Renewable energy deployment in the electricity sector: Three essays on policy design, scope, and outcomes

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Abstract

Due to the large environmental impact of the electric energy sector, evaluating the policy instruments employed in this arena is a particularly pressing issue. In the United States, state policy is a major driver of sustainable energy development and provides a unique opportunity to conduct comparative policy research. Thirty-two states have implemented a renewable portfolio standard (RPS), a policy instrument that mandates renewable resource use. Although similar on the surface, these policies present staggering variation in the design elements they incorporate.

This dissertation investigates patterns of policy design, scope and outcomes of RPS, contributing to the literature on policy design and effectiveness, and expanding the empirical knowledge of state sustainable energy policies. The first essay presents an in-depth state-by-state analysis of RPS design elements, complemented by the development of a policy classification scheme. Examining RPS design under the angle of stringency of goals, discretion in means, and strength of the enforcement regime introduces a measure of comparability. It highlights that a rigid focus on singular measures of policy strength and broad policy types detracts from understanding the impact of individual design features.

The second essay underlines this argument, relating RPS design characteristics quantitatively to policy response. The results show that both more stringent goals and, to some extent, increased discretion in means are associated with higher policy response. The research design used is innovative, in that it accounts for the full complexity of RPS, while measuring outcomes at the level the policy targets (retail sales).

The final essay concentrates on a single design attribute, policy scope. Focusing on a sector currently excluded from most state sustainable energy policies - consumer-owned utilities - it assesses future policy scenarios for their inclusion. To remediate the complete lack of emissions data on consumer-owned utilities, it develops for the first time a method to estimate the carbon intensity of electricity sales from this sector. Based on these estimates, future carbon management scenarios are developed for the inclusion of consumer-owned utilities in renewable policies, including interaction with energy efficiency policies.

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Chapter 1

Introduction

> *"If in fact we are all environmentalists now, the central issues today are what works, what doesn't and what it costs."* Harrington et al. (2004)

Today's unprecedented global energy (Goldemberg and Johansson, 2004) and environmental challenges (Rockström, 2009) call for decisive policy action and effective business adaptation. Global environmental change, in particular, requires a portfolio of mitigation and adaptation approaches to coordinate complex ecological systems with technical advances and socio-economic dynamics. In the electric energy sector, greenhouse gas mitigation involves a host of technical solutions, which are implemented by private as well as public actors and applied to different geographic areas and political constituencies.

Evaluating the policy instruments employed in this arena therefore is a particularly pressing issue. The highly complex meshwork of policies raises the question not only of individual policies' effectiveness, but also of their interactions with each other. A better understanding is needed of policy instruments performance in achieving intended goals. To deepen this understanding, this dissertation investigates patterns of sustainable energy policy design and scope, and analyzes the effects on policy outcomes.

The central argument made in this dissertation is that the relationship between a policy instrument and its outcomes is contingent on the complex design characteristics it incorporates. Widely used dichotomous measures of policy absence or presence, or other blunt measures such as policy experience and stated goals do not take into account the full complexity of a policy. Furthermore, policies cannot be seen in isolation, but their interactions with other policies need to be taken into account.

The policy design literature has traditionally focused on policy output, addressing the early stages of the policy cycle, where coalitions come together to set political agendas and to formulate and pass legislation. Nevertheless, how a policy was applied in practice and whether it achieved its intended goals can only be discerned after adoption. Supplementing *ex ante* policy output analysis (Howlett and Ramesh, 1993; Ringquist, 1993a; Tews, 2006;

Varone and Aebischer, 2001), policy outcome analysis evaluates the results of a policy *ex post* (Herrick and Sarewitz, 2000) and investigates factors for its success (Keiser and Meier, 1996). Policy outcomes are traced back to legal rules, the administrative implementation, and strategic reactions by business to regulation. Policy design and instrument choice determine cost-benefits of policies (Goulder and Parry, 2008). Enforcement and implementation regimes, as well as larger socio-political and economic factors influence the course of policy outcomes.

Examining the late stages of the policy cycle provides important lessons on the comparative effectiveness of design elements and the complexity of technology deployment pathways. It informs future policies and can help bridge the gap between conceiving policies and implementing them successfully on the ground. Despite the potential importance of this field, many policy outcome studies remain descriptive, listing idiosyncracies of a specific policy or comparing a small number of cases (Popp, 2006). This reflects both the lack of existing data and the complexity of measuring – and comparing – policy design and outcomes (Jaffe et al., 1995; Newmark, 2005).

This dissertation presents a method of comparative empirical policy evaluation to overcome these challenges. It focuses on U.S. state energy policy, because it provides a unique opportunity to conduct comparative policy research. At the state level, case numbers are sufficiently large to allow for quantitative analysis, and policies are similar enough to allow for comparison. In addition, U.S. states play a prominent role in rendering the energy system more environmentally sustainable, as energy regulation remains largely in their domain: new generation technologies are permitted and built, and broad energy objectives are decided and implemented at the state level.

In the absence of a nationwide policy for carbon emissions, renewable energy, or energy efficiency, states have served as laboratories of sustainable energy policy for the electric energy sector (Rabe, 2008). In contrast to the more unified, federally driven emissions allowance trading systems for SO_2 and NO_x, this has produced considerable variation across states in these policies, particularly where renewable targets, energy efficiency regulation and accompanying market mechanisms (Rabe, 2006; Holt and Wiser, 2007) are concerned.

Thirty-two states have now implemented a renewable portfolio standard (RPS), a policy instrument that mandates renewable resource use and regulates permissible strategies for compliance. Policies supporting energy conservation are also widespread, and are employed by more than half of all U.S. states. On the surface, these policies are relatively similar, in that they set a goal for increasing renewable generation and energy efficiency over time. In actuality, however, they present an extraordinary amount of variation in their provisions and implementation, rendering them an interesting subject for comparative policy research.

Although the importance of such policies cannot be understated, the melange of state policies for sustainable energy not only obscures their comparative effectiveness, but also complicates the functioning of energy markets. State policies such as renewable portfolio standards constitute a bottom-up approach to creating a nationwide renewable energy market, but their incompatibility has resulted in small, regionalized markets, which feature compounded uncertainty about pricing and quantities (Chupka, 2003). In addition, significant portions of the energy market remain excluded, since most renewable and energy efficiency policies target only the largest retail sellers of electricity. Therefore, the scope of these policies remains a significant impediment to achieving their full potential.

To appreciate the role of these policies, their complexity and outcomes need to be better understood. In this dissertation, three essays are presented that evaluate the design and scope of sustainable energy policies in U.S. states and relate these characteristics to their outcomes. In doing so, they contribute to the literature on policy design and effectiveness, and expand the empirical knowledge of prominent sustainable energy policy instruments.

The structure of this dissertation is organized as follows. To characterize the research context, Chapter 2 briefly describes the role and historical development of renewable energy in the United States.

Chapter 3 offers a comparative policy analysis of renewable portfolio standards (RPS) in the American states. It introduces the idea that the frequently presented dichotomy between direct and flexible regulation is simplifying, as most policies contain elements of both. Based on a content analysis of legislative texts and administrative statutes, a comprehensive comparison of design elements is provided. These features include compliance schedule, scope, eligibility of resources and technologies, quotas and subsidies, as well as enforcement and penalties. Special attention is paid to the treatment of renewable energy credits (REC) and accompanying trading mechanisms. For each design element, this chapter discusses the impact on policy implementation and outcomes, notably renewable energy deployment and cost of compliance. Drawing on the policy design literature, a classification of design elements according to stringency of goals, discretion in means, and strength of the penalty regime is developed. This makes apparent patterns of variation across state RPS and serves as a basis for discussing policy outcomes.

Chapter 4 addresses the impact of policy design on the outcomes of a policy. A quantitative study is presented that analyzes the outcomes of RPS design aspects on renewable energy deployment by electric utilities. It develops hypotheses on the impact of various policy design elements, drawn from policy design theory. Based on the content analysis of RPS in Chapter 3, individual design aspects are quantified and their association with renewable power deployment reported by utilities is tested. In contrast to prior studies in this area, the cross-level design takes into account the full complexity of the policy, while measuring outcomes at the level the policy targets. This innovative research design can associate different levels of renewable deployment reported by electric utilities with specific policy instruments they are exposed to. The systematic analysis enables a discussion of the instrument-specific effectiveness of state policies.

Chapter 5 addresses the impact of policy scope. With few exceptions, the scope of renewable and energy policies in U.S. states excludes municipal utilities, rural electricity cooperatives, and district power providers. These energy service providers, collectively referred to as consumer owned utilities (COU), operate in every U.S. state and make up more than a quarter of retail electricity sales. The policy realm's inattention to this sector is compounded by the general lack of available data, although addressing COU is a reasonable future pathway of policy extension. Considering potential future policy pathways, this chapter demonstrates proof for the growing relevance of COU within the context of climate change. It evaluates the policy landscape and the present state of energy efficiency and renewable generation among COU. To address the unavailability of data on COU carbon emission, it develops a method to estimate the carbon intensity of electricity sales from the COU sector, incorporating both generation and purchased power on a state-by-state basis. The estimates are then used to build carbon management scenarios for the inclusion of consumer-owned utilities in renewable policies, including interaction with energy efficiency policies.

Chapter 6 offers a final discussion of the analysis presented in the dissertation.

Chapter 2

Renewable energy in the U.S. electric power system

This chapter provides a brief background on renewable power's current and historical role in the U.S. electric power systems and discusses the factors that influence its future expansion.

2.1 Historical development of renewable power

Renewable energy is electric power produced from resources that are environmentally clean and replenish themselves over time. It generally is understood to include sources such as wind, solar, biomass, biogas, landfill gas, geothermal power, hydropower, biogenic municipal solid waste, and tidal or wave power. The United States have used small amounts of renewable energy as part of the electric resource mix for decades. Nevertheless, renewable sources have long taken a back seat to fossil fuels, nuclear energy and hydropower. Between 1989 and 2004, non-hydro renewable generation has oscillated between 2 and 2.5 % of the resource mix (Figure 2.1). Since that time, it has started to grow rapidly, breaking the 3 % barrier by 2007. After 2005, annual growth in renewable power was extremely high, topping 12 % each year (EIA, 2009a).

The history of renewable energy in the U.S. electric power sector is closely linked to political, technical and economic developments. The 1973 oil shock can be described as the first impetus for developing clean domestic energy sources. Along with new subsidies for renewable energy R&D and tax incentives, it was the Public Utility Regulatory Policies Act of 1978 (PURPA) that originally paved the way for generating electricity from renewable sources other than hydropower. It required all utilities to buy power generated by qualified facilities at the cost of avoided supply additions and to integrate these facilities into the electric grid (Braun and Smith, 1992). This provision substantially lowered the risk of investing in renewable technologies, and made distributed generation more attractive (Nola and Sioshansi, 1990).

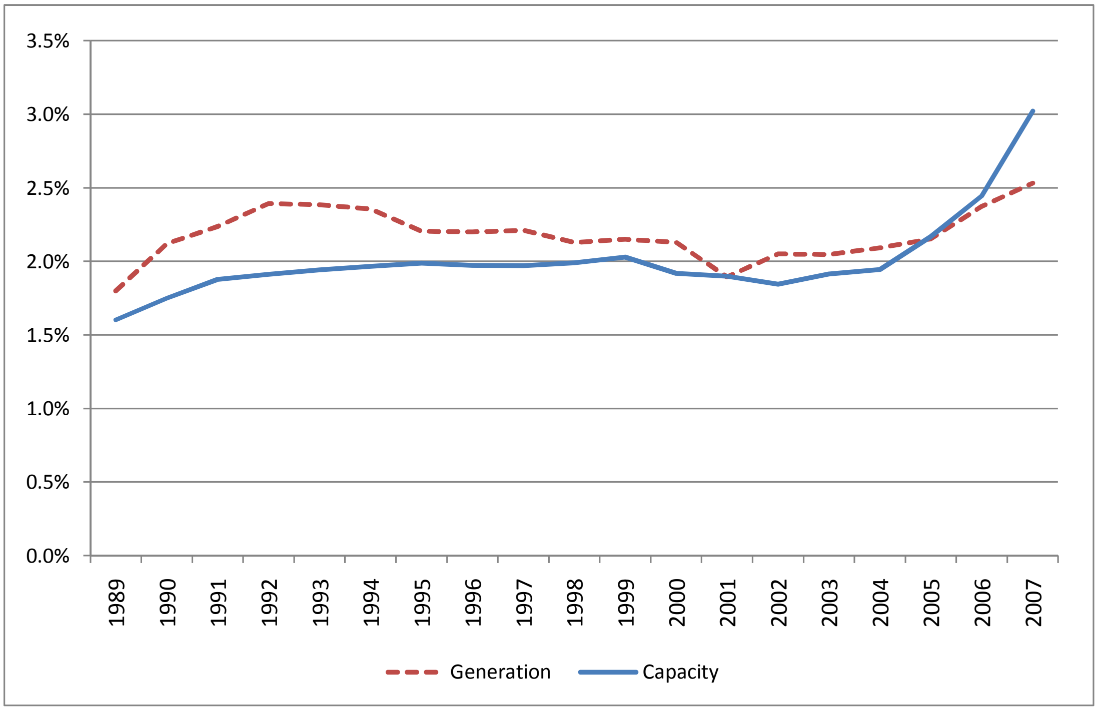

Figure 2.1: Historical proportion of renewable capacity and generation for U.S. electric utilities. Source: EIA (2009a)

Initially, PURPA caused a wave of investment in renewable technologies and co-generation, but a combination of sinking fuel prices, diminishing government funding for research into renewable energy, and lower than expected cost declines for renewable technologies (McVeigh et al., 2000) resulted in a downturn during the late 1980s and early 1990s. Due to its lack of cost competitiveness, renewable generation experienced a sharper decline in capacity additions than co-generation, which mostly relied on natural gas and profited from the decline in fossil fuel prices.

Investment in renewable generation technology was also affected by the deregulation wave of the 1990s. In the face of competition, keeping costs down became the main mantra of the utility industry. As stated by Heiman and Solomon (2004), “with market reform there is less direct incentive for utilities to provide renewable energy and promote energy efficiency since direct requirements for attaining these goals are dropped and linked rate hikes no longer guaranteed.” Continued market distortions are another reason for renewable energy’s failure to take off, with subsidies for conventional fuels and technologies surpassing those for renewable energy by orders of magnitude (McVeigh et al., 2000). To counter the effects of deregulation, many restructured states adopted system benefits charges or public benefit funds to provide for services that used to be assured by utilities. Part of these funds were designated for renewable energy research and funding, helping a recovery of capacity additions in the late 1990s.

In the final years of the 20th century, renewable energy took up steam again, under the influence of policy mandates. In view of environmental and human health impacts, as well as strategic concerns about energy security, a growing number of state as well as federal policies supported the diversification of electric energy resources. Climate change mitigation is one of the most important drivers of policy support for renewable energy. At 40 % of U.S. greenhouse gas emissions (EIA, 2008d), any attempt to mitigate climate change necessarily needs to include electricity production and consumption (Pacala and Socolow, 2004). The United States have 4 % of the world's population, but accounted for roughly a fifth of global CO_2 emissions in 2008, and per capita emissions are higher than those of all other developed nations (EIA, 2010b). The United States also continue to suffer from local air pollution, warranting the push for cleaner electricity resources. Concerns about increasing reliance on natural gas and fuel oil imports have contributed to framing renewable energy development as a pathway to increased energy security. Furthermore, businesses and policymakers alike increasingly recognize the need to diversify the resource mix to limit exposure to price risks.

Among the policies newly put into place to tackle these challenges, the federal production tax credit (PTC) has played an important role in driving renewable capacity additions. Construction of new wind capacity, in particular, has closely tracked the life-cycle of the PTC (Porter et al., 2009; Wilson and Stephens, 2009), which Congress allowed to expire three times in 1999, 2001, and 2003. Whenever it was in place, new capacity development jumped, but fell off again when it expired.

The second supporting leg for renewable energy deployment are policies at the state level. Beginning in the mid-1990s, state after state began putting into place subsidies, tax credits and quotas for renewable energy. Prominent among these state policies are green pricing rules, which mandate utilities to offer voluntary programs for renewable electricity to their customers, and renewable portfolio standards (RPS). Since the 1990s, 35 states have introduced an RPS, specifying goals for renewable electricity generation, usually expressed as a percentage of electricity sales (MWh) or absolute capacity (MW). Goals vary in the proportion of renewable resources and the time horizon prescribed. Most states mandate a 15-25 % renewable share of total capacity, with timelines as far out as 2030 (DSIRE, 2009). At the same time, advances in renewable energy technology continued to shrink the gap in commercial viability between renewable and conventional electric generation.

The analysis of renewable generation by fuel reveals changes over time in the resource mix (Figure 2.2). To a large extent, early renewable generation came from biomass, municipal solid waste and geothermal sources. These sources are not intermittent and except for geothermal energy, they use conventional thermal electric generation techniques. There has not been much change in the amount of electricity generated from these sources over the past decades. Although advanced geothermal resources are expected to become commercially viable in the near future (MIT, 2006), exploitation of conventional geothermal resources has remained level over the past twenty years. It represented 12 % of U.S. renewable generation in 2008. Electric power production from biomass and municipal solid waste

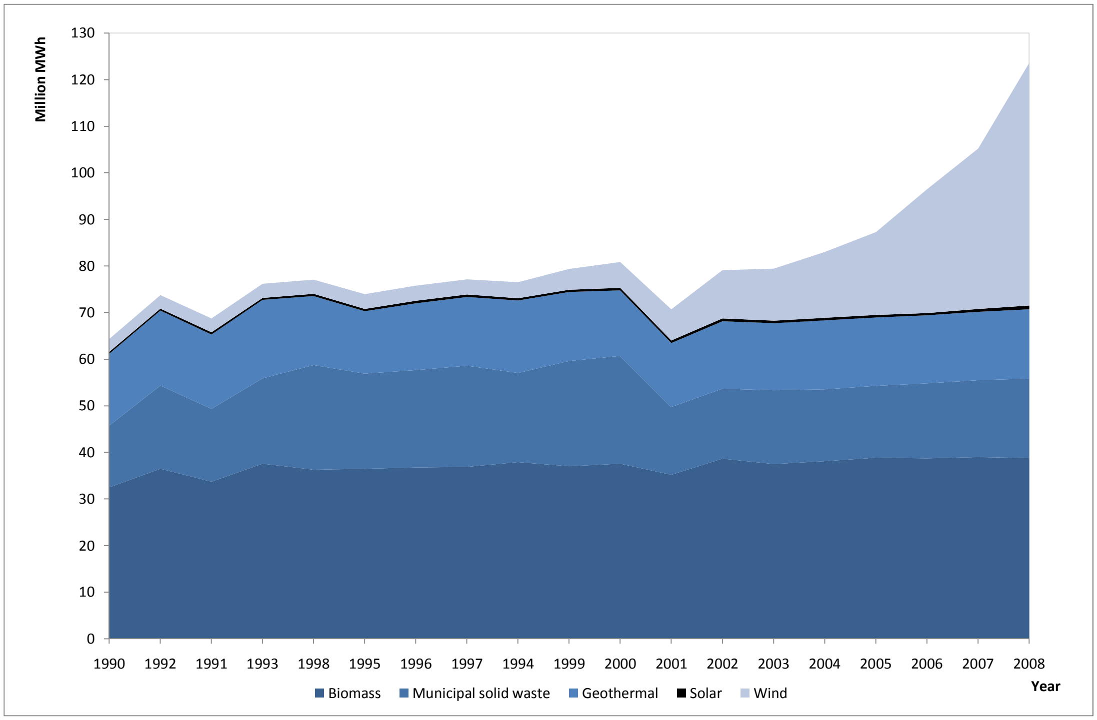

Figure 2.2: Non-hydro renewable generation by fuel, 1990-2008. Source: EIA (2009a)

has grown slowly, on the order of 1 % annually since 1990. Biomass makes up close to a third of renewable generation, while municipal solid waste represents 14 %.

Solar and wind power were barely in use for many years. Around the turn of the century, both resources started to experience remarkable growth rates, which continue today. Between 1990 and 2008, solar energy production more than doubled (EIA, 2009a). Despite this strong growth, solar power remains a very small part of the resource mix. Wind power has experienced the most remarkable development of all renewable fuels. It provided more than eighteen times as much energy in 2008 than in 1990, for 42 % of all renewable generation and close to 1.3 % of all electric generation in the United States (EIA, 2009a).

Overall, there has been a marked increase in both renewable capacity and generation since 2005. In 2008, the electric power sector generated 123.6 million MWh of electricity from non-hydro renewable fuels (EIA, 2009a). Although renewable energy production has increased rapidly, renewable generation sites are not uniformly distributed across the country. Some states have experienced very rapid development of renewable energy, while others continue to rely heavily on conventional power generation. Interestingly, the distribution of renewable resources shows little relation with where renewable capacity is built, particularly where wind power is concerned (Toke et al., 2008). Table 2.1 provides an overview of non-hydro renewable generation and capacity in all U.S. states (excluding co-generation).

	Capacity			Generation		
State	**MW**	**% of state**	**Rank**	**GWh**	**% of state**	**Rank**
AK	3	0.08%	50	15.6	0.12%	48
AL	574	0.92%	31	3,628.0	1.24%	25
AR	302	0.99%	28	1,605.8	1.46%	22
AZ	46	0.09%	49	109.3	0.05%	50
CA	5,825	4.54%	6	25,404.3	6.11%	2
CO	1,087	4.33%	8	3,152.2	2.95%	7
CT	165	1.05%	26	759.2	1.25%	24
DC	-	0.00%	51	-	0.00%	51
DE	7	0.10%	48	158.5	1.05%	30
FL	993	0.90%	32	4,321.0	0.98%	32
GA	672	0.92%	30	3,147.3	1.16%	27
HI	204	4.19%	9	767.2	3.37%	5
IA	2,676	9.76%	1	3,953.9	3.72%	4
ID	205	3.03%	14	657.4	2.75%	9
IL	1,107	1.28%	23	2,793.1	0.70%	38
IN	169	0.31%	44	465.7	0.18%	46
KS	665	2.77%	16	1,768.4	1.90%	15
KY	63	0.16%	47	447.7	0.23%	44
LA	394	0.75%	34	2,831.6	1.53%	20
MA	301	1.11%	25	1,297.4	1.53%	21
MD	135	0.54%	39	605.4	0.64%	40
ME	744	8.78%	2	4,230.4	12.37%	1
MI	516	0.85%	33	2,512.9	1.09%	29
MN	1,705	5.99%	4	5,367.7	4.90%	3
MO	168	0.41%	42	207.1	0.11%	49
MS	229	0.72%	35	1,508.5	1.56%	19
MT	189	1.68%	20	664.6	1.12%	28
NC	342	0.62%	37	1,856.2	0.74%	36
ND	762	6.95%	3	1,536.7	2.35%	11
NE	35	0.25%	45	275.1	0.42%	42
NH	193	2.31%	17	1,224.5	2.68%	10
NJ	218	0.59%	38	899.3	0.71%	37
NM	500	3.14%	12	1,657.4	2.24%	12
NV	280	1.24%	24	1,322.4	1.88%	16
NY	1,072	1.38%	22	3,294.2	1.17%	26
OH	112	0.17%	46	455.3	0.15%	47
OK	767	1.89%	18	2,596.5	1.70%	18
OR	1,318	4.94%	5	3,440.1	2.93%	8
PA	859	0.95%	29	2,868.7	0.65%	39
RI	24	0.67%	36	150.9	1.02%	31
SC	253	0.53%	40	1,804.6	0.89%	35
SD	193	3.11%	13	137.6	0.97%	34
TN	203	0.49%	41	879.5	0.49%	41
TX	7,194	3.43%	11	15,531.1	1.92%	14
UT	56	0.39%	43	288.2	0.31%	43
VA	687	1.46%	21	2,695.8	1.85%	17
VT	84	3.73%	10	434.5	3.19%	6
WA	1,666	2.82%	15	4,920.1	2.22%	13
WI	660	1.87%	19	1,652.7	1.30%	23
WV	330	1.01%	27	391.5	0.21%	45
WY	626	4.38%	7	910.4	0.98%	33

Table 2.1: Absolute and proportional renewable generation and capacity by state, 2008. Rankings are based on percentage values. Source: EIA (2009b)

The top five states in terms of MW installed (CA, TX, IA, MN, and WA) house more than 50 % of all renewable capacity in the country. Penetration levels also fluctuate, with some states generating almost no renewable energy, while others achieve 4, 5 or 6 %. The state with the highest penetration of renewables is ME (12.4 %), followed by CA (6.1 %).

2.2 Opportunities and barriers for renewable energy expansion

Sustained development of renewable energy will depend on technical, socio-political, economic and organizational factors. From a technical perspective, the expansion of renewable power requires developing and securing a sufficient, reliable, and well-performing supply of generation equipment. For instance, the boom in wind power currently means significant waiting times in procuring wind turbines. With regard to more advanced technologies, such as wave and tidal power, or advanced geothermal, a number of technical challenges need to be resolved to achieve commercial viability. Due to the intermittency of some renewable fuels, their integration into the power grid can present a technical challenge (Hoogwijk et al., 2007). High levels of wind power penetration not only require additional firming resources, but also the development of capabilities by grid operators for dispatching and balancing intermittent resources. Ultimately, storage systems may be needed to provide this service. Finally, the transmission infrastructure will have to be significantly upgraded to accommodate more renewable energy. Renewable resources are often located far away from load centers. Already, grids in areas with strong wind power development (e.g., CA, Southwestern MN, Western TX) experience grid congestion and bottlenecks. Currently, it takes roughly five years to build new transmission, while the average wind project takes less than two years from conception to completion. Clearly, transmission represents an important technical (and political) barrier to increasing the share of renewable power in the United States.

The experience with renewable energy in the United States has shown that socio-political factors often play a large role in whether – and where – renewable energy is developed. In section 2.1, specific policies were mentioned that are thought to have contributed to renewable development in the United States (Doris et al., 2009). These include the production tax credit, renewable portfolio standards, public benefit funds, mandatory green pricing, and other subsidies. Equally important, though less visible, are political and institutional factors, like the political climate, public acceptance, and the nature of relationships between regulators and utilities. There also exist a myriad of ancillary rules and regulations that can be instrumental in paving the way for renewable generation. For instance, integrated resource planning can support renewable policy development when carbon emissions or other pollutants are valued.

Permitting and siting rules are also essential. For example, simplified siting rules in TX have contributed to the state's extraordinary boom in wind power (Fischlein et al., 2010). In contrast, the siting and permitting process in MA is both extremely complicated and drawn-out, and has contributed to stalling the off-shore Cape Wind Project for nine years and counting. Another example of influential ancillary rules concern the interconnection procedures in place. In order to connect to the electric grid, new generation projects have to join the queue for their respective regional grid. In the case of the Midwest Independent Transmission System Operator (MISO), the complicated queueing system has led to a significant backlog, to the point where in 2008, only 7 % of all interconnection requests made between 2000 and 2007 had gone into service (Porter et al., 2009). Until recently, projects were handled on a first-come, first-serve basis. Required deposits were relatively low and projects could easily be suspended, without losing their position in the queue. MISO changed these rules in 2008, which should help clear the backlog.

A final important factor for continued expansion of renewable energy is directly related to the business sector, which needs to develop the necessary organizational capacities. Electric utilities in the United States have traditionally adopted a hub-and-spoke model of electricity generation and distribution, where power is generated in few, very large power stations and then distributed to surrounding areas (Hirsh, 1999). This centralized model conflicts with the capabilities required to successfully build and operate small, distributed and intermittent renewable resources (Sovacool, 2006). This dissonance may explain regulated utilities' hesitation to engage in renewable generation. In the past, regulated utilities have not usually produced renewable electricity themselves. In 2006, all electric utilities taken together generated 6,600 GWh of electricity from renewable fuels, while independent power producers generated 56,000 GWh (EIA, 2007c).[1] This likely reflects risk avoidance behavior on the part of the utilities, which are heavily regulated and new to distributed and renewable generation. In order to recoup their costs in rates, they have to justify to the regulator that the investment was prudent.

Although regulated electric utilities are more than six times as likely to buy renewable energy credits (REC) for resale from independent generators than to engage in renewable generation themselves, renewable generation is growing faster among regulated utilities than among independent power producers (EIA, 2007c). This suggests that utilities are adapting their strategies to changed regulatory and business environments. In fact, the passage of RPS setting a quota for renewable energy contributes to legitimizing investments in renewable energy. Regulation can validate certain activities (Scott, 1995), and therefore help their wider use.

Nevertheless, one of the biggest problems for utilities in expanding their renewable energy efforts has been the uncertainty related to policy. Not only do policies change rapidly, but they also interact with each other. For instance, considerable variation exists

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[1] Not all of this independently generated renewable energy is sold in the compliance market, with roughly 12,000 GWh sold in the voluntary offset market.

across states in renewable targets and accompanying market mechanisms (Rabe, 2006; Holt and Wiser, 2007). The lack of correspondence among state policies complicates the effective functioning of market mechanisms, and has resulted in small, regionalized renewable energy markets, which feature compounded uncertainty about pricing and quantities (Chupka, 2003).

Additionally, electric utility companies face a strategic decision when assembling their compliance mechanism with state RPS. Since most of these mandates include a market mechanism to provide for heightened flexibility, utilities can build their own renewable capacity or buy renewable energy credits (REC), with any combination of the two methods possible. Under an RPS, electric utilities have to demonstrate that the number of REC in their possession is sufficient to cover the mandated quantity of renewable energy. Faced with the alternative between building their own renewable capacity or purchasing REC, utilities are expected to choose the least cost option (Berry, 2002). As with pollution cap and trade systems, this market-based approach is believed to culminate in efficient allocation of resources, innovation and competition (Mozumder and Marathe, 2004). The decision to make or buy brings about considerable uncertainty for individual firms. Developing renewable generation resources entails long term, capital intensive investments, requiring the development of capabilities outside the core competence of many utilities. In turn, buying REC to satisfy state requirements for renewable energy may expose the utility to price volatility and other uncertainties associated with the REC market.

This short overview has made clear that the renewable energy sector is institutionally complex, historically path-dependent and susceptible to both market and political influences. It also seems set up to increase its importance in the electric energy supply. Consequently, a better understanding is necessary of the main policy drivers for this sector, as well as their implementation in practice.

Chapter 3

The design of renewable portfolio standards in U.S. states

Renewable portfolio standards (RPS) are prominent policies driving renewable energy development in the United States. This chapter presents an in-depth analysis of the design characteristics of these policies, analyzing their distribution across states and discussing potential impacts on policy outcomes. A rating system is developed to classify states according to RPS design aspects.

3.1 Introduction

At the outset, climate change was cast as a global problem, where increased dependence between nation-states results in increased need for cooperative action (Rabe, 2008). Therefore, it was to be addressed primarily in the international policy realm, through the top-down approach of an international regime (Biermann and Dingwerth, 2004). More recently, scholars have contended that the pervasive nature of the climate change issue may in fact require new models of governance where nation-states cease to be the sole actors (Rabe, 2008). Increasingly, attempts to govern climate change are cross-sector, with both private and public actors contributing to governance, and bottom-up, with sub-national and community-level entities taking the lead in formulating climate policy and local action plans (Betsill and Bulkeley, 2006). While territory-bound policies may shape the playing field, private initiatives progressively impact the carbon strategy decisions of firms. They also influence what is seen as feasible and desirable when policy makers decide to address an issue via the policy process. Therefore, environmental governance of climate change issues is a mix of deterritorialized regulatory instruments, processes and institutions, enacted by private and public actors, that aim at changing activities and their environmental outcomes (Lemos and Agrawal, 2006). The electric energy sector is no exception: historically a tightly regulated sector of the economy, it has seen much movement in the development of decentralized initiatives for climate change governance. Private initiatives and public-private agreements abound, and local and sub-national entities have taken the lead in addressing climate change via green pricing programs, renewable procurement and production standards, conservation programs and other initiatives (Rabe, 2008).

States have played an especially prominent role in this process, as U.S. energy regulation is largely in their domain: new generation technologies are permitted and built, and broad energy objectives are decided and implemented at the state level. In the absence of a nationwide carbon emissions or renewable energy policy, they have served as laboratories of climate change policy for the electric energy sector (Rabe, 2008). In contrast to the more unified, federally driven emissions allowance trading systems for SO_2 and NO_x, this has produced considerable variation across states in CO_2 reduction policies, particularly where renewable targets and accompanying market mechanisms (Rabe, 2006; Holt and Wiser, 2007) are concerned. Thirty-two states have now implemented a renewable portfolio standard (RPS), a policy instrument that mandates renewable resource use and regulates permissible strategies for compliance. On the surface, these policies are relatively similar, in that they set a goal for increasing renewable generation (or, in some cases, capacity) over time. In actuality, however, they present an extraordinary amount of variation in their provisions and implementation. This makes it difficult to compare their outcomes. RPS can be described as hybrid policies that include elements of direct regulation (e.g., quantity mandate) and of incentive-based regulation (e.g., renewable energy credit trading).

The melange of state policies for renewable energy not only obscures their comparative effectiveness, but also complicates the functioning of the renewable energy market. State policies constitute a bottom-up approach to creating a nationwide renewable energy market, but their incompatibility has resulted in small, regionalized markets, which feature compounded uncertainty about pricing and quantities (Chupka, 2003). While state renewable energy policies represent an important step towards carbon governance in the electric energy sector, their heterogeneity is problematic with regard to building an efficient market for renewable energy. The treatment of market mechanisms in RPS is illustrative. Some states have implemented broadly defined renewable energy credit (REC) trading, while others have put in place restrictive geographical and technical eligibility rules, forbidding trading outside the state. Competing policy goals, like job creation and localized pollution improvement, are a possible motivation behind restricting REC trading. Market mechanisms, then, cannot unfold their full potential.

To address market integration issues and appreciate the role of RPS in renewable energy deployment, the complexity of RPS needs to be better understood. In view of these challenges, this chapters presents a content analysis of RPS across all U.S. states that use this policy instrument. It analyzes the variation of policy design across state RPS and discusses potential impacts on policy implementation and outcomes, notably renewable energy deployment and cost of compliance. To help generalization, a rating of RPS in three

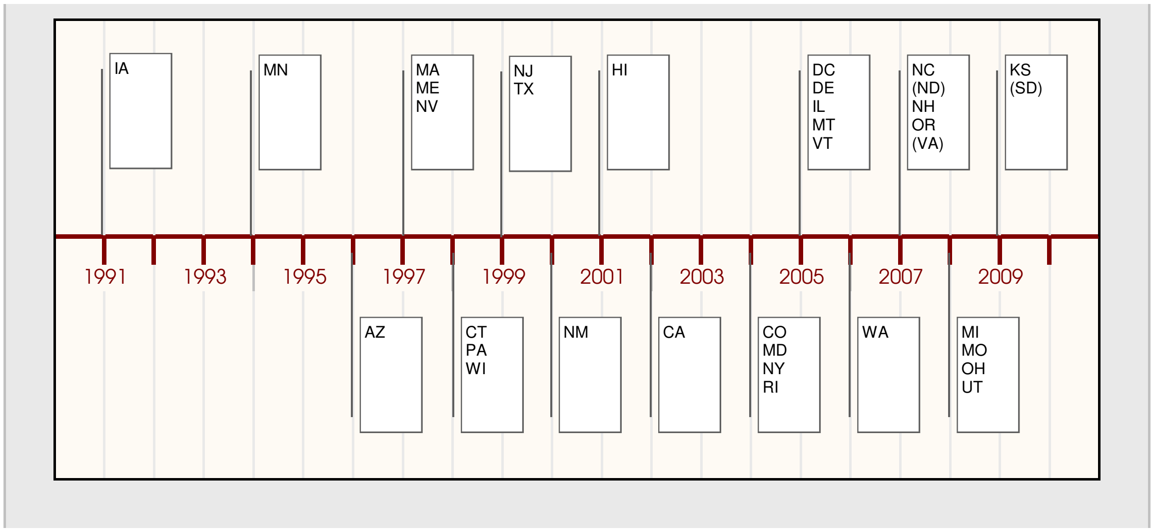

Figure 3.1: Timeline of RPS adoption. States in parentheses have a voluntary goal.

commonly studied policy dimensions is developed. These dimensions refer to the difficulty of the policy goal, the discretion in compliance pathways, and the penalty regime.

3.2 Background and approach

While renewable portfolio standards are not sufficient by themselves to mitigate climate change (Arar and Southgate, 2009; Sovacool and Barkenbus, 2007), renewable power represents an important strategy in a portfolio approach to greenhouse gas emissions reduction (Patrinos and Bradley, 2009). First enacted in Iowa in 1991, RPS policies were soon legislated by a small number of leading states with adoption accelerating after 2003 (Figure 3.1). The swift diffusion and popularity of this policy is sometimes attributed to the fact that it requires no allocation of public funds, while at the same time presenting a market-based solution for the provision of a public good (Berry and Jaccard, 2002; Wiser et al., 2007). Given the simple underlying principle of setting a goal for renewable energy, and letting electric utilities figure out how to achieve it, RPS systems have proven to be both popular and politically expeditious. Goals are set as a percentage of renewable sales or capacity, and can vary in the types of eligible renewable resources and the time horizon prescribed. Most states mandate a 15-25 % renewable share of total capacity, with timelines as far out as 2030 (DSIRE, 2009).

As more and more states have adopted these policies (Menz, 2005), they have garnered considerable research interest. Several studies have assessed the role of states as policy leaders in this area (Kosloff et al., 2004; Rabe, 2004; Wheeler, 2008), or investigated the factors driving adoption of these standards (Fremeth, 2009; Huang et al., 2007; Matisoff, 2008). Some research also builds on the experience with state policies to discuss advantages and disadvantages of a national renewable portfolio standard (Apt et al., 2008; Cooper, 2008; Michaels, 2008). Additionally, a number of studies focus on the costs of such policies, investigating for example their effectiveness as pollution reduction tools (Dobesova et al., 2005), their state level cost impacts (Chen et al., 2009), and their cost and health effects compared to other renewable electricity policies (Palmer and Burtraw, 2005).

A number of detailed case studies of single state renewable portfolio standards illustrate their history and implementation. As one of the first RPS systems in the country, the CA standard has been analyzed by several authors (Golden, 2003; Hilton, 2006; Horiuchi, 2007; Wiser et al., 2005; Wong Kup et al., 2009). TX, the state with the most new renewable capacity deployment in the United States, has also been extensively studied (Hurlbut, 2008; Langniss and Wiser, 2003). A handful of authors look at other individual state RPS such as AZ (Ratliff and Smith, 2005) or HI (Costello, 2005). These studies provide insights on specific provisions in a state's RPS, and detail the experience with legislating and implementing the standard. Quantitative analysis of RPS outcomes has examined whether the development of renewable energy is fueled by the presence of such policies. Earlier studies have used in-state renewable capacity additions as outcome variable (Kneifel, 2008; Menz, 2005), with some newer studies assessing impacts on renewable generation (Carley, 2009; Yin and Powers, 2010) or combined renewable generation and purchases (Fremeth, 2009). With the exception of Yin and Powers (2010), these studies treat RPS as monolithic policies, and only differences between states with or without policies are analyzed.

This is problematic, because the mere presence or absence of an RPS policy does not explain how or where renewable energy is deployed. Three quarters of all electricity in the United States was traded wholesale before reaching consumers (EIA, 1998) and electricity often crosses state-lines (Jiusto, 2006). In addition, real world deployment of renewable energy varies widely across U.S. regions. The distribution of natural resources may play a role, as well as other social, political and economic variables (Bird et al., 2005; Bohn and Lant, 2009; Fischlein et al., 2010; Menz and Vachon, 2006; Stephens et al., 2008). Besides these factors external to the RPS policy, however, the question has recently been raised whether elements of the renewable policy itself are a factor in determining deployment outcomes (Yin and Powers, 2010). Policy instruments affect costs and benefits of environmental policies, as well as their performance in achieving intended goals (Goulder and Parry, 2008). Therefore, blanket statements on the effectiveness of RPS based on measuring just policy presence should be avoided.

When comparing renewable policies across U.S. states, it becomes apparent that not all state standards are equal. While most states define a renewable goal as a percentage of retail sales, some (e.g., TX, IA) mandate renewable capacity goals, or use both (e.g., MN, IL). Timelines and aspirations diverge widely: some state RPS systems translate into genuine stretch goals, while others might be relatively easy to accomplish. RPS policies also vary with regard to their inclusiveness. The majority of RPS target only investor-owned or large utilities. RPS also set different source eligibility rules as to the types of permissible renewable fuels, and some define technology quotas (i.e., a minimum amount of generation from a specific source, such as solar energy) or subsidize certain resources. States also handle recovery of policy costs, trading of renewable energy credits (REC) and enforcement and penalties in different ways.

Given the variety and complexity of RPS, mapping the individual design aspects is an important step towards evaluating the comparative effectiveness of design elements. Berry and Jaccard (2002), Cory and Swezey (2007), Doris et al. (2009), Espey (2001), as well as Wiser and Barbose (2008) and Wiser et al. (2007) have offered overviews of the experience with state RPS, but concentrate selectively on certain design aspects, and/or provide little information on individual state characteristics. Furthermore, since the publication of the most recent comprehensive study (Wiser and Barbose, 2008),[1] the number of states adopting an RPS has increased by more than 50 %.

To update and extend their findings, I conduct a content analysis of existing state policies and systematically map individual state requirements. I collected all relevant state statutes, regulatory codes and administrative rules for the 32 states that have mandatory renewable portfolio standards. I reviewed both the legislative texts and the regulatory rulings associated with them, because it is administrative codes that often determine the specific rules of implementation (Koski, 2006). For instance, a number of RPS do not specify rules for renewable energy credit (REC) trading or list only big milestones in their compliance schedules. It is often left to the public utility commission to clarify such aspects.

The 72 documents, totaling 1854 pages, were coded for policy design aspects using the NVivo 8 qualitative analysis tool. With this software, predefined codes can be assigned to text segments, and coding frequency and proportion can then be quantitatively expressed and graphically represented. An initial list of codes was developed based on a review of RPS design elements described in the DSIRE (2009) database, and checked against other reviews of policy design characteristics (Berry and Jaccard, 2002; Cory and Swezey, 2007; Doris et al., 2009; Espey, 2001; Wiser et al., 2007). Information was tracked for 42 individual design aspect, across all 32 RPS states. The design elements can be grouped into eight areas of policy design:

- Stated goal and compliance schedule
- Scope (applicable utilities)
- Eligible resources and technologies
- Other eligible technologies
- Quotas and subsidies

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[1] The study by Doris et al. (2009) is more recent, but includes RPS only among other policies and provides no detail on individual state's RPS beside presence of the policy.

- Attribute trading (renewable energy credits)
- Waivers, exemptions and penalties

3.3 Design elements of RPS in U.S. states

RPS encompass a large number of design characteristics, ranging from big picture items such as the ambitiousness of the renewable goal and the types of eligible resources to administrative concerns such as the disposition of penalty funds and the mode of cost recovery. In this section, I compare RPS design elements across states, and consider their potential impact on policy outcomes. Policy outcomes refer to the "consequences for society, intended and unintended that stem from governmental action and inaction" (Anderson & Smallwood, 1980, cited in: Ringquist (1993a, p.93)).

Policy outcome researchers distinguish between effectiveness and efficiency of a policy. Effectiveness addresses whether the policy is meeting its goal, and efficiency assesses the cost of a policy, often in comparison to other tools (Harrington et al., 2004). For RPS, effectiveness can be assessed as their potential to drive new renewable energy deployment, while their efficiency can be evaluated in terms of the cost per unit of renewable electricity. I discuss potential impacts of design aspects on both effectiveness and efficiency of RPS.

3.3.1 Stated goal and compliance schedule

Most attention with regard to RPS design has focused on the compliance schedule, perhaps due to its signaling effect. Arguably, the percentage of renewable generation to be achieved at a certain point in time is the most visible indicator of the strength of an individual state policy. Figure 3.2 shows the nominal deployment schedules for the 30 states that set a renewable goal as a percentage of all electricity sales. The intention is to show the general trend, as the large number of states obscures individual schedules. Capacity goals are depicted where transferable to a generation goal (TX, but not IA). Clearly, there is much variation in both the absolute size of renewable requirements , and the speed with which requirements increase over time.

With the exception of UT and VT, which set far-out goals, all states have devised a compliance schedule that increases the renewable requirement over time. Between 2010 and 2020, the average goal mandated by RPS states will rise from 7 % to slightly more than 16 %. The highest absolute goal is set by HI, at 40 % renewable sales to be achieved by 2040. In terms of speed of deployment, the state of MN tops the list. It is directing the state's largest electric utility, Xcel Energy, to sell 30 % renewable energy by 2020.

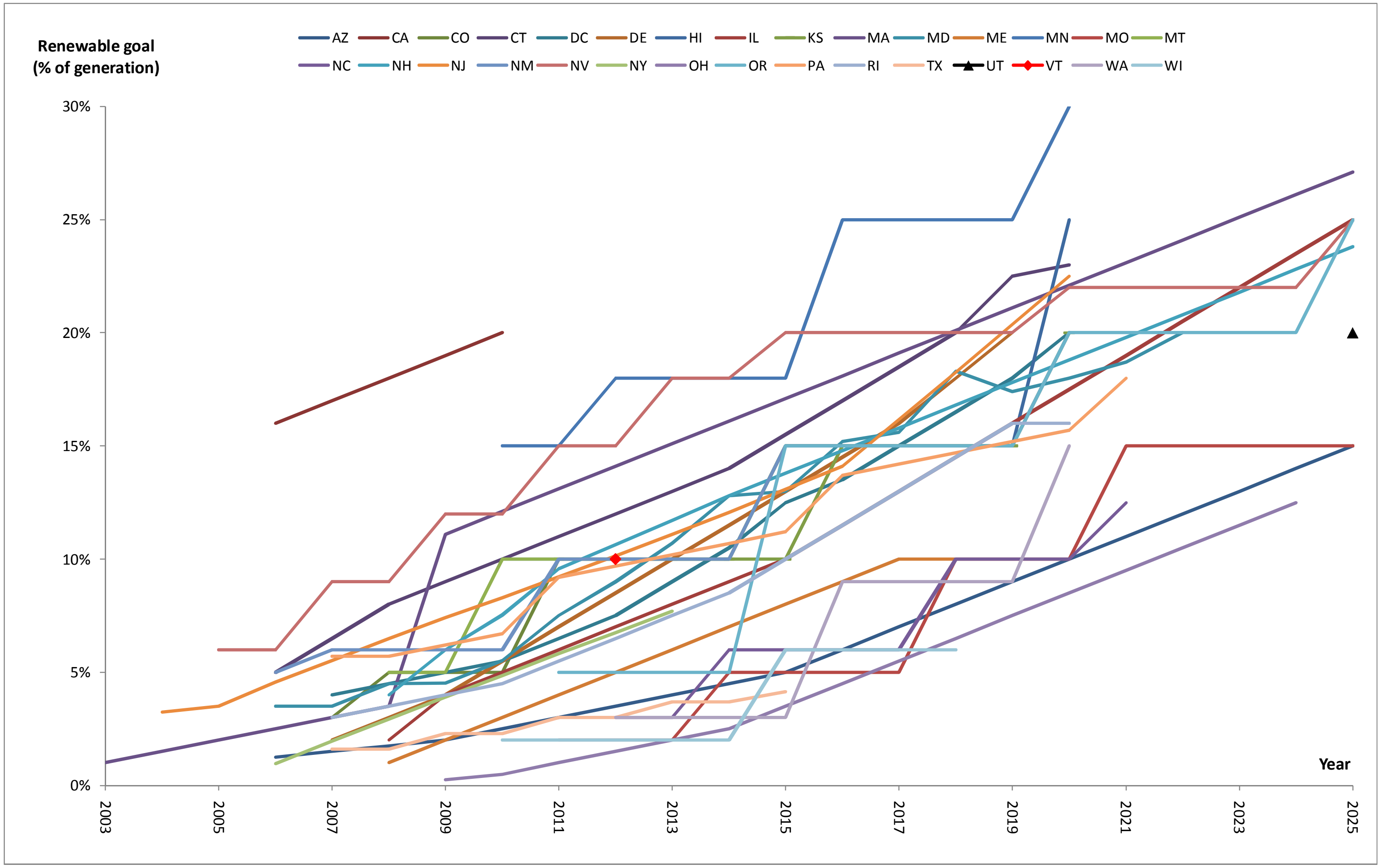

Figure 3.2: RPS compliance schedule. States with voluntary (ND, SD, VA) and capacity goals (IA) are not shown.

Two states (IA and TX[2]) have mandated a capacity goal, specifying the construction of a certain quantity of renewable resources, and three additional states (MN, MI, WI) have both a general sales goal and a capacity goal for certain large utilities. Capacity goals seem to have more direct impacts on *in-state* capacity. The effect of such a requirement on new renewable capacity in the state was statistically significant in a study by Kneifel (2008), while a generation requirement was not. Capacity goals usually require or prefer in-state location of the power-source, making this result plausible. In contrast, generation requirements place fewer restrictions on the location of the renewable power source (refer to Table 3.6 for an overview of geographical origin rules).

The size of the nominal renewable goal was also a significant driver of in-state renewable generation studies by Fremeth (2009) and Yin and Powers (2010). Businesses react to increased regulatory pressure, and therefore it is not surprising that larger goals are associated with more renewable generation or capacity. Nevertheless, as renewable power output depends on choosing sites with a good renewable resource, in particular for wind power, in-state capacity requirements could be costlier than mandates that allow out-of-state generation.

As RPS continue to mature and goals continue to increase, it is possible that a u-shaped relationship will start to appear. A study by the National Renewable Energy Laboratory (Bird et al., 2009) predicts that the concurrence of rising RPS goals in many North-Eastern states will sooner or later lead to supply shortfalls for renewable energy in this region. In this situation, stronger goals may have little additional effect on renewable deployment. In a similar fashion, prices can be expected to rise with increased demand created by RPS, mitigated by the supply available in the region.

Unfortunately, the focus on factual compliance schedules obscures that other provisions can effectively curtail the *prima facie* goal. In practice, it can make a large difference whether the statute allows existing renewable resources to count towards compliance, or requires all new resources. Furthermore, states often do not include all types of utilities, lowering the impact on new resource deployment. Goals are also affected when credit multipliers or subsidies are granted for specific resources. In addition to these factors influencing the actual strength of the renewable mandate, there exist other provisions that influence how much discretion utilities have in attaining the mandate. Compliance pathways are for example circumscribed by renewable energy credit trading or the setting of quota for certain technologies. Finally, the strength of the compliance regime is affected where state statutes provide easy ways to circumvent the RPS, whether by granting waivers or by accepting alternative compliance payments. The following subsections address these aspects of RPS design in detail.

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[2] Although TX has a capacity goal, compliance is based on renewable energy credits (MWh). Regulators calculate the required credits using a capacity factor.

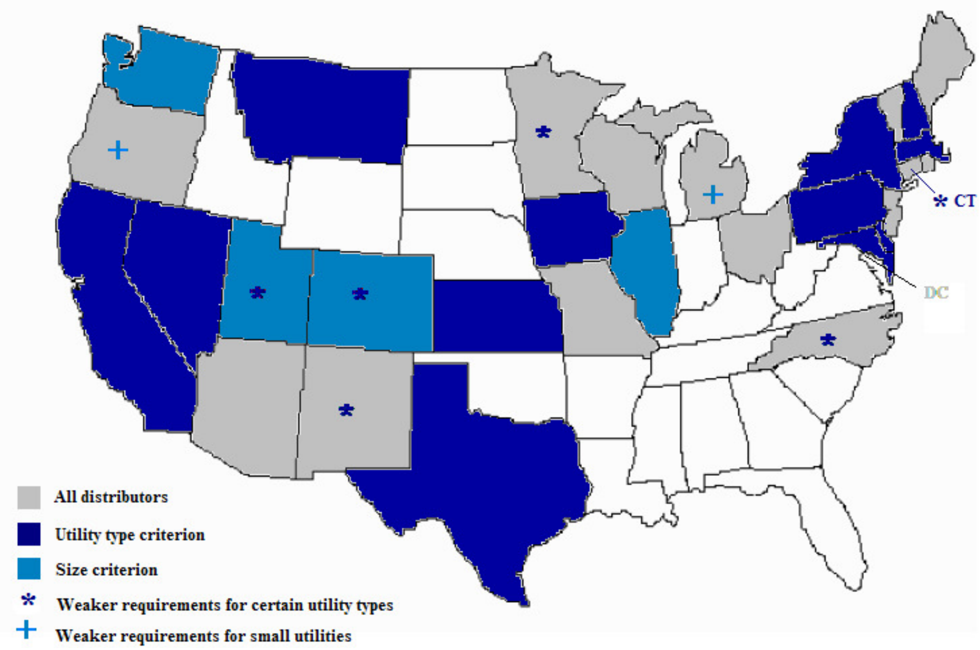

Figure 3.3: Applicability of RPS goals to utility type and size. HI (all distributors) is not depicted.

3.3.2 Scope of utility inclusion

Sixteen RPS states require all electric distributors to sell some quantity of renewable electricity, but only eight have uniform rules for all electric distributors. OR and MI stagger their requirements by utility size. In another five states, municipal utilities and cooperatives have a lower renewable goal (NM, NC, CO), set their own standard (CT), or benefit from other allowances (UT). MN is a special case, where utilities owning a nuclear power plant are subject to a tighter standard.[3]

More importantly, the remaining sixteen states with an RPS completely exclude some organizations, based either on size or utility type (Figure 3.3). Four states (CO, IL, UT, WA) only include utilities beyond a certain customer size or sales amount. The most widespread exclusion concerns municipal utilities and rural electric cooperatives. Their non-profit status and customer-ownership model mean they are generally not subject to rate regulation, and they face special challenges due to their smaller size and more rural service territories (Wilson et al., 2008). In 12 states, municipal utilities and/or cooperatives are completely exempt. Interestingly, these are not necessarily the states with the smallest amount of power sold by these utilities, or the cleanest fuel mix (Fischlein et al., 2009), indicating that political reasons play a role in this choice.

On average, RPS cover 86 % of state electricity sales. The scope of the RPS is quite small in a handful of states. IL has targets only for IOU, which sell no more than a third

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[3] Effectively, this only concerns Xcel Energy, which sells 50 % of the state's retail electricity.

of the state's electricity. The 25 % renewable sales goal for 2025 effectively translates to an 8 % goal. CA, IA and TX also exclude significant proportions of the electricity market. CA's 20 % goal by 2020 applies only to the large investor-owned utilities and effectively covers only 70 % of state sales, meaning the actual goal is closer to 14 % of retail sales in the state. Clearly, the impact of an RPS on renewable deployment is directly related to the definition of the policy's target group. The relationship with compliance cost is also influenced by the scope of the policy. As a larger share of utilities is included, demand for renewable power increases, and prices can be expected to rise accordingly. Additionally, rural electric cooperatives and municipal utilities, being smaller, may find it more difficult to comply, with added costs to their customers.

3.3.3 Eligible renewable resources

The ability to use renewable resources of different type and vintage varies from state to state (Table 3.1). Many RPS strive to support the development of new generation and therefore forbid existing sources to be counted. Nineteen states allow only resources that have become operational after a certain date. In the remaining states, the ability to fall back on existing renewable capacity weakens the impact on new technology deployment. Arguably, existing renewable generation is small enough in most states so that its eligibility makes little difference.

This changes drastically once hydropower is taken into account. It is an eligible resource in all thirteen states not restricting the use of existing resources, substantially weakening policy pressure to develop new, non-hydro renewable resources. NY's factual goal of 24 % renewable generation by 2020 actually will add no more than 7.3 % new resources over the baseline, given existing renewable facilities, which are mostly hydropower. Similarly, when existing hydropower and renewable sources are accounted for, AZ already fulfills 40 % of its ultimate 25 % target. NV had already achieved close to a third of its 25 % target with existing sources before its standard went into effect. Consequently, whether existing resources are allowed or not is an important factor in the overall potential of an RPS to impact renewable generation. Lower compliance costs can be expected, but it will reduce new renewable energy deployment where renewable energy from existing resources can be used for compliance.

The types of renewable resources listed as eligible can also influence the difficulty of achieving the RPS goal. The decision to include certain resources seems to be driven primarily by their availability or environmental impact. Due to non-availability, ocean wave and tidal power is excluded in many interior land-locked states. Geothermal power is accessible with conventional methods only in the Western part of the country, and some Eastern states are not listing it as eligible.

State	Max. age	Biogas	Biomass	Geo-thermal	Existing hydro	New hydro	Landfill gas	Munic. solid waste	Ocean wave, tidal	Photo-voltaic	Solar thermal	Wind
AZ		x	x	x	x	x	x	x		x	x	x
CA	2005		x	x	x^{1}	x	x		x	x	x	x
CO	2004		x	x	x^{1}	x	x			x	x	x
CT			x		x		x		x	x	x	x
DC			x	x	x		x	x^{2}	x	x	x	x
DE	1997	x	x	x	x^{1}		x		x	x	x	x
HI		x	x	x	x	x	x	x	x	x	x	x
IA		x	x		x	x	x	x		x	x	x
IL			x		x		x			x	x	x
KS			x		x	x	x			x	x	x
MA	1997	x	x	x	x^{1,2}	x	x	x^{2}	x	x	x	x
MD			x	x	x^{2}		x	x^{2}	x	x	x	x
ME	2005		x	x	x^{1}	x			x	x	x	x
MI			x	x	x		x	x	x	x	x	x
MN			x	x	x	x	x	x		x	x	x
MO			x		x		x			x	x	x
MT	2005		x	x	x^{1}		x			x	x	x
NC	2007	x	x	x	x^{1}		x		x	x	x	x
NH	2006	x	x^{2}	x	x^{1,2}	x	x		x	x	x	x
NJ	2003	x	x	x	x^{1}	x	x	x^{2}	x	x	x	x
NM	2008	x	x	x		x	x			x	x	x
NV		x	x	x	x		x			x	x	x
NY	2003	x	x		x^{1}	x			x	x	x	x
OH	1998	x	x	x	x^{1}	x	x	x		x	x	x
OR	1995	x	x	x	x^{1}	x	x		x	x	x	x
PA		x	x	x	x^{2}	x	x	x		x	x	x
RI	1997	x	x	x	x		x		x	x	x	x
TX	1999		x	x	x		x		x	x	x	x
UT	1995	x	x	x	x^{1}	x	x		x	x	x	x
VT	2004	x	x		x^{1}	x	x			x	x	x
WA	1999		x	x		x	x		x	x	x	x
WI	2004		x	x	x^{1}	x	x		x	x	x	x
No. of states		17	32	25	30	20	30	11	19	32	32	32

Table 3.1: Maximum age and types of resources eligible for RPS compliance

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[1] In states with maximum age restrictions, “existing hydro” refers to facilities built between the cut-off date and the time the standard entered into effect.

[2] Second tier resource; restricted due to environmental concerns.

Environmental impact is another driver of exclusion. Photovoltaic, solar thermal and wind power seem to be unobjectionable and can be counted in all states. In contrast, the use of biogas, biomass, municipal solid waste, and hydropower is more contentious, and subject to restrictions even in states that allow it. Biomass is permitted everywhere, but subject to different restrictions. All states accept agricultural and untreated woody biomass, but many exclude treated woody materials and old-stand timber. Additionally, dedicated energy crops, wood waste, pulping residues and food wastes are not eligible in all states. Municipal solid waste is the most heavily restricted of all resources and the only resource that is explicitly forbidden in some states. Only eleven states permit its use towards RPS goals and in four of those states (MD, NJ, OH and PA) it is only eligible as a second tier resource. In MA and MD, a recycling program has to be associated with the facility.

Most states count a certain amount of hydropower resources towards RPS compliance. Existing hydropower is completely ineligible in NM and WA. Fifteen states have implicit restrictions on existing hydropower, due to their rules on the maximum age of facilities. Seventeen states explicitly limit the capacity of eligible existing facilities. Generally, they cannot be larger than 30 MW, with the notable exception of VT (200 MW), MN (100 MW) and WI (60 MW). Fewer states allow new hydropower, due to concerns about its environmental impacts. It is eligible without restrictions in no more than eight states. AZ, CO and KS restrict capacity to ten MW or less, while larger facilities are eligible in MA, MN and VT. NH, OR and WA count only efficiency upgrades to existing facilities. Some states make meeting water quality and fish passage criteria a prerequisite for eligibility.

Overall, the more renewable resources a state allows, the larger the pool of facilities a utility can draw from to achieve RPS compliance. Arguably, compliance will be more difficult and more costly for a utility in MO, where only six types of renewable resources are permissible, than for a utility in NJ, where eleven resource types can be used. Overall, the types of renewable resources eligible for compliance will affect both cost of compliance and renewable energy deployment. Where eligibility rules are the most restrictive, higher costs can be expected. Total new deployment will only be affected where rules are so restrictive that they make compliance close to impossible. Nevertheless, the eligibility rules are likely to shift deployment across energy sources.

3.3.4 Eligibility of other resources and technologies

Besides renewable resources, some states also allow other types of technologies and resources. This could decrease the impetus for renewable technology deployment, because utilities can tap alternative compliance strategies that are not renewable in the narrow sense. In many cases, this will lower the cost of compliance to utilities. Table 3.2 shows an overview of the rules for non-renewable resources.

Of particular significance is the eligibility of energy efficiency as a resource in eight states. It offers substantial cost savings over building or contracting for new renewable resources and can change the nominal renewable goal. In CT, utilities can meet their entire requirement with energy efficiency, and in OH and HI, they can meet half of their requirement. NV and NC allow energy efficiency to count for up to 25 % of the goal. UT subtracts all energy efficiency savings from a utility's baseline retail sales before calculating its renewable goal. PA counts energy efficiency as a Tier II resource and CO allows it as an alternative for utilities with existing all-requirements contracts.

Resource	**Eligible in**
Advanced Fossil	IL, OH, PA, UT
Energy efficiency	CO, CT, HI, NC, NV, OH, PA, UT
Distributed energy	AZ, CA, CO, DE, KS, NC, NV, OH, PA, UT

Table 3.2: Eligibility of other resources

Energy from distributed facilities can be used for RPS compliance in ten states. Given that utilities are subject to the Public Utilities Regulatory Policy Act (PURPA) and have to work with distributed facilities anyway, this opens up an additional compliance pathway in these states. This is likely of minor importance, because of the small amount of distributed generation across the country. Additionally, integration of distributed generation comes with its own complications and transaction costs, because it requires utilities to work with several, and sometimes small businesses.

Finally, four states even permit fossil or nuclear resources to count. In IL, "clean coal" facilities can be counted. In OH, half of the 25 % goal can be generated from advanced energy resources, including advanced nuclear and "clean coal." In PA, waste coal and coal mine methane count as Tier II resources, and can therefore be used to achieve a portion of the renewable goal. In UT, zero carbon emission and carbon sequestration generation is deducted from sales before the renewable goal is calculated. The eligibility of resources not renewable in the strict sense of the word therefore enlarges the pool of compliance strategies utilities can draw from. It is expected to decrease the deployment of new renewable resources, because it effectively reduces the stated goal. It is also expected to decrease the cost of compliance, since the alternative resources generally have a lower cost than renewable resources in the strict sense. Currently, there is no case where these provisions around fossil and nuclear resources have been made use of for RPS compliance. This could change as the standards mature and goals become increasingly difficult to achieve.

3.3.5 Technology quotas and subsidies

In legislating RPS, policymakers oftentimes not only attempt to increase the amount of renewable energy, but try to influence the fate of specific technologies. This is often driven by the desire to increase the deployment of promising technologies that are not yet competitive. Local economic development and job creation also play a role. States have used different instruments to reach these goals, including quotas for certain technologies and direct monetary subsidies, such as production incentives and feed-in tariffs (Table 3.3). These instruments affect incentive structures for utilities by altering prices and/or restricting compliance choice.

The use of quotas is widespread. Twenty-three states have set a minimum generation or capacity amount for certain technologies. The most common requirement concerns solar power and is generally far below 1 % of annual electric sales in the state. This number may sound low, but requires tremendous growth rates in solar energy, considering the small role it currently plays in energy generation, and its high price compared to other renewable technologies. A handful of states also require minimum amounts of distributed energy or community-based renewable energy projects. IL, MN, NM and TX mandate a minimum amount of wind power.

Typically, technology quotas increase over time, along with the overall compliance schedule. Technology quota impact compliance price far more than renewable deployment. Like resource eligibility rules, they can shift deployment across fuels. The quantities required are often small, meaning that overall policy outcomes are not likely to change much. The cost, however, can be very high, if the policy is not well designed. For instance, the price for a MWh of solar energy eligible for compliance in NJ has topped US$ 200 several times between 2006 and 2008 (Wiser and Barbose, 2008). Compared to the average retail price of electricity of US$ 144 per MWh in the state, the solar RECs are very expensive (EIA, 2010d).

Instead of mandating quantities, some states grant subsidies. Production incentives exist in fourteen states and commonly take the form of a tax credit per unit of installed capacity. In a new development, AZ, CA, HI, and VT have started experimenting with feed-in tariffs, where producers are guaranteed a certain direct payment for each MWh they produce. These policies have been very successful in driving renewable development in Europe. Distributed energy is the prime beneficiary of subsidies, followed by solar energy (Table 3.3). A few states (AZ, CO, MN, MO, NJ, NV, and OR) have both a minimum quota and a subsidy for the same resource, indicating strong political will to support development of that particular resource. Subsidies will probably not affect the overall quantity of renewable energy deployed, but advantage certain resources and could bring down compliance cost for utilities, though not the overall cost of the policy.

State	Technology quota for:	Production incentive[1] for:
AZ	Distributed energy (30 % of RPS goal after 2011)	Distributed energy
CA	-	Distributed energy (based on market price referent and adjusted for time of use), Feed-in tariff for all renewables in 2010
CO	Solar (4 % of annual RPS goal)	Solar (2 $ per W), Distributed energy (at utility's discretion)
CT	Distributed energy (4 % of RPS goal after 2010)	-
DC	Solar (0.011 % of all sales in 2008, .4 % in 2020)	-
HI	-	Distributed energy, Feed-in tariff for solar, wind, hydro in 2010
IA	-	Distributed energy
IL	Wind (75 % of all renewables)	-
MA	Distributed energy (a "portion" of the RPS goal – not determined as of 2009)	-
MD	Solar (.005 % of all sales in 2008, 2 % in 2022)	-
ME	Community-based development (50 MW)	-
MN	Solar (Utility owning a nuc1ear facility: 1 % of all sales by 2020), Wind (Utility owning a nuc1ear facility: 24 % of all sales by 2020), Biomass (110 MW)	Wind, Biogas, Biomass, Hydro ($ 9.4 million for up to 200 MW until 2021)
MO	Solar (2 % of annual RPS goal)	Solar (2 $ per W)
MT	Community-based development (50 MW starting in 2010, 75 MW after 2015)	-
NC	Solar (0.02 % of all sales in 2010, 0.2 % after 2018), Swine waste (0.07 % of all sales in 2010, 0.2 % after 2018), Poultry waste (170 GWh in 2021, 900 GWh after 2014)	-
NH	Solar (0.04 % of all sales in 2010, 0.3 % after 2014)	Distributed energy (3 $ per W)

State	Technology quota for:	Production incentive[1] for:
NJ	Solar (0.01 % of all sales in 2004, 2.12 % in 2020), distributed energy (up to 2.5 % of peak demand)	Distributed energy, Solar
NM	Wind (20 % of RPS goal after 2011), Solar (20 % of RPS goal after 2011), Other renewables (10 % after 2011), Distributed energy (1.5 % of RPS goal starting in 2011, 3 % after 2015)	-
NV	Solar (5 % of RPS goal until 2015, 6 % thereafter)	Solar (2 $ per W)
NY	Distributed energy (2 % of RPS goal)	-
OH	Solar (0.004 % of all sales in 2009, 0.5 % in 2024)	-
OR	Community-based development (8 % of all sales by 2025)	Solar
PA	Solar (0.0013 % of all sales in 2006, 0.5 % in 2021)	-
RI	Distributed energy (2 % of peak demand)	-
TX	Sources other than wind energy (500 MW)	Existing distributed energy eligible as new source
VT	Sources < 2.2 MW (50 MW)	Methane (0.12 $/kWh), Small wind (0.20 $/kWh), Solar (0.30 $/kWh)
WA	-	Solar (in-state manufactured: 0.24 $/kWh, other: 0.18 $/kWh), Wind (in-state manufactured: 0.18 $/kWh, other: 0.12 $/kWh), Biogas (0.15 $/kWh)

Table 3.3: Quota and subsidies for specific renewable technologies in state RPS

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[1] Incentives are quantified were specified in the law. In some states, incentives depend on the tax base or the size of the renewable facility built, or specific directives had not been passed yet.

3.3.6 Renewable energy credits

The treatment of renewable energy credits (REC) is one of the most interesting aspects of RPS, because it introduces a market mechanism to this direct regulation.

Definition and trading

Renewable energy credits (REC) are tradable certificates that incorporate the environmental benefits of renewable generation, and present a means of verifying and tracking the *bona fide* provenance of renewable generation. REC are either bundled with the physical electricity, or sold separately from it. With unbundled REC, utilities trade the environmental benefits of renewable generation separately from the physical unit of electricity, easing the transmission constraints of the electrical grid and the complexities of the electricity market. Electricity cannot be stored and line losses add up when it is transmitted over long distances. On average, combined line losses amounted to 5.8 % in 2003 (World Bank, 2004). Furthermore, load centers are often distant from where renewable resources exist in abundance. Consequently, unbundled REC allow renewable generators to feed the power they produce into the local grid, while selling the REC independently. In turn, utilities can buy REC for compliance without actually having to find ways to have the power delivered to their system. The vast majority of states include this market mechanism to provide for heightened flexibility (Table 3.4).

Unbundled REC	**State**
not permitted	AZ, CA, NV, WI
capped	KS, NC, OR, UT
permitted	CO, CT, DC, DE, HI, MA, MD, ME, MI, MN, MO, MT, NH, NJ, NM, OH, PA, RI, TX, VT, WA
n.a.	IA, IL, NY

Table 3.4: Treatment of unbundled renewable energy credits

Only AZ, CA, NV, and WI completely forbid the use of unbundled REC. The only other states not using unbundled REC have a capacity goal (IA) or a central procurement mechanism (IL and NY). Unbundled REC can influence both price and renewable deployment. They introduce an additional, flexible means of compliance, reducing risk to all parties. Where trading is permitted, renewable energy can be produced by the lowest cost supplier. All this should drive down prices. They also create an incentive for over-compliance, because extra credits can be sold freely, and they can therefore be expected to drive additional renewable deployment.

The existence of REC that are separate from the physical electricity has had some unexpected consequences in the context of existing electricity purchasing agreements. A number of renewable facilities were constructed before REC were created and older contracts often do not specify whether the environmental benefit remains with the producer or is transferred to the purchaser along with the electrical energy. This has resulted in several lawsuits and appeals to public utility commissions. Policymakers and regulators have started to address this issue, albeit in different ways. Only MI, NV and VT attribute REC to the power purchaser when the contract is not specific. More commonly, REC remain with the generator or owner of the renewable generating facility. Seven states have a provision to this effect. All of them are more recent adopters of RPS, indicating that the issue was not recognized by earlier RPS adopters, and its resolution is now being handled in the courts.

REC, unbundled or not, help track renewable generation and guarantee that each credit is claimed only once (Gillenwater, 2008a). They also provide assurance that the validity period of certificates has not elapsed and that they stem from eligible resources and geographic areas (Berry, 2002). Accordingly, even where unbundled REC are not permissible, states generally use credits to measure compliance and prevent double-counting. Currently, there exist nine regional tracking systems for renewable energy credits (Table 3.5).

Regional tracking system	**Acronym**	**Participating states**
Electric Reliability Council of TX	ERCOT	TX
Midwest Renewable Energy Tracking System	M-RETS	IL, IA, MN, MT, ND, SD, WI[1]
MI Renewable Energy Certification System	MIRECS	MI
New England Power Pool General Information System	NEPOOL-GIS	CT, ME, MA, NH, RI, VT
NC Renewable Tracking System	-	NC
NY State Energy Research and Development Authority	NYSERDA	NY
PA-Jersey-MD Power Pool Generation Attribute Tracking System	PJM-GATS	DE, IL, IN, KY, MD, MI, NJ, NC, OH, PA, TN, VA, WV, DC
Western Renewable Energy Generation Information System	WREGIS	AZ, CA, CO, ID, MT, NE, NV, NM, OR, SD, TX, UT, WA, WY[2]
North American Renewables Registry	NARR	Remaining states[3]

Table 3.5: Renewable energy tracking systems in North America

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[1] Canadian province Manitoba also participates in M-RETS.

[2] Canadian provinces Alberta and British Columbia also participate in WREGIS.

[3] APEX, the company operating the majority of regional REC tracking systems, created NARR to provide access to renewable markets to generators in the South-Eastern United States, where most states do not have an RPS.

Despite the tracking systems, the incongruence between states' definitions of REC actually complicates their function to provide flexibility. Resource eligibility is not the same across states (see Section 3.3.3), and rules on regional origin and shelf life also differ (Table 3.6). Holt and Wiser (2007) point out that "many states have not fully defined a REC or specified which environmental attributes must remain with renewable energy transactions for those transactions to count towards RPS compliance." Most states rule out the double-counting of REC for another state's standard, but remain silent on whether REC include all environmental benefits and emissions offset. Only CA, DE and PA clearly specify that REC do not include emissions reductions. In turn, only CO, NM and VT unequivocally state that REC include all environmental attributes associated with renewable generation.

The fact that 26 states provide no guidance on this issue is startling, given the potential for interactions with other policies and markets for environmental commodities (Gillenwater, 2008b; Lokey, 2007). With the advent of regional, national, or international carbon trading, repercussions in the REC market could be considerable. The only regional U.S. cap and trade system currently up and running, the Regional Greenhouse Gas Initiative (RGGI) in New England, does not permit renewable generation used to comply with a state RPS to also claim carbon credits. Other regional and national efforts at greenhouse gas reduction (e.g., Midwest Governors Association Climate Accord) are currently under development. They have not settled the question of how to treat REC used for compliance with state mandates under a carbon trading system.

Interactions with voluntary markets also cause considerable uncertainty, since private firms' and individuals' demand for carbon offsets associated with renewable generation is difficult to predict and competes with compliance demand. It is not clear whether and how renewable energy will be counted towards future federal and regional carbon emission reduction mechanisms, and how emissions registries will interact with REC tracking systems. The resulting uncertainty in REC markets could slow the diffusion of renewable energy technologies, since policy uncertainty can hamper innovation (Marcus, 1981; Meijer et al., 2007) and lead to delayed or suboptimal investments (Blyth et al., 2007; Brunekreeft and McDaniel, 2005; Fuss et al., 2009; Yang et al., 2008). The effect on achieving RPS goals owes less to the type of policy characteristic than to the lack of coordination among states, but is mentioned here for completeness.

Credit multipliers

Other effects of REC are more directly related to their design, and not to the differences across states. Fourteen states advantage certain technologies by granting one or several credit multipliers (Table 3.6).

State	Credit multipliers	REC Origin
AZ	Solar (manufactured in state: nameplate capacity x 25%), In-state installation or manufacturing (150% for life), Early installation (2001: 130%, 2002: 120%, 2003:110% for 5 years)	Delivered to WECC[1] control area
CA	-	Generated in state
CO	Generated in state (125%), Community-based energy < 30 MW (105%), Solar (300%)	-
CT	-	Delivered to ISO-NE[2] control area
DC	Solar (120% until 2006, 11% until 2009), Wind (same as solar), Biogas (110% until 2009)	Delivered to PJM[3] control area
DE	Fuel cells (installed before 2014: 300%), In-state customer-sited solar (installed before 2014: 300%), In-state wind (installed before 2012: 150%), Off-shore wind (installed before 2017: 350%)	-
HI	-	Generated in state (island)
IA	-	Generated in state or utility's service area
IL	-	Generated in state (through 2011) and adjoining states thereafter
KS	In-state installation (installed after 2000: 110% for each MW)	-
MA	-	Delivered to ISO-NE[2] control area
MD	Wind (installed 2004-2005: 120%, 2006-2008: 110%), Methane (installed before 2008: 110%)	Delivered to PJM[3] control area (exception: solar REC)
ME	Community-based renewable energy pilot program (150%)	Delivered to ISO-NE[2] or NMISA[4] control areas
MI	Solar power (200%), Peak generation (120%), In-state equipment/labor (110% for 3 years)	Generated in state or service territory of provider (new resources/contracts)
MN	-	-
MO	In-state installation (125%)	-
MT	-	Delivered to state
NC	-	-

State	Credit multipliers	REC Origin
NH	-	Delivered to ISO-NE[2] control area
NJ	-	Delivered to PJM[3] control area (new resources), generated in PJM[3] area (existing resources)
NM		Delivered to state
NV	Line loss (105%), Peak load (200%), Customer sited generation, including solar (240%)	Delivered to provider
NY	-	Delivered to NYISO[5] control area
OH	Biomass retrofits of conventional plants (before 2013: at least 100%)	At least 50 % generated in state, remainder delivered to state
OR	-	Generated in US and WECC[1] control area, delivered to state
PA	-	Generated in control region (PJM[3], ISO-NE[2])
RI	-	Delivered to NEPOOL-GIS[6] area
TX	Non-wind renewable technologies (200%)	Generated in state
UT	Solar photovoltaic or solar thermal (240%)	Generated in WECC[1] control area or delivered to transmission system of the utility
VT	-	Generated at facilities owned by or under contract with VT utilities
WA	Distributed energy (200%), In-state labor (installed after 2005: 120%)	Generated in Pacific NW, or delivered to state
WI	-	Delivered to state

Table 3.6: Credit multipliers and regional origin of credits in RPS

Similar to technology minima and production incentives, solar energy is the most favored resource, both in the number of states offering extra credit for solar energy and in the size of the credit multipliers. One MWh of solar energy is worth three REC in CO and DE, and two or more REC in MI, TX, NV, and UT. DC has a comparatively small solar credit of 120 %. The support of in-state labor, manufacturing and installation is also common,

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[1] Western Electricity Council

[2] Independent System Operator New England

[3] Pennsylvania-New Jersey-Maryland Interconnection

[4] Northern Maine Independent System Administrator

[5] New York Independent System Administrator

[5] New England Power Pool Generation Information System

although additional credit hovers in the order of 10-50 % in this case, much lower than for solar. As these subsidies artificially lower the price of in-state resources, they represent a case of competing policy goals of local economic development and policy flexibility.

In parallel to other subsidies in RPS regulations, in-state multipliers may weaken the factual renewable goal and/or lead to different patterns of technology deployment and fuel diversity. Additionally, credit multipliers decrease the cost of compliance to utilities. Consider for example the case of CO. This state grants an extra 25 % credit to all renewable energy generated in-state. If the entire 1,325 MWh of in-state renewable generation for 2007 (EIA, 2009c) is applied to the RPS, it yields 1,656 MWh in REC - more than sufficient to cover that year's 3 % renewable goal with 2.5 % actual renewable generation. Again, a narrow focus on the stated goal will miss this effect. Multipliers, although in effect similar to a technology quota or subsidy, also act as a masking agent. They make the renewable goal appear much more stringent than it is in reality. From a political point of view, they can serve a rhetoric of significant progress in renewable deployment, while giving a break to utilities. This is facilitated by the general focus on simplifying, single-measure goals (e.g., 25 % renewable energy by 2025).

Geographic origin

Another significant factor in REC design concerns provisions on their geographic origin (Table 3.6). Very few states will allow REC from all parts of the nation to be counted towards compliance. This is likely driven by a desire to secure localized benefits of renewable energy, such as cleaner air, investments and job creation. As mentioned above, most states do not forbid the use of unbundled REC. However, many still require the associated energy to be delivered to the regional grid or to the state. The most restrictive states (CA, HI, IA, IL, MI, NV, OH, and TX) allow only in state generation, or generation within the service territory of electric providers. Previous analysis by Yin and Powers (2010) found that allowing free trading in REC lowered the amount of new renewable generation deployed in a state, presumably because utilities took advantage of a larger market to buy REC from out of state. This effect is due to the measurement of RPS effectiveness at the state level. Were we able to measure RPS effectiveness across state lines, we might well find that allowing free REC trading actually increased overall renewable generation. Where only in-state REC are permitted, supply of REC would likely be lower and prices higher. Utilities may be forced (or choose) to make alternative compliance payments or pay a fine instead.

Shelf-life

The final relevant aspect of REC design concerns their shelf-life (Table 3.7). States have passed different rules on how long a REC can be used for compliance after it was created, and whether utilities can make up for shortfalls with future REC.

State	**Banking**	**Borrowing**
AZ	indefinite	-
CA	indefinite	3 years
CO	5 years	6 months
CT	-	3 months
DC	3 years from creation	-
DE	3 years from creation	-
HI	-	-
IA	n.a.[1]	n.a.[1]
IL	n.a.[2]	n.a.[2]
KS	-	-
MA	2 years (30 % cap)	-
MD	3 years from creation	-
ME	1 year (33 % cap)	1 year (33 % cap)
MI	3 years	120 days
MN	4 years	-
MO	3 years from creation	-
MT	2 years (30 % cap)	3 months
NC	indefinite (within 7 years of cost recovery)	-
NH	2 years from creation (30 % cap)	3 months (30 % cap)
NJ	none (exception: 1 year for solar REC)	-
NM	4 years from creation	-
NV	4 years	-
NY	n.a.[2]	n.a.[2]
OH	indefinite	-
OR	indefinite	3 months
PA	2 years	90 days
RI	2 years (30 % cap)	-
TX	2 years	-
UT	indefinite	-
VT	-	-
WA	1 year	1 year
WI	4 years after creation	-

Table 3.7: Shelf-life of REC specified in RPS. Banking and borrowing periods start after the end of the compliance year, unless otherwise specified.

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[1] Capacity goal

[2] Central procurement

Borrowing or true-up periods are either zero, or very short. No state allows borrowing beyond a one year period. In addition, some states cap the portion of the renewable goal that can be met with REC borrowed from the future. For banking REC, the rules are much more diverse. Most states allow at least one year of banking and commonly, REC are valid for two to four years. In six states (AZ, CA, OH, OR, UT, NC) utilities can even bank REC indefinitely. The effect of banking provisions on renewable energy deployment is not straightforward. Being allowed to bank REC could accelerate diffusion early on, as utilities develop renewable resources above the required amount to take advantage of banking opportunities for later compliance stages with more stringent goals. This also advantages renewables of larger scale (wind farms, biomass etc.) that can be deployed in blocks.

In contrast, smaller sources (e.g., solar) would appear more advantageous in an RPS without banking, to cover incremental increases in required renewable sales. Without banking, utilities have fewer incentives to go beyond compliance and accelerate diffusion. On the other hand, where banking is permitted and utilities have some lead time before the start of the RPS schedule, or surpass the renewable mandate for the first compliance stages, they are likely to delay investment. Banking and especially borrowing could help avoid REC price spikes, as supply evens out across years. Interestingly, most utilities seem to adopt a conservative strategy at this point and prefer to bank surplus REC instead of selling them for profit.[4] This appears to be driven by the risk-avoiding management style adopted by most utilities, as well as the expectation that REC prices will increase in the future as standards tighten.

3.3.7 Penalties, enforcement and waivers

As for any policy, deterrence is crucial to ensure that RPS policy goals are met. State statutes specify financial consequences for non-compliance in 25 states (Table 3.8). Fines are levied by ten states, while fifteen states use alternative compliance payments (ACP).

Fines do not relieve utilities of their compliance requirement. In contrast, when a utility pays an ACP, it acquits itself of its renewable energy obligation. Consequently, ACP must be set at a sufficiently high price to avoid discouraging technology deployment. ACP range between US$ 25-57 per MWh, with higher charges for solar energy in a handful of states. Clearly, ACP may be a lower cost option in some states than purchasing renewable energy. Some states base fines on the procurement cost of renewable energy or the price of REC (multiplying them by some factor, or setting them as the minimum amount of the fine), and a few levy administrative fines. AZ and CA simply require utilities to meet the shortfall the following year.

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[4] Observation based on personal communication with utility managers, and RPS compliance reports showing that roughly a third of utilities bank significant amounts of REC.

State	Penalty mechanism	Financial safety valve: Trigger	Financial safety valve: Action triggered	Other exemptions and waivers
AZ	Meet shortfall following year	-	-	Compliance waiver for good cause
CA	Meet shortfall following year	Cost cap (equal to public goods charge)	Procurement only at or below market price	Compliance waiver for insufficient transmission
CO	Fine	Retail rate impact (2 %)	Penalty waiver	Green pricing can be counted towards RPS goal
CT	ACP	-	-	-
DC	ACP	-	-	-
DE	ACP	ACP, REC price comparison. ACP > 30 % in 3 years	ACP adjustment (-10 %). Delay of RPS schedule	Exemption for customers with industrial load > 1.5MW
HI	Fine	-	-	Compliance waