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RENEWABLE PORTFOLIO STANDARDS IN THE USA: EXPERIENCE AND COMPLIANCE WITH TARGETS

by

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Abstract

Economic growth requires growth of energy consumption. In the second half of the twentieth century energy consumption began to outgrow its production and the United States. Consequently, we observe growing dependence of the U.S. economy on energy imports which is causing political and economic insecurity; increasing pollution and depletion of natural resources. One way to alleviate these problems is to encourage renewable electricity production. Because the electric power industry is the largest consumer of energy sources, including renewable energy, it has become one of the most frequent subjects of the regulatory policies and financial incentives aiming to stimulate renewable electricity production.

One of the most promoted renewable energy policies in this industry is a renewable portfolio standard (RPS), which requires electric utilities and other retail electric providers to supply a specified amount of electricity sales from renewable energy sources. Currently 29 states and District of Columbia have the RPSs, while 7 states have goals; but only about two third of those with the RPS have certain targets to meet.

To my best knowledge, there are no studies analyzing compliance with the RPSs targets or the role of penalty mechanism in the RPS design on meeting its goal. In my Master Thesis I estimate which states are in compliance with their individual RPSs goals and analyze which factors affect the probability of compliance, with the focus on the role of penalty size, and controlling for complimentary policies promoting renewable energy production. I use a fixed effects linear probability model and state level data. Results indicate that including a penalty in the RPS design significantly increases the probability that states will comply with their goals.

Table of Contents

List of Figures iv

List of Tables v

Dedication vi

1. Introduction 1

2. Literature Review 6

3. Data and Model 11

4. Hypotheses and Empirical Results 17

5. Conclusion 23

References 24

Appendix A - Fractional Goals 28

Appendix B - U.S. Energy Supply and Demand in 2009 32

Appendix C - State Characteristics 34

Appendix D - Net Metering 39

List of Figures

Figure A.1 Fractional goals in States with implemented RPS policies in 2003-2009 31

Figure B.1. Structure of the U.S. energy supply and demand in 2009 32

Figure B.2. Structure of the renewable energy supply in the U.S. in 2009 33

Figure C.1. States with Renewable Portfolio Standards and Goals in 2011 34

Figure C.2 Achieved percentage of eligible RE resources (2003-2009) 35

Figure C.3 States with Net Metering Policy in September 2009 36

Figure C.4 Grades given to States with Net Metering Policy in 2009 37

Figure C.5 LCV house score by states in 2009 38

List of Tables

Table 1.1. RPSs adoption in the USA.. 4

Table 3.1. Descriptive statistics for Dependent Variables... 13

Table 3.2. Descriptive statistics for Explanatory Variables... 14

Table 4.1. Coefficients estimates for Y as dependent variable (100% target)............................. 18

Table 4.2. Coefficients estimates for Y5 as dependent variable (95% target)............................. 20

Table 4.3. Coefficients estimates for Y10 as dependent variable (90% target)........................... 21

Table A.1. Fractional Goals set by RPS 28

Table A.2. Fractional Goals set by RPS minus 5% 29

Table A.3. Fractional Goals set by RPS minus 10% 30

Table D.1. Score Methodology used in 2007-2009 39

Table D.2. Grades Methodology used in 2007-2009... 40

Table D.3. Transfer of 2006 grades in 2007-2009 methodology... 41

Dedication

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1. Introduction

Being a key factor of economic growth, energy consumption is positively correlated with the gross domestic product (GDP). Growth of the energy consumption in the U.S. was balanced with the domestic energy production until the mid-fifties of the 20th century. According to the U.S. Energy Information Administration, in the second half of the twentieth century consumption began to outgrow its production, and the United States lost its energy self-sufficiency: during the 1949-2009 years, total energy consumption in the USA increased from 32.0 to 94.6 Quadrillion Btu, while energy production increased from 31.7 to 73.4 Quadrillion Btu (US EIA, table 1.1, 2009). Consequently, we observe a growing dependence of the U.S. economy on energy imports resulting in political and economic insecurity; increasing pollution and depletion of natural resources.

Total carbon dioxide emissions from the energy consumption in the USA increased from 4,776.569 million metric tons in 1980 to 5,833.133 million metric tons in 2008 (US EIA, 2008). The structure of the U.S. energy supply and demand presented in the figure B.1 indicates that petroleum, natural gas and coal together comprise 78.4% of the U.S. energy supply, while nuclear electric power accounts for 8.3% of energy supply, while the share of renewable energy is only 7.7% (US EIA, 2009). Figure B.2 indicates that from these 7.7% of renewable energy 35% are produced from hydro-sources, 24% from wood, 20% from biofuels, 9% from wind, 6% from biomass waste, 5% from geothermal and 1% from solar (US EIA, 2010).

The electric power industry is the largest energy consumer. As one can see from the figure B.1, in 2009, the electric power sector consumed 38.3 Quadrillion Btu, from which 48% was coal, 22% - nuclear electric power, 18% natural gas, 11% - renewable energy (including hydro) and 1% - petroleum. The electric power industry is also the largest consumer of renewable energy (its share in 2009 was 53%), 26% of renewable energy are used in industrial production (mostly, paper), 12% - in transportation sector (for production of transportation fuels) and 9% for residential and commercial space heating (mostly, biomass).

Recent debates on climate change are raising public concerns about the environment. The public good nature of good environment (it is non-excludable and non-rival) and market failures (pollution and natural resources depletion) require government to step in and offer effective public policy instruments. Because electric power industry is the largest consumer of energy sources, including renewable energy, it has become one of the most frequent subjects of regulatory policies and financial incentives aiming to stimulate renewable electricity production.

First attention to the problems of energy security and dependence on fossil fuels was brought by the 1973 energy crises. As a result, the U.S. Congress enacted the National Energy Act (NEA) of 1978, which comprised five Public Utility Regulatory Policies Act (PURPA) aimed to promote domestic production and the use of renewable energy; it required electric utilities to buy power from independent producers, therefore allowing them to enter the market and providing guarantee that power they produce will not be wasted. Despite the expiration of many contracts signed under it and restructuring electricity markets which gave more freedom to independent power producers, PURPA is important because it exempts the developers of renewable energy from numerous State and Federal regulatory regimes. Energy Tax Act provided income tax credits to residential sector and businesses for renewable energy equipment. National Energy Conservation Policy Act (NECPA) obliged utilities to implement energy audits and demand management programs. Power Plant and Industrial Fuel Use Act constrained construction of power plants based on using oil and natural gas and limited use of oil and natural gas in large boilers. Natural Gas Policy Act restricted the use of natural gas by industrial users and electric utilities (was repealed in 1987).

In the foreword for 2007 report "Freeing the Grid", annually prepared by the Network for New Energy Choices (NNEC), Michael Dworkin, Director of the Institute for Energy and the Environment and Professor of Law, ex-chairman of a Vermont Public Service Board emphasized that modern energy world faces an "Energy Trilemma" - financial, environmental and security constraints (NNEC, 2007).

Two main types of energy and environmental policy can be offered to ensure sustainable economic growth: demand-side policies are focusing on the creating incentives to implement energy efficiency solutions in energy consumption, while supply-side policies are developed to stimulate renewable energy production. Financial incentives to motivate energy-efficiency and renewable energy production in the USA are offered by government at all levels, utilities and non-for-profit organizations. They are taking the form of tax credits (for property tax, corporate tax, personal and sales taxes), rebates, bonds, loan and grant programs, industry support (i.e. alternative energy investment tax credits), bonds, performance-based incentives (feed-in-tariffs, renewable energy credit programs) etc. Rules, regulations and policies include appliance/equipment efficiency standards, building energy codes, contractor licensing, energy standards for public buildings, equipment certification requirements, green power purchasing policies, interconnection standards, mandatory utility green power option, net metering, public benefits funds, renewable portfolio standards, solar and wind access laws and permitting standards. One of the most promoted renewable energy policies in this industry is a renewable portfolio standard (RPS). RPS requires electric utilities and other retail electric providers to supply a specified amount of electricity sales from renewable energy sources. Data about the

RPSs across the U.S. are collected in the Database of State Incentives for Renewables and Efficiency (DSIRE), funded by the U.S. Department of Energy (US DOE). The history of RPS policies adoption the USA is shown in the table 1.1.

Table 1.1. RPSs adoption in the USA

Year of adoption	States with the RPSs
1983	IA (105 MW, n.d.)
1997	MA (4%, 2009 + 1% each year after 2009), NV (20%, 2015)
1998	CT (27%, 2020)
1999	ME (30% by 2000, +1% since 2007), NJ (22.5%, 2021), TX (2880 MW, 2009, 5000 MW, 2015, 10000MW, 2025), WI (10%, 2015)
2001	IA (1000 MW, 2010)
2002	CA (20%, 2010), NM (20%, 2020)
2004	CO (20%, 2020), HI (20%, 2020), MD (20%, 2022), NY (24%, 2013), PA (18%, 2020), RI (16%, 2020)
2005	DC (20%, 2020), DE (20%, 2019), MT (15%, 2015)
2006	AZ (15%, 2025), WA (15%, 2020)
2007	IL (25%, 2025), MN (25%, 2025), NC (12.5%, 2020), NH (23.8%, 2025), OR (25%, 2025)
2008	MI (10%, 2015), MO (15%, 2021), OH (12.5%, 2025)
2009	KS (20%, 2010)

The first legislature act related to the stimulation of renewable energy production was enacted in the Iowa in 1983 in the form of the Alternative Energy Law. In 1997, Massachusetts and Nevada have adopted RPS policy. Connecticut enacted RPS in 1998, following by 4 states in 1999. California and New Mexico adopted the RPSs in 2002. Active diffusion of this policy started in 2004, when six more states joined this policy. Other 18 states adopted the RPSs during the years 2005-2008, following by Kansas in 2009 and Oklahoma with West Virginia in 2010. Thus, during the 1998-2010 thirty three more states and District of Columbia have passed the RPS legislation. From the map presented in the figure C.1.one can see that by March 2011 already 29 states and District of Columbia have the RPSs, while 7 states have goals (DSIRE, 2011).

These policies are very diverse in terms of eligibility of different alternative energy sources, target percentages, and schedule to meet established targets. It is assumed, that this policy will create such benefits as environmental improvement, increased diversity and security of energy supply, lower natural gas prices (due to higher competition among energy suppliers), and local economic development (mostly in rural areas). The main research interest of this paper is the compliance of states with their current goals, and it is necessary to review what studies of the RPSs policies were already undertaken.

2. Literature Review

As a new public policy, RPSs are actively discussed in literature. The first researchers raised questions on the proper policy design and implementation, debating on whether it should be adopted on national or state levels. Several papers provide econometric analysis of factors leading to RPS adoption. Another stream in the RPS studies includes discussions about expected impact of RPS policies (more often using cost-benefit analysis). However, very few papers analyze actual effectiveness of RPS policies already enacted.

Although policy adoption is not the main factor of my study, these papers are helpful in choosing variables affecting demand for renewable energy one have to take into account in impact studies. Several publications investigating the adoption of RPSs are taking into an account four groups of explanatory variables: potential variables (solar and wind potential), private interest variables, public interest variables and political ideology. Huang at al. (2007) present a cross-sectional analysis for the year 2003, using a logit model of probability to adopt RPS policy. They found as significant such factors of RPSs' adoption as gross state product (GSP), growth rate of population, percentage of the population 25 years and over with at least a bachelor's degree, political party dominance and natural resources expenditures. The impact of the first three factors is found as positive: the higher GSP, the higher its population growth and the more people older than 25 years in this state have at least a bachelor degree, the more probability that this state would adopt RPS policy. The impact of political party is found negative, as predicted – states with dominant republican ideology are less likely to adopt environment-related policies. The coefficient of the natural resources expenditures was found as positive, contrary to expectations. The share of coal in electricity generation was not found to be significant, the authors expected to find a negative impact of this variable reasoning that states with higher share of coal energy economically depend on coal industry would like to protect it from competition and are not be willing to promote alternative energy production to prevent. The authors conclude, that "if the federal government would like to promote the RPS policy, focus should be more on the states with lower GSP, greater GRP, and lower education levels".

Chandler (2009) confirmed as significantly affecting on the RPSs adoption such determinants as disposable personal income and government ideology. The author finds that population growth rate, industry dependence, and percent of population in non-attainment for sulfur dioxide are not significant in explanation RPSs adoption. Chandler also estimated three diffusion models, testing the impact of the percent of states already adopted such policy, taking into account all the states, or only regional states or only neighbors. He confirmed that diffusion is significant factor for RPSs adoption if the similar states (regional or neighboring) have already adopted such policy, with regional effect stronger than that of neighbors. Chandler analyzes adoption of the RPSs for the years 1997-2008. He uses an event history analysis approach, excluding from the model a state once it has adopted a RPS policy. The author recognizes that the limitations of his work include weak predictive power of the presented model; non-significance of three explanatory variables; and exclusion of Iowa, Hawaii and Alaska from their analysis; repetition of government ideology scores for 2006 in the years 2007 and 2008 because of the absence of these data. The author suggests that in future research it might be more interesting to concentrate on the states-"non-adopters".

Lyon and Yin (2010) examine factors of adoption for RPS policy in general, and for in-state requirements in particular. They assume that states with poorer air conditions, higher unemployment rates, more environmental group members, stronger renewable industry interests, higher LCV (League of Conservation Voters) scores and more congressional seats occupied by

Democrats are more likely to adopt RPS policy. They consider data for 1997-2005, excluding Iowa, Colorado and the District of Columbia. Following Chandler (2010) Lyons and Yin (2010) exclude state from the sample once had adopted RPS. They use logistic conditional probability model, assuming that "the conditional probability of RPS adoption varies across period one (1997-1999), period two (2000-2002) and period three (2003-2005), but stays constant within each period." They found that main factors driving RPS adoption are "poor air quality conditions, strong environmental preferences of the general public and state congress persons, and the presence of organized renewable developers in the state". Contrary to their assumptions, authors found that impact of the unemployment rates is negative. They explain this finding, suggesting that states which adopt as are less likely to adopt an RPS.

Policy studies provide necessary background on design and implementation of renewable portfolio standards in the United States. For example, Michaels (2008) also points out differences in state RPS rules and argues that national RPS policy would be inefficient because it "will not affect the total emission of criteria pollutants, but it will allocate emission rights ineffectively". He also briefly describes RPS policies in Texas, Massachusetts, Nevada, Pennsylvania, Colorado and California. Michaels argues that job creation and infant industry arguments have no solid ground, and that main reasons to adopt RPS are not economical, but political; but his opinion has no objective proof. Rossi (2010) also opposes national RPS, disputing that it would cause wealth redistribution from states that lack natural resources to those states which are more fortunate to be endowed by renewable potential because of the difference in costs and benefits of their implementation. He also argues that direct carbon tax would be more effective in encouragement renewable energy production and would have less impact on the cost of using renewable.

L., Bird et al. (2005) analyze factors driving wind energy development in the USA, among which they name renewable portfolio standards, system benefit funds, integrated resource planning, property and sale tax incentives, green power markets and wholesale market rules. This study does not provide econometric analysis of the marginal contribution of these factors, but gives an insight on what control variables might be included when one is looking at the impact of RPS policies.

Swisher and McAlpin (2006) show that "states with renewable portfolio standards have a higher average percent of generation from renewable sources" and that "deregulation process creates an opportunity for implementation of state policies to reduce emissions". This study suggests that it is necessary to control for deregulation status in the analysis of renewable generation.

Carley (2009) use fixed effects model to analyze factors determining renewable energy electricity (total MWh and logged share) using state level-data from 1998-2006. She found that political institutions, natural resource endowments, deregulation, gross state product per capita, electricity use per person, electricity price and the presence of regional RPS policies are significant factors of renewable energy deployment. She concludes that RPS implementation is not a significant predictor of the percentage of renewable energy, although she observes its increase every year. The main drawback of this conclusion is the used timeframe. Dates when RPS policies were enacted maybe different from dates when these policies were put into effect, while targets established by these RPSs may be required to reach even at a later date in future: from 19 states established RPS by 2006 only ten had targets they had to meet in 2006 (comparing 2 in 2003). Because the author did not distinguish these dates, reached conclusion was wrong. Yin and Powers (2010) employ panel data to investigate the impact of RPSs on in-state electricity investment. Taking into account the difference in the stringency of RPS policies in various states, they conclude that RPS policies have significant and positive effect on in-state renewable investment.

Cory and Swezey (2007) describe difference in such RPSs' features as definitions of eligible renewable energy sources, the manner in which RECs are treated (ability to bank RECs, RECs tradability, tracking systems), compliance rules and enforcement mechanisms. They consider as strong those RPS Policy mechanisms those that include non-compliance penalties which can take a form of fines or alternative compliance payments (ACP). They classify as "weak" RPSs with such features as ambiguous definitions, frequent change of rules and weak enforcement mechanisms. This paper does not provide any empirical analysis. Its main contribution is broad classification of features that make up difference in RPSs policy designs.

To my best knowledge, there are no other studies analyzing nor compliance with RPS targets, neither the role of penalty mechanism in RPS design on meeting its goal. My main research interest is the analysis of the effectiveness of the RPS policies and defining the determinants of its successful implementation. Implementation of RPSs can bring about various economic, environmental and social benefits. In my opinion, the most important criterion of success of the certain RPS is whether it was able to bring about renewable energy electricity generation to achieve its goals. I assume that penalty size will play an important role in the successful implementation of the RPS: the higher penalty size the more likely that individual state will achieve its goal. Thus, in this paper, I am looking at the probability that a particular state implemented RPS meets its fractional goals in a given year with the focus on the penalty size. In the next paragraph I describe the data and introduce the model I will estimate.

3. Data and Model

All the data about the individual RPSs are derived from the Database of State Incentives for Renewables and Efficiency (DSIRE, 2011). Only 20 states and District of Columbia had RPS targets in 2009 or earlier. Two states (Iowa and Texas) are excluded from the analysis because their goals are set not as fractions but as capacity size. District of Columbia is excluded because of the lack of several variables. Figure A.1. visually represents fractional goals set by 18 states subject to his study. Panel is imbalanced because only 2 states had fractional goals in 2003, 1 more – in 2004, 2 more – in 2005, 4 in 2006, 3 in 2007, 4 in 2008 and 2 in 2009 etc. There are totally 68 state-year observations. To find out whether states are in compliance with their fractional goals I calculate the share of eligible renewable resources in the total electricity resources (REfact) using data on distribution of electricity generated (in MWh) by energy sources (coal, geothermal, hydro, natural gas, nuclear, wood and other biomass, petroleum, solar, wind and other gases) derived from historical tables (US EIA, 2011). Total renewables include geothermal, hydro, solar, wind, wood and other biomass. The total share of renewable in the electricity generated is found as the ratio of total amount of electricity generated from renewable sources to the total amount of electricity generated, expressed as a percentage. To get REfact (see figure C.2), I correct this number if necessary (i.e. deducting hydroenergy in Arizona, Connecticut and Montana), while counting only small hydro in California. I get data on small hydro from the California Energy Almanac (California Energy Commission, 2011).

I compare REfact with three parameters: Goal, Goal5 and Goal10. Goal is fractional Goal set by the RPS for the particular state and year. Goal5 takes value equal to 95% of the established Goal. We need it to find whether goal was met within a 5% margin. Similarly, Goal10 takes value equal to 90% of the established Goal and indicates whether state is in compliance with its goal within a 10% margin. I present tables including data about Goal, Goal5 and Goal10 set in the states of interest in tables A.1-A.3 of Appendix A. Therefore, I use three specifications for a binary dependent variable: Y, Y5 and Y10 as following:

$$Y = 1 \text{ if REfact} \geq \text{Goal, 0 otherwise} \tag{1}$$

$$Y5 = 1 \text{ if REfact} \geq \text{Goal5, 0 otherwise} \tag{2}$$

$$Y10 = 1 \text{ if REfact} \geq \text{Goal10, 0 otherwise} \tag{3}$$

I use a linear probability model (LPM) with state fixed effects, because I want to make conclusions on the fixed set of states and all of my explanatory variables are time-variant.

The model is a one way fixed effects model:

$$Y_{it} = \alpha + X_{it} * \beta + Z_{\mu} * \mu_{it} + \gamma_{it} \tag{4}$$

Model is called a one-way because it utilizes a one-way error component, consisting of individual specific effect and the remainder disturbance, unlike a two-way error component model, including also time-effects. Data comprise 18 states (i: 1…18), including Arizona (AZ), California (CA), Colorado (CO), Connecticut (CT), Delaware (DE), Illinois (IL), Massachusetts (MA), Maryland (MD), Maine (ME), Montana (MT), New Hampshire (NH), New Jersey (NJ), New Mexico (NM), Nevada (NV), New York (NY), Ohio (OH), Pennsylvania (PA) and Rhode Island (RI). I have at most 7 observations per state (t: 2003…2009).

X is a matrix of explanatory variables, including penalty or alternative compliance payment (PENALTY) in cents per kwh; net metering score (NM_SCORE), electricity price (ELPRICE) in cents per kwh, League of Conservation Voters House score (LCV_H), carbon dioxide emissions in million metric tons lagged by one year (CO2lag), real gross state product per capita (GSP_CAP) in thousands of the U.S. dollars, educational attainment of at least bachelor degree by people who are 25 years and older (EDU) as a percentage.

Z is a matrix of individual (state) dummies.

Table 3.1. Descriptive Statistics for Dependent Variable

Variable	Mean		St. Dev.	Min	Max	Observations	
	overall	0.40	0.49	0	1	N	65
	between		0.39	0	1	N	18
Y	Within		0.34	-0.4	1.23	T-bar	3.61
	overall	0.46	0.50	0	1	N	65
	between		0.44	0	1	N	18
y5	Within		0.28	-0.34	1.29	T-bar	3.61
	overall	0.51	0.50	0	1	N	65
	between		0.44	0	1	N	18
y10	Within		0.28	-0.16	1.17	T-bar	3.61

Table 3.1. shows that during the years 2003-2009 overall 40% of states were in compliance with their RPS goals on the percentage of renewable energy by 100%, 46.15% were within 5% margin from the established goal, while 50.77% achieved goal within 10% margin. Between variation was the lowest for 100% goal achievement (0.3935 or 39.35%), while within variation for the same target was the highest.

Table 3.2. presents statistics for explanatory variables.

PENALTY is the main variable of interest in this study. Some states have established either penalty or alternative compliance payment in dollars per each MWh of non-compliance. Other states did not establish any enforcement mechanism. It varied from 0 to 66.03 $/MWh, with overall mean $27.93.

NM_SCORE is score given to states to evaluate the effectiveness of established net metering standards which allow electric customers to offset the electricity consumed by the amount of electricity they generated if they generate their own electricity. As it is shown in figure C.3, derived from the IREC report (Barnes at al., 2009), in September 2009 there were 42 states enacted net metering standards, which allow consumers who produce their own electricity to sell back their excess power reducing their electric bill up to zero.

Table 3.2. Descriptive Statistics for Explanatory Variables

Variable		Mean	St. Dev.	Min	Max	Observations	
PENALTY, USD per MWh	overall	27.93	25.69	0	66.03	N	65
	between		25.69	0	60.70	N	18
	Within		1.41	23.92	33.27	T-bar	3.61
NM_SCORE, score	overall	11.64	4.99	0	20	N	65
	between		3.94	6.875	18.5	N	18
	Within		2.98	.14	19.76	T-bar	3.61
ELPRICE, cents per KWh	Overall	11.96	2.90	7.37	18.06	N	65
	between		2.82	7.65	16.78	N	18
	Within		1.15	8.83	14.54	T-bar	3.61
LCV_H, score	overall	68	27.71	0	100	N	65
	between		28.00	0	100	N	18
	Within		8.06	52	109	T-bar	3.61
CO2lagged, metric tons	overall	125.74	112.21	10.22	402.15	N	65
	between		111.21	10.57	394.39	N	18
	Within		4.04	112.99	137.44	T-bar	3.61
GSP_CAPITA, thous. USD per capita	overall	45.55	7.03	33.32	64.96	N	65
	between		7.89	33.73	63.05	N	18
	Within		1.17	41.89	49.02	T-bar	3.61
EDU, %	overall	30.71	4.98	20.8	40.4	N	65
	Between		4.74	22.06	38.03	N	18
	Within		0.73	29.06	33.08	T-bar	3.61

Net metering score system was first introduced in 2006. It is calculated as index based on several characteristics, such as individual system capacity, total program capacity limits, restrictions on “Rollover”, metering issues, renewable energy credit ownership, eligible technologies and customers, there are also bonuses for additional net-metering provisions and penalties for standby charges or other fees. States are graded on scale presented in table B.2. Net Metering score varied from 0 to 20 with overall mean 11.63846 (“B” grade). Distribution of states by net metering grades is shown in the figure C.4 from Barnes et al. (2009).

Data on League of Conservation Voters score in House (LCV_H) are collected from the annual scorecards downloaded from its web-site (League of Conservation Voters, 2010). LCV-H scores varied from 0 to 100, which means that there were states where house representatives voted for none (0%) to all (100%) environmental statutes. Overall mean was 68, which says that observed states have higher than average interest in pro-environmental legislature. Distribution of states in 2009 by LCV house-score is shown on the figure C.5. Average electricity prices (ELPRICE) in the states during the given time period varied from 7.37 to 18.06 cents per KWh, with the mean 11.96 cents per KWh. These data were derived from the EIA web-site. Data on carbon dioxide emissions are also derived from the EIA web-site. Carbon-dioxide emissions varied from 10.21 to 402.15 mln. metric tons with overall mean 125.74 mln. metric tons.

To calculate real gross state product per capita, I sourced raw data on current GDP by state, GDP deflator and population. Data for current GSP by state (millions of current dollars) were derived from two tables: GSP (for 1990-1997) and GDP by State (for 1998-2008) from the Bureau of Economic Analysis (2011). GDP deflator is sourced from the Federal Reserve Bank of St. Louis (2011). Then I calculated real gross state products as follows:

$$\text{Real GSP} = \text{Current GSP} / \text{Deflator GDP} \quad (5)$$

To avoid trendiness I obtain real GSP per capita, using population estimates from the U.S. Census Bureau.

$$\text{Real GSP per capita} = \text{Real GSP}/\text{Population} \quad (6)$$

Real GSP per capita varied from 33.32 to 64.96 thousands of the U.S. dollars per capita with overall mean 45.55 thousands of the U.S. dollars per capita.

Data on educational attainment (% of people 25 years and older with a bachelor degree or higher) are derived from the Census' Statistical Abstract of the United States. These data are not available for the years 1998 and 2008. We impute data for 1998 (as average of 1997 and 1999). I impute data for 2008 implying the average annual growth rate for the observed time-period. From 20.8% to 40.4% of people 25 years and older had at least bachelor degree with overall average 30.71%.

4. Hypotheses and Empirical Results

In this paper I test several hypotheses, which are the same for all three specifications of the dependent variable (compliance with the RPS in 100%, 95% and 90%).

Hypothesis 1: the probability that a state will achieve their established target goals is higher for states with a higher penalty or alternative non-compliance payment, because it makes states better of to invest in renewable electricity generation.

Hypothesis 2: the probability that a state will achieve their established target goals is higher for states with a net-metering program enacted and is positively correlated with net metering score because effectiveness of net metering defines how easy it is for small energy producers to sell the electricity they produced to utility.

Hypothesis 3: the probability that a state will achieve their established target goals is higher for states with higher average electricity prices. Because renewable energy is more expansive than traditional sources, renewable energy is not price-competitive with low prices. Higher electricity prices encourage investments in the industry in general, and in renewable electricity generation, in particular.

Hypothesis 4: the probability that a state will achieve their established target goals is higher for states with higher GSP per capita, because good environment as a public good, and therefore a normal good (demand for normal goods increases with income growth).

Hypothesis 5: the probability that a state will achieve their established target goals is higher for states with higher CO_2 pollution level if RPS policy was implemented based on the environmental concerns: more polluted states should more care about environment and be more motivated to develop electricity generation using clean, renewable energy sources.

Hypothesis 6: the probability that a state will achieve their established target goals is higher for states with higher percentage of educated people over 25 years (with bachelor degree or higher), because more educated people are more likely to recognize the negative consequences of non-sustainable economic development and to promote green policies and renewable energy production.

I estimate four models for the probability that state will totally comply with its target a presented in the columns 1-4.

Table 4.1. Coefficient estimates for Y as the dependent variable (100% target)

Explanatory Variable	1	2	3	4
Constant	2.708*** (0.994)	-2.686*** (0.016)	-6.602*** (1.881)	-16.592*** (3.289)
PENALTY	0.111*** (0.032)	0.111*** (0.034)	0.193*** (0.047)	0.192*** (0.045)
NM_SCORE		-0.001 (0.016)	-0.013 (0.016)	-0.002 (0.015)
ELPRICE			0.147*** (0.060)	0.103 (0.073)
LCV_H				0.004 (0.005)
CO2_lagged				0.033*** (0.010)
GSP_capita				0.102** (0.043)
EDU				0.043 (0.058)
Fixed effects	Yes	Yes	Yes	Yes
Within R-square	0.2123	0.2123	0.3058	0.4942
Between R-square	0.0059	0.0059	0.0050	0.0049
Overall R-square	0.0040	0.0040	0.0042	0.0035

In the column (1), I examine how PENALTY itself affects the probability of compliance and find that it has a significant and positive coefficient. Without taking into account the other factors, an increase in the penalty by one dollar per MWh will increase the probability that a state complies with the 100% fractional goal by 11.1 percentage points. In the column (2), I include another variable – NM_SCORE, because net metering is a policy which facilitates the RPS compliance. Including NM_SCORE did not change the marginal effect of the penalty, but the variable itself has no statistically significant impact on compliance. It is possible due to the lack of scores for 2003-2005 years, which I imposed on the level of 2006. Adding ELPRICE in the model (column 3) has increased the coefficient of PENALTY by almost a half, which means that omission of ELPRICE resulted in the negative bias of the PENALTY. This could be a result of negative correlation between ELPRICE and PENALTY, if we assume that penalties are not necessary to impose when high electricity prices favor to the investments in renewable energy. The full model presented in the column (4) is my baseline model. It includes four more variables, controlling for demand for renewable energy. According to the columns (3) and (4), net metering score (NM_SCORE), LCV_H (LCV score for House representatives) and education (EDU) are not significant to explain states' compliance with their RPS targets. F-test in all four specifications gives a strong evidence to reject the hypothesis about zero fixed effects and favor fixed effects model.

Referring to the full model in column (4) of table 4.2, given other factors equal, a one dollar increase in the non-compliance penalty increases the probability that a state complies with its RPS target by 19.2 percentage points. The sample mean of the dependent variable is 0.4 for full compliance. Therefore an increase of the penalty by a one dollar per MWh increases the probability of full compliance with the RPS from 40% to 59.2%. This is equivalent to 48%

([19.2:40.0]*100%) increase in the probability, which is very large impact. An additional million metric tons emissions of the carbon dioxide increases the probability that a state will comply with its RPS target by 3.3 percentage points, which is equivalent to 8.25% ([3.3:40.0]*100%) increase in the probability of compliance. An additional thousand dollars of the real gross state product per capita increases the probability that a state will comply with its RPS target by 10.2 percentage points, which is equivalent to a 25.5% ([10.2:40.0]*100%) increase in the probability of compliance. In table 4.2, I analyze the probability that a state will comply with its target within a 5% margin.

Table 4.2. Coefficient estimates for Y5 as the dependent variable (95% target)

Explanatory Variable	1	2	3	4
Constant	2.589*** (0.701)	-2.449*** (0.814)	-3.820*** (1.569)	-9.826*** (2.959)
PENALTY	0.109*** (0.025)	0.106*** (0.027)	0.135*** (0.039)	0.137*** (0.041)
NM_SCORE		-0.004 (0.013)	-0.009 (0.013)	-0.002 (0.014)
ELPRICE			0.051*** (0.050)	0. 031 (0.065)
LCV_H				0.002 (0.005)
CO2_lagged				0.021** (0.009)
GSP_capita				0.062 (0.039)
EDU				0.019 (0.052)
Fixed effects	Yes	Yes	Yes	Yes
Within R-square	0.2920	0.2939	0.3103	0.4158
Between R-square	0.0074	0.0073	0.0079	0.0062
Overall R-square	0.0166	0.0163	0.0152	0.0080

According to column (4) of table 4.2, with other factors equal, a one dollar per MWh increase in the non-compliance penalty increases the probability that a state complies with its RPS within 5% of its target by 13.7 percentage points (from 46.15% to 59.85%), which is equivalent to a 29.69% ([13.7:46.15]*100%) increase in the probability (also a large impact). One more million metric tons emissions of the carbon dioxide increases the probability that state comply with its RPS within 5% of its target by 2.1 percentage points (equivalent to 4.55% ([2.1:46.15]*100%) increase in probability. In table 4.3. I analyze the probability that state will totally comply with its target within 10% margin.

Table 4.3. Coefficient estimates for Y10 as the dependent variable (90% target)

Explanatory Variable	1	2	3	4
Constant	-2.956*** (0.627)	-2.882*** (0.728)	-5.000*** (1.371)	-8. 428*** (2.673)
PENALTY	0.124*** (0.022)	0.122*** (0.024)	0.167*** (0.034)	0.171*** (0.037)
NM_SCORE		-0.002 (0.011)	-0.009 (0.012)	-0.008 (0.012)
ELPRICE			0.079** (0.043)	0.092* (0.059)
LCV_H				0.003 (0.004)
CO2_lagged				0.017* (0.009)
GSP_capita				0.005 (0.035)
EDU				0.018 (0.047)
Fixed effects	Yes	Yes	Yes	Yes
Within R-square	0.3994	0.4000	0.4414	0.4937
Between R-square	0.0044	0.0044	0.0040	0.0005
Overall R-square	0.0286	0.0285	0.0272	0.0125

Therefore, according to the column (4) of table 4.3, given other things equal, one dollar per MWh increase in non-compliance payment or penalty increases a probability that state will comply with its RPS within 10% of its target by 17.1 percentage points (from 50.77% to 67.87%), which is equivalent to a 33.68% ([17.1:50.77]*100%) increase in probability. One more million metric tons emissions of the carbon dioxide increases the probability that state comply with its RPS within 10% of its target by 1.7 percentage points, which is equivalent to 3.34% ([1.7:50.77]*100%) increase in probability. One more cent per Kwh of electricity price increases the probability that state comply with its RPS target by 9.2 percentage points, which is equivalent to an 18.2% ([9.2:50.77]*100%) increase in probability. Again, F-test of the fixed effects for the models presented in tables 4.2 and 4.3 fail to refuse a hypothesis about the absence of the fixed effects, favoring fixed effects model.

5. Conclusion

In this paper I analyzed how penalty measures if they are established in renewable portfolio standards affect the probability that a state will achieve its RPS fractional targets (by 100%, 95% and 90% accordingly). I estimated a fixed effect one-way linear probability model. As expected, I found that the penalty has a significant and large impact on the probability that a state will comply with its RPS target. Given other factors equal, a one dollar increase in the non-compliance penalty increases the probability that a state will achieve 100% compliance with its RPS target by 19.2 percentage points (equivalent to a 48% increase in probability). Allowing states under-compliance within 5% and 10% from the established fractional goal, a one dollar per MWh increases the probability that a state will comply with its RPS by 13.7 and 17.1 percentage points accordingly (equivalent to a 29.69% and 33.68% increase in probability respectively).

So, it is important to include the penalty features in the RPS design if a state wants its RPS to be a strong and effective instrument for developing renewable energy. Another significant factor of the RPS compliance is pollution, which is captured by the carbon dioxide emissions level variable in my model. Given other factors equal, an additional million metric ton of emissions of the carbon dioxide increases the probability that a state will comply with its RPS target by 100% by 3.3 percentage points (equivalent to a 8.25% increase in probability). When we are looking at the compliance within 5% and 10% margins of the goal, the marginal effect of the additional million metric ton of the carbon dioxide emissions changes to 2.1 and 1.7 percentage points (equivalent to 4.55% and 3.34% increase in probability) respectively. The above findings show that a state with a higher carbon dioxide pollution level is more concerned about developing renewable electricity generation and more likely to meet its fractional goals.

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Appendix A - Fractional Goals

Table A.1. Fractional Goals set by RPS

State	2003	2004	2005	2006	2007	2008	2009
AZ				1.25	1.5	1.75	2
CA		14	15	16	17	18	19
CO					3	6	6
CT				5	7.5	10	12
DE						2	3
IL							2
MA	1	1.5	2	2.5	3	3.5	11.1
MD				3.5	3.5	4.505	4.51
ME						1	2
MT						5	5
NH						4	6
NJ			3.25	3.5	4.576	5.506	6.5
NM				5	6	6	6
NV			6	6	9	9	12
NY	19.752	19.642	18.831	19.843	19.844	19.908	21.675
OH							0.25
PA					5.7	5.7	6.2
RI					3	3.5	4

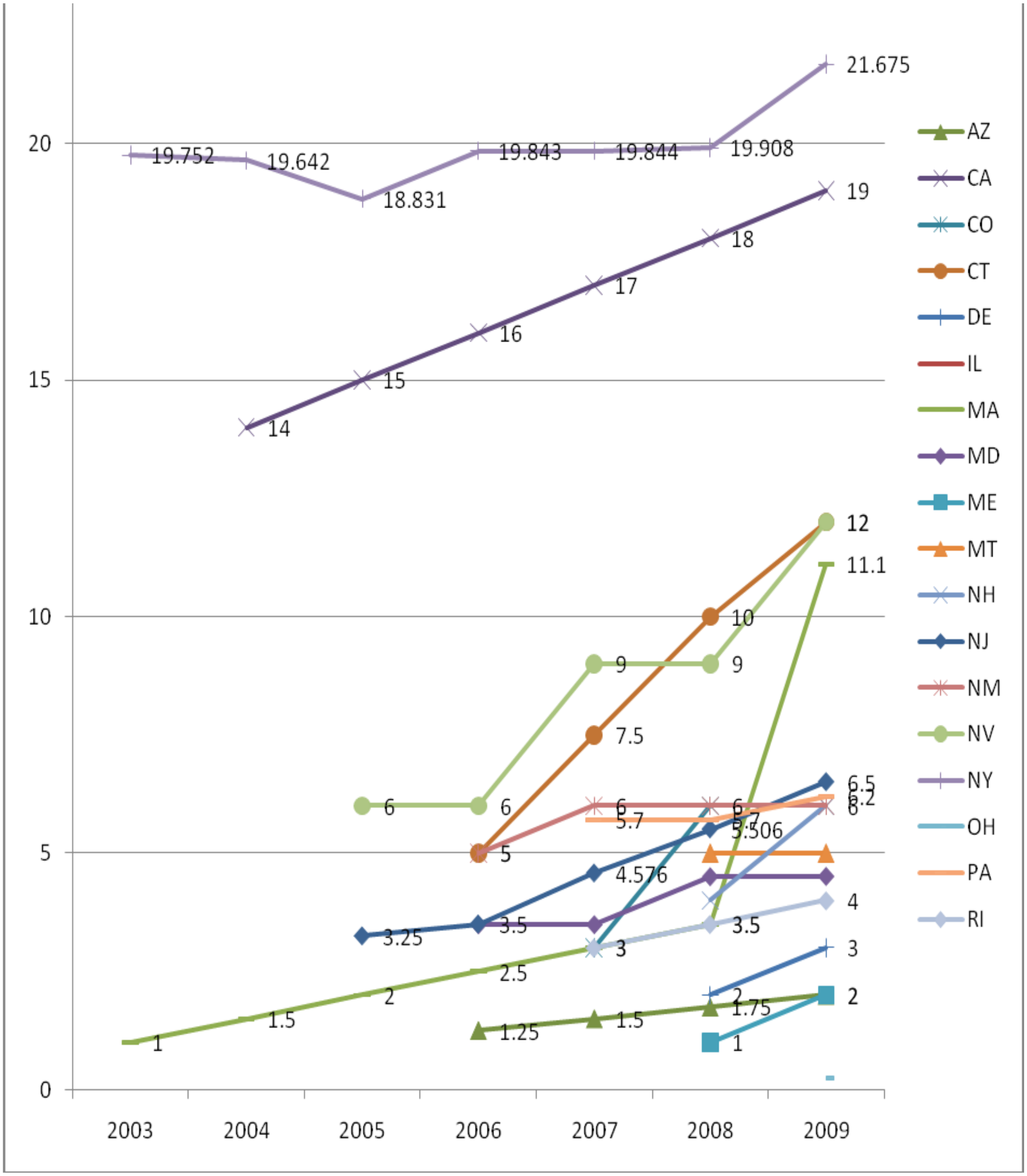
Table A.2. Fractional Goals set by RPS minus 5%

State	2003	2004	2005	2006	2007	2008	2009
AZ				1.1875	1.425	1.6625	1.9
CA		13.3	14.25	15.2	16.15	17.1	18.05
CO					2.85	5.7	5.7
CT				4.75	7.125	9.5	11.4
DE						1.9	2.85
IL							1.9
MA	0.95	1.425	1.9	2.375	2.85	3.325	10.545
MD				3.325	3.325	4.27975	4.2845
ME						0.95	1.9
MT						4.75	4.75
NH						3.8	5.7
NJ			3.0875	3.325	4.3472	5.2307	6.175
NM				4.75	5.7	5.7	5.7
NV			5.7	5.7	8.55	8.55	11.4
NY	18.7644	18.6599	17.8895	18.8509	18.8518	18.9126	20.5913
OH							0.2375
PA					5.415	5.415	5.89
RI					2.85	3.325	3.8

Table A.3. Fractional Goals set by RPS minus 10%

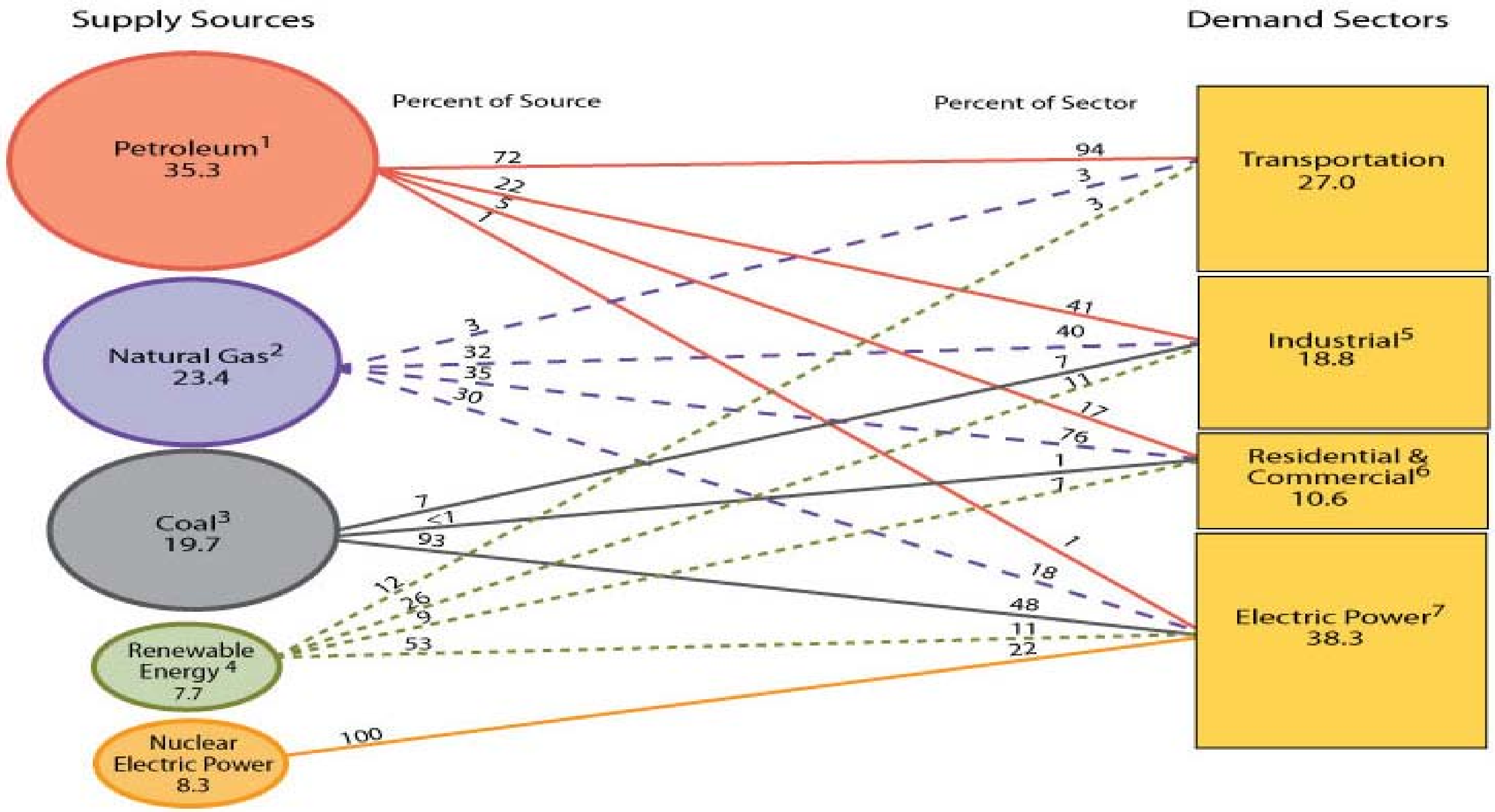
State	2003	2004	2005	2006	2007	2008	2009
AZ				1.125	1.35	1.575	1.8
CA		12.6	13.5	14.4	15.3	16.2	17.1
CO					2.7	5.4	5.4
CT				4.5	6.75	9	10.8
DE						1.8	2.7
IL							1.8
MA	0.9	1.35	1.8	2.25	2.7	3.15	9.99
MD				3.15	3.15	4.0545	4.059
ME						0.9	1.8
MT						4.5	4.5
NH						3.6	5.4
NJ			2.925	3.15	4.1184	4.9554	5.85
NM			0	4.5	5.4	5.4	5.4
NV			5.4	5.4	8.1	8.1	10.8
NY	17.7768	17.6778	16.9479	17.8587	17.8596	17.9172	19.5075
OH							0.225
PA					5.13	5.13	5.58
RI					2.7	3.15	3.6

Figure A.1 Fractional goals in States with implemented RPS policies in 2003-2009



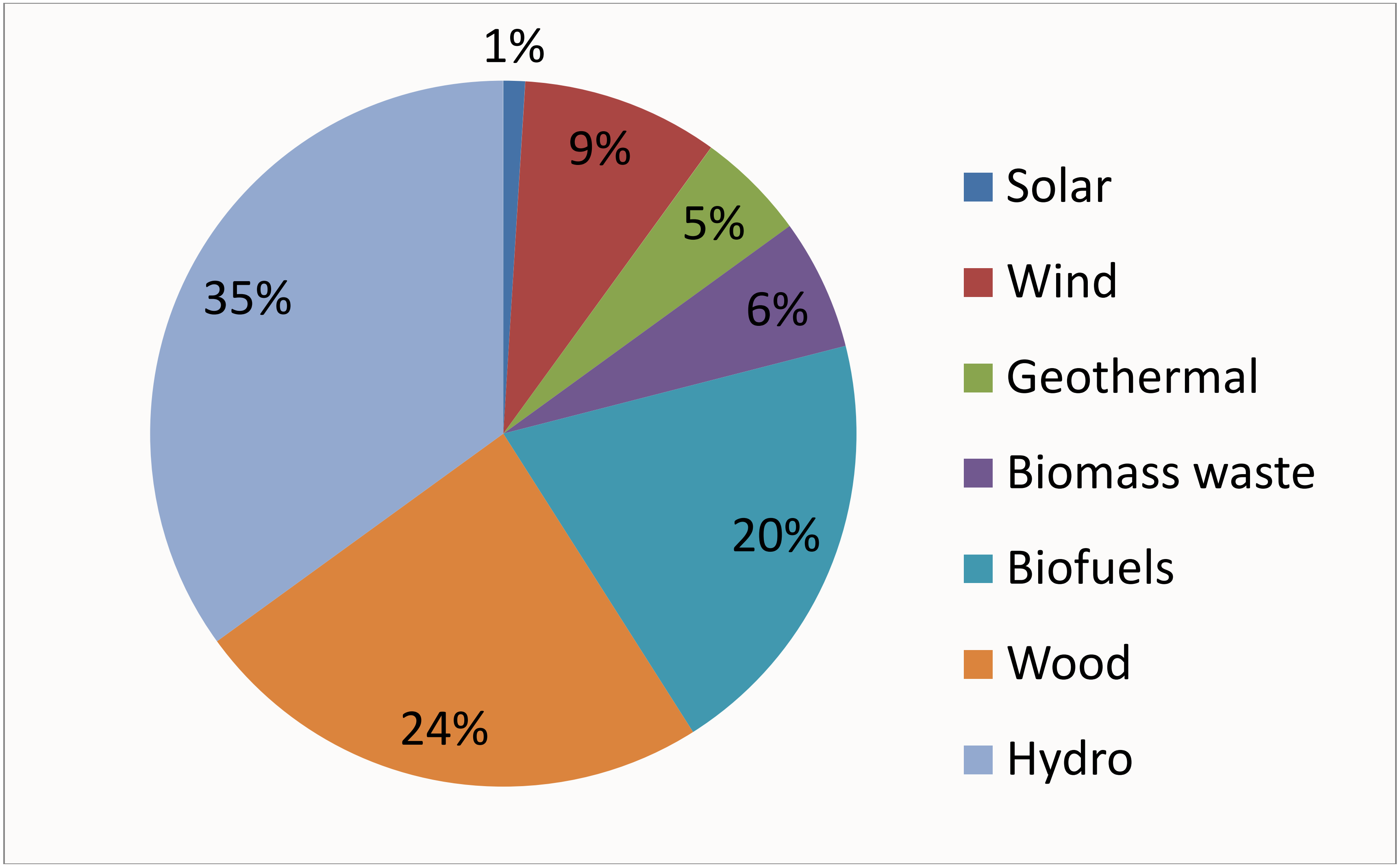
Appendix B - U.S. Energy Supply and Demand in 2009

Figure B.1 Structure of the U.S. energy supply and demand in 2009[1]



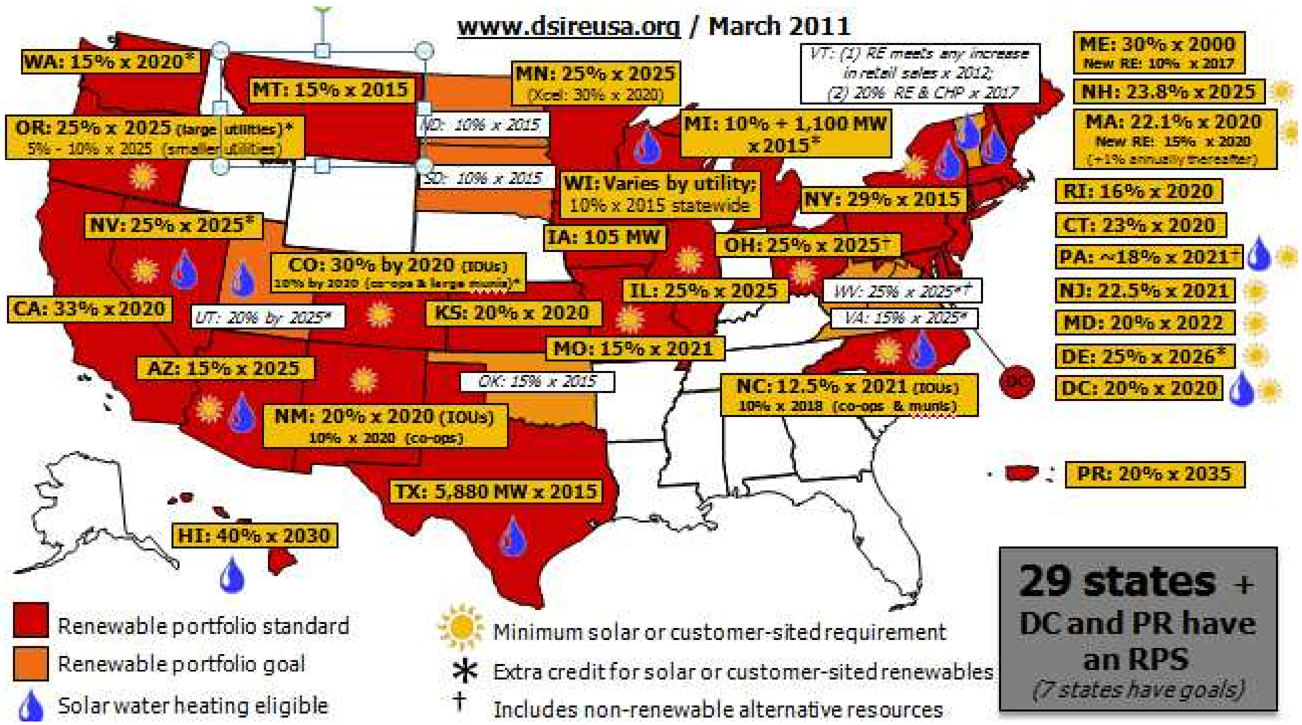
[1] http://www.eia.doe.gov/emeu/aer/pecss_diagram.html

Figure B.2 Structure of the renewable energy supply in the U.S. in 2009



Appendix C - State Characteristics

Figure C.1 States with Renewable Portfolio Standards and Goals in 2011[2]



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[2] http://www.dsireusa.org/summarymaps/index.cfm?ee=1&RE=1

Figure C.2 Achieved percentage of eligible renewable resources (2003-2009)

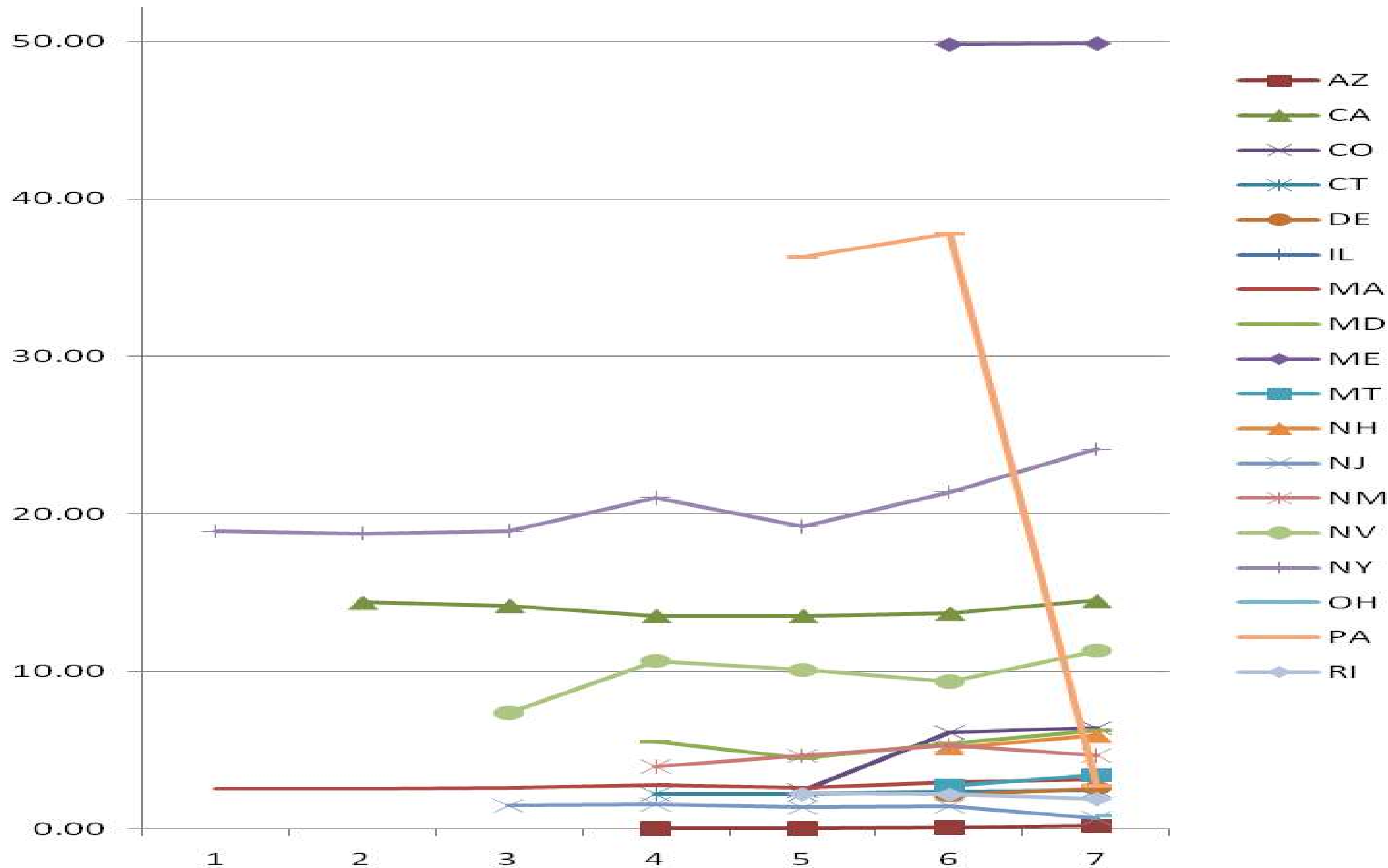
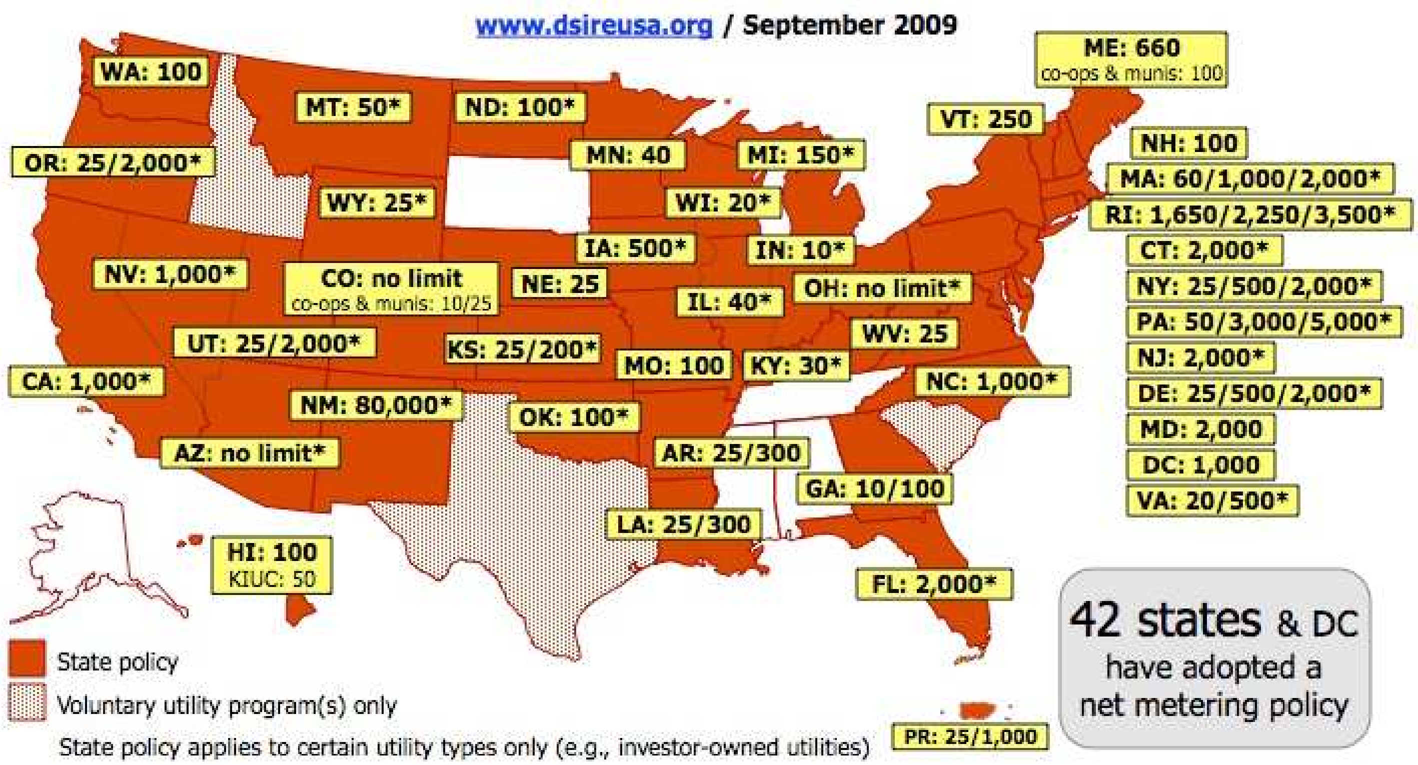
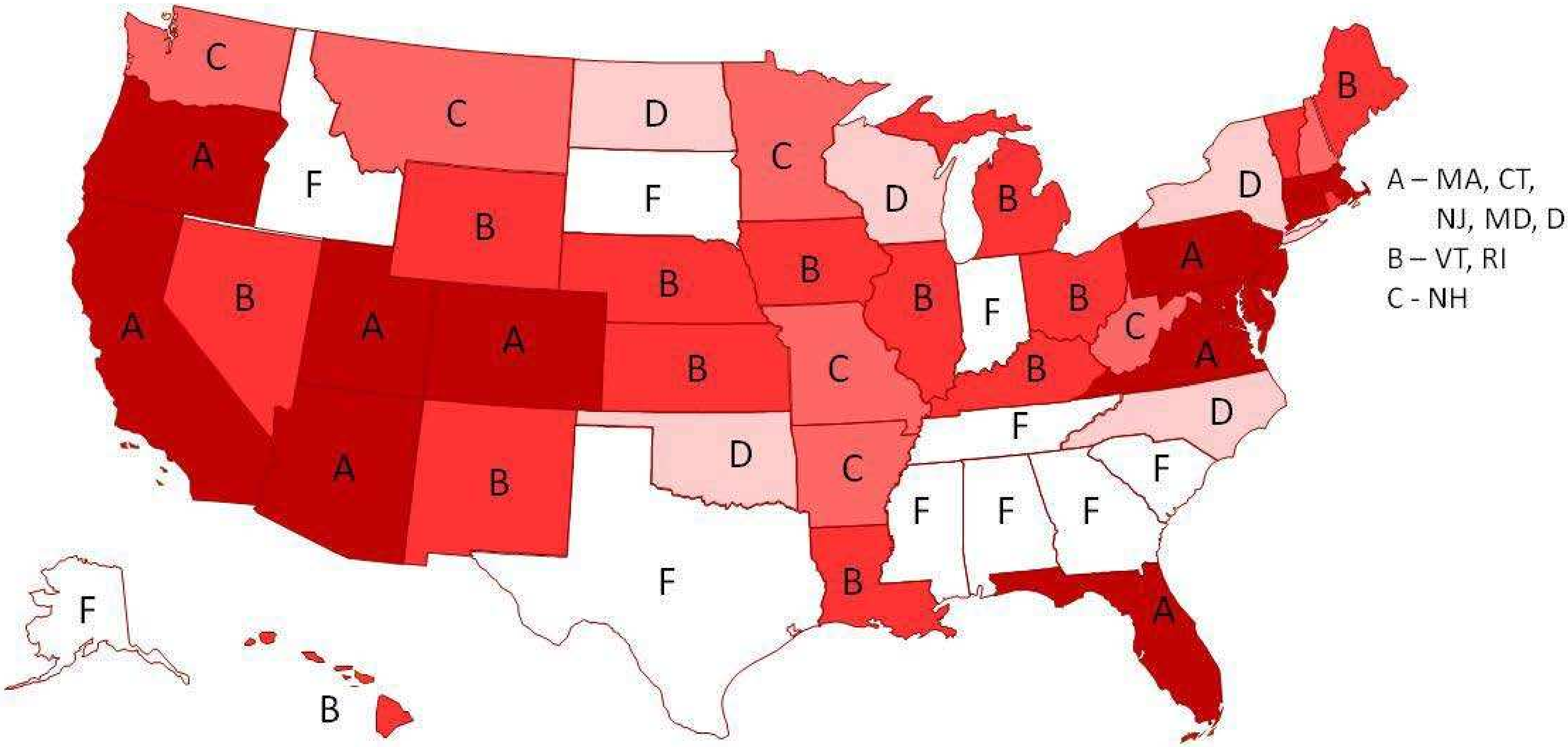


Figure C.3 States with Net Metering Policy in September 2009[3]



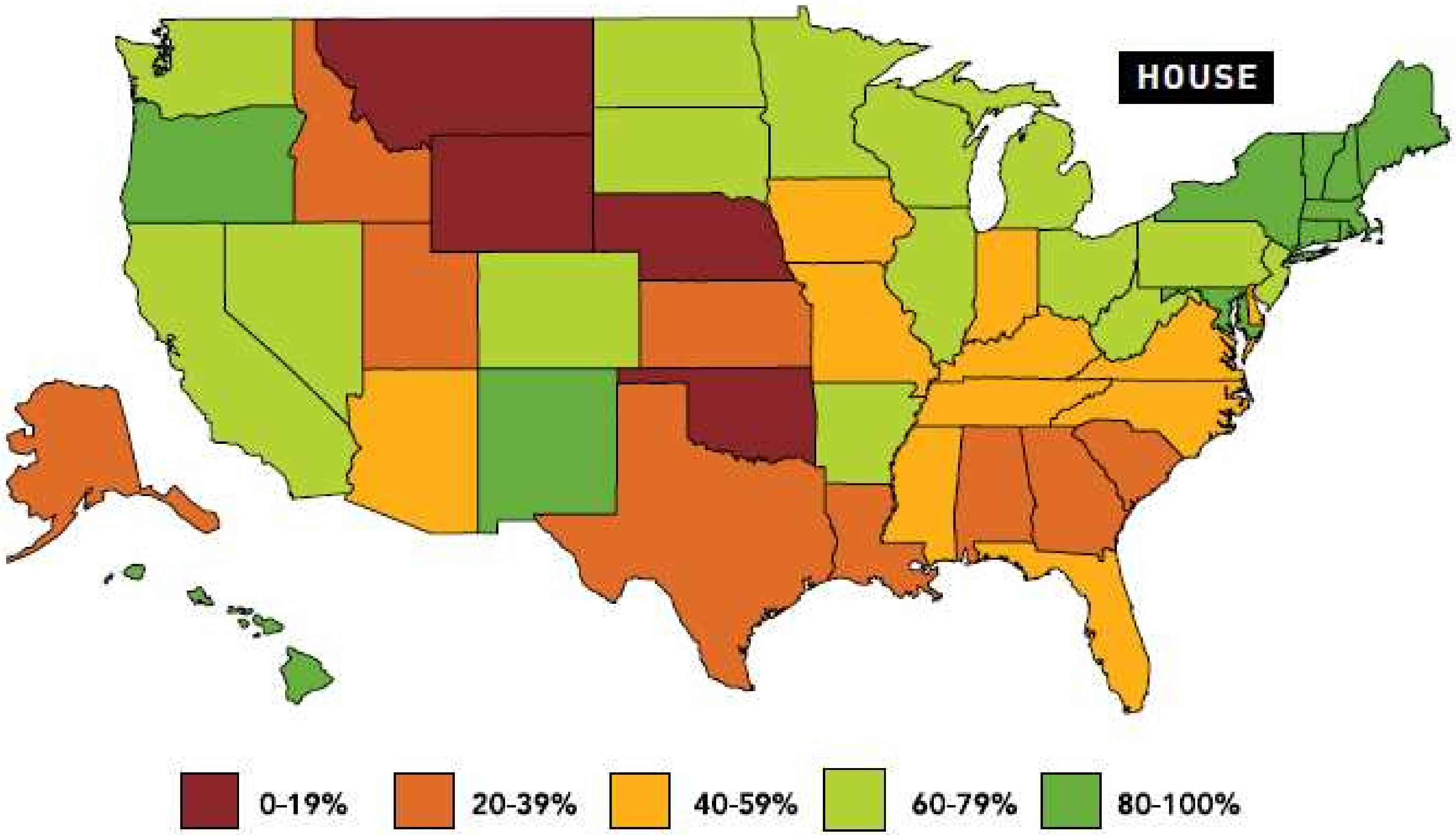
[3] http://www.dsireusa.org/documents/summarymaps/net_metering_map.ppt

Figure C.4 Grades given to States with Net Metering Policy in 2009[4]



[4] http://www.newenergychoices.org/uploads/FreeingTheGrid2007_report.pdf

Figure C.5 LCV house score by states in 2009[5]



[5] http://lcv-ftp.org/scorecard09/2009_LCV_scorecard.pdf

Appendix D - Net Metering

Table D.1. Score Methodology used in 2007-2009.

Individual System Capacity (Max=5, Min=-1)	+5 Greater than 1-MW +4 Between 750-kW and 1-MW +3 Between 500-kW and 750-kW +2 Between 100-kW and 500-kW +1 Between 50-kW and 100-kW 0 Not greater than 50-kW -1 Residential systems capped below 20-kW Notes: Some permit up to 80 MW on very large loads (such as a military base or corporate headquarters campus)
Total Program Capacity Limits (Max=2.5, Min=-0.5)	+2.5 > 5% or no limit +2 Between 2% and 5% +1.5 Between 1% and 2% +1 Between 0.5% and 1% +0.5 Between 0.2% and 0.5% 0 Between 0.1% and 0.2% -0.5 Less than 0.1% Bonus +1 For excluding generators that don't export electricity, or measuring basing measurement on energy produced instead of total capacity.
Restrictions on "Rollover" (Max=1.5, Min=-4)	+1.5 Indefinite rollover at retail rates. +1 Monthly rollover for one year, annual payment at retail rates (It is key to limit payout in this case so that customers do not oversize their generator beyond their own needs. Indefinite rollover is easier.) +0.5 Monthly rollover for one year; annual payment at wholesale or avoided cost 0 Monthly rollover for one year; excess energy donated to utility annually -2 Monthly payment at wholesale or avoided cost -4 No rollover permitted; excess energy donated to utility monthly
Metering Issues (Max=2, Min=-1)	+2 Single meter +1 Dual meters or dual registers – utility pays for the additional meter 0 Dual meters or dual registers – customer pays for the additional meter Metering Provisions Under Time of Use +2 TOU meters with time bin carryover +1 TOU meters with segregated time periods -1 Fixed TOU rate disadvantages small generators

Renewable Energy Credit Ownership (Max=1, Min=-5)	Points REC Ownership +1 Owned by customer -5 Transferred to utility
Eligible Technologies (Max=1, Min=-0.5)	+1 All renewable and zero-emission technologies +0.5 Solar and wind included, one or more other renewables excluded +0.5 All renewables, plus one or more non-renewable technologies 0 Solar only -0.5 Solar excluded from standard
Eligible Customers (Max=2, Min=-1)	+2 No eligible class restrictions +1 Commercial at overall net-metering limits, and residential larger than 10-kW permitted 0 Residential only, larger than 10-kW permitted 0 Commercial only -1 All other restrictions
Bonuses for additional net-metering provisions (Max=5, Min=0)	+1 One customer can aggregate net meter within contiguous property +1 Utility provides a meter change if needed at utility cost +3 "Safe harbor language" protects customers from unspecified additional equipment, fees, requirements to change tariffs, etc
Standby Charges or Other Fees (Max=0, Min=-5)	Points Fees -1 Minor additional fees for net metering -5 Significant additional charges or fees6 -5 Per kWh fee on all production (in addition to other fees) 7
	Max: 5+2.5+1.5+2+1+1+2+5+0=20 Min: -1-0.5-4-1-5-0.5-1+0-5=-18

Thus, each state ih a given year could achieve score as high as 20 or as low as -18. These scores were transferred to grades using scale given in table B.2 as follows.

Table D.2. Grades Methodology used in 2007-2009.

Score	15+	9-15	6-9	3-6	<3
Grade	A	B	C	D	F

Methodology in 2006 was much different: index -8 characterized the program that most discourages the goals of net metering, 0 characterized a minimal net metering program, but one that does not strongly encourage or discourage program goals, +316: characterizes the program that displays the most features that encourage the goals of net metering. Also scores were presented as percentage (from 0 to 100%), and grades “were curved”: A was given from 79% and higher, B from 61%.

We need to change scores in 2006 for 2007 methodology. To be consistent, I rely on percentages and define new score as (percentage)*15/20 which is the maximum possible score in 2007 methodology without/with bonuses. In table B.3 I present my calculations of NM_SCORE in 2006.

Table D.3. Transfer of 2006 grades in 2007-2009 methodology.

	Grade	Percentage	Score 2006	Percentage *15	Percentage *20	Score 2007	Score 2006 I use corrected avg
Arizona	N/a, voluntary policy						0
New Jersey	A	100	305	15	20	17.5 A	17.5 A
California	A	94	15	14	19	15.5 A	16.5 A
Nevada	A	88	7	13	17.5	11 B	15 A
Connecticut	C	48%	1	7	9.5	10 B	8 C
New Mexico	C	48%	1	7	9.5	9 B	8 C
Massachusetts	F	-1	27%	4	5.5	6.5 C	5 D
Maryland	F	-2	9%	1.5	2	16A	2 F