |
| Sex | 432 | 1.514 | .007 | 1.496 | 1.532 |
| Regulatory Policy Dummy | 432 | 1 | 0 | 1 | 1 |
| Financial Incentive Dummy | 432 | .951 | .215 | 0 | 1 |
| Building Energy Code Dummy | 432 | .697 | .46 | 0 | 1 |
| Solar/Wind Access Policy Dummy | 432 | .764 | .425 | 0 | 1 |
| Sales Tax Incentive Dummy | 432 | .576 | .495 | 0 | 1 |
| Energy Standard for Public Buildings Dummy | 432 | .678 | .468 | 0 | 1 |

Table 9:

| State (Low Population Group) | Utility-Scale Net Electricity Generation (share of total)<br>Renewables | U.S. Average |
|---|---|---|
| Alabama | **10.30%** | 22.20% |
| Arizona | **13.40%** | 22.20% |
| Colorado | 37.90% | 22.20% |
| Connecticut | **2.90%** | 22.20% |
| Iowa | 71.60% | 22.20% |
| Kentuckey | **9.20%** | 22.20% |
| Maryland | **11.00%** | 22.20% |
| Minnesota | 32.80% | 22.20% |
| Missouri | **13.70%** | 22.20% |
| Nebraska | 34.80% | 22.20% |
| Nevada | 29.50% | 22.20% |
| New Mexico | 37.10% | 22.20% |
| North Dakota | 43.80% | 22.20% |
| Rhode Island | **7.90%** | 22.20% |
| South Carolina | **8.70%** | 22.20% |
| South Dakota | 90.50% | 22.20% |
| Utah | **10.80%** | 22.20% |
| Vermont | 99.50% | 22.20% |
| Wisconsin | **11.40%** | 22.20% |
| **% of States Below National Average** | **52.63%** | |

Figure 1:

| Renewable Energy Policies | | |
|---|---|---|
| Sales Tax Incentive | Grant/Loan Policy | Building/Green Policy |
| | Grant Program<br>Loan Program | Building Energy Code<br>Energy Standards for Public Buildings<br>Green Building Incentive<br>Green Power Purchasing |
| Energy Standards for Public Buildings | Solar/Wind Access Policy | Building Energy Code |
| Financial Incentive Policy | Renewable Portfolio Standard (RPS) | Regulatory Policy |
| Loan Program<br>Grant Program<br>Rebate Program<br>Corporte Tax Credit<br>Property Tax Incentive<br>Personal Tax Credit<br>Sales Tax Incentive<br>Green Building Incentive<br>Solar Renewable Energy Credit Program | | Renewable Portfolio Standards<br>Appliance/Equipment Efficiency Standards<br>Energy Efficiency Resource Standard<br>Generation Discolsure<br>Interconnection<br>Net Metering<br>Building Energy Code<br>Energy Standards for Public Buildings<br>Green Power Purchasing<br>Solar/Wind Access Policy |

Figure 2:

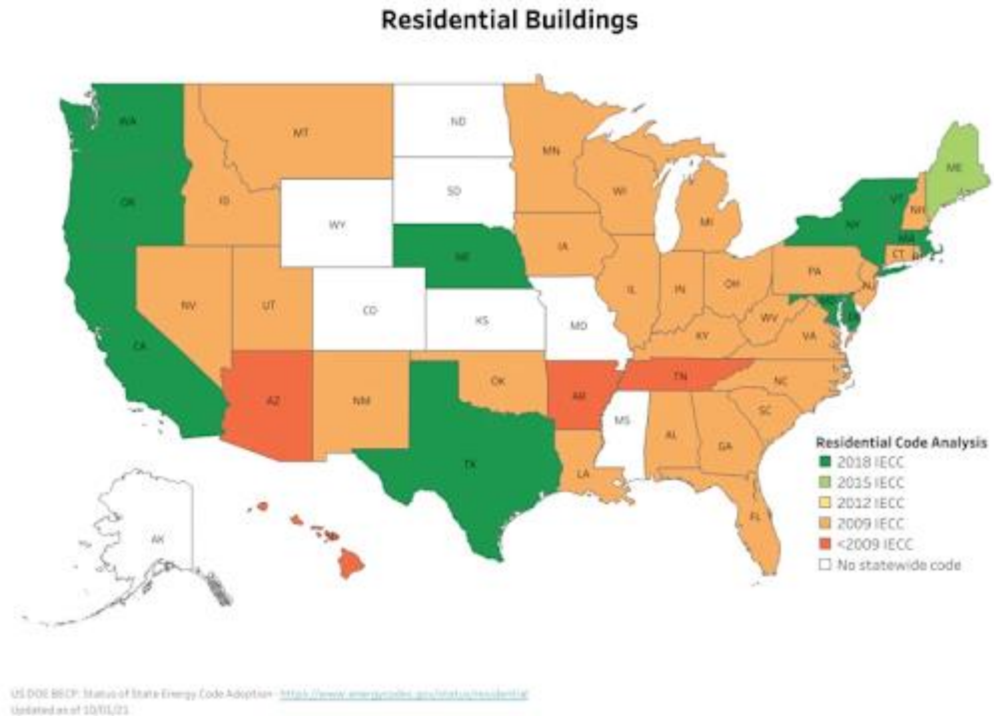



Figure 3:

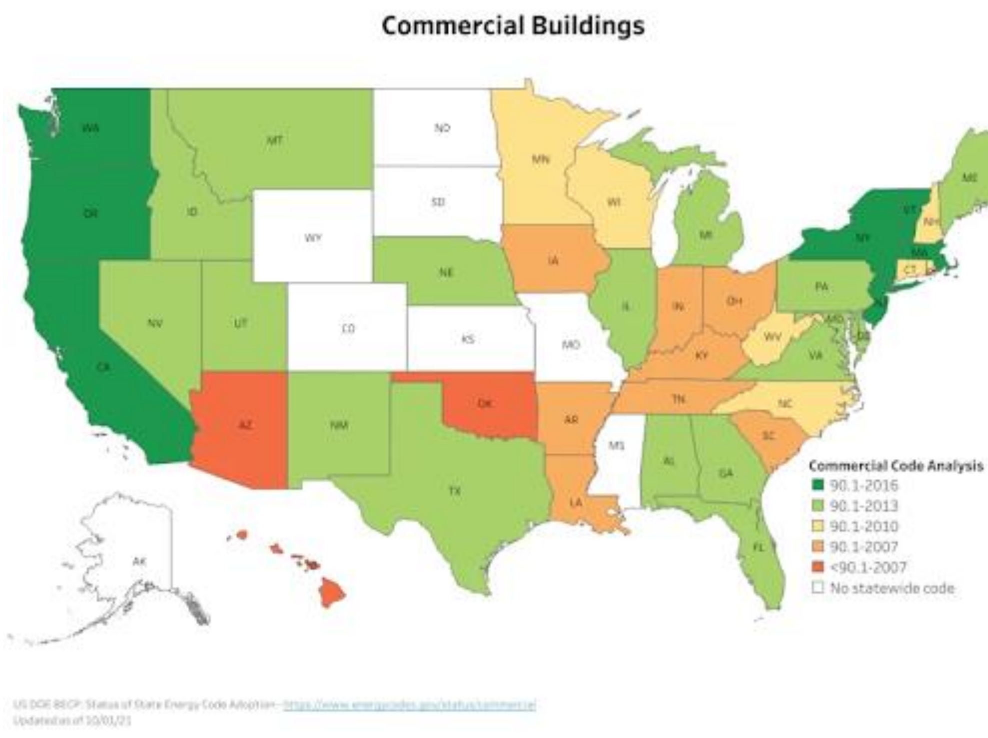
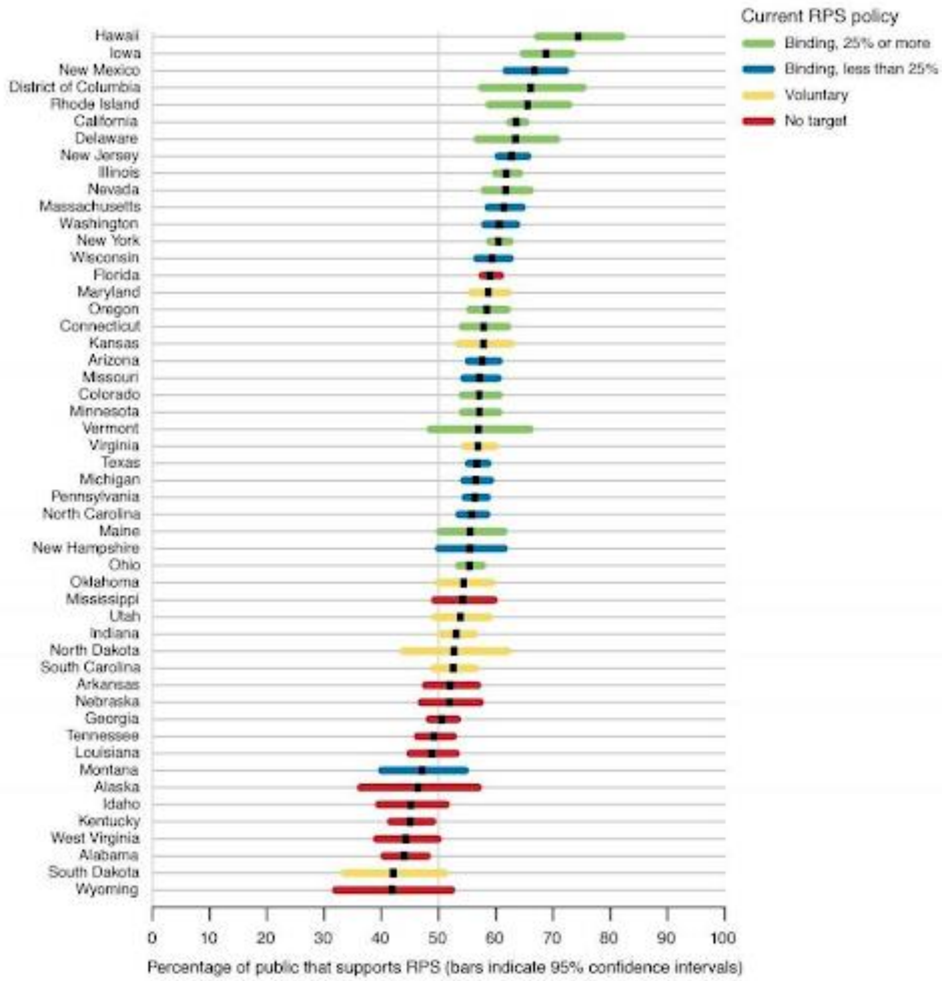


Figure 4:



Current RPS policy
Binding, 25% or more
Binding, less than 25%
Voluntary
No target
Hawaii
Iowa
New Mexico
District of Columbia
Rhode Island
California
Delaware
New Jersey
Illinois
Nevada
Massachusetts
Washington
New York
Wisconsin
Florida
Maryland
Oregon
Connecticut
Kansas
Arizona
Missouri
Colorado
Minnesota
Vermont
Virginia
Texas
Michigan
Pennsylvania
North Carolina
Maine
New Hampshire
Ohio
Oklahoma
Mississippi
Utah
Indiana
North Dakota
South Carolina
Arkansas
Nebraska
Georgia
Tennessee
Louisiana
Montana
Alaska
Idaho
Kentucky
West Virginia
Alabama
South Dakota
Wyoming
0
10
20
30
40
50
60
70
80
90
100
Percentage of public that supports RPS (bars indicate 95% confidence intervals)

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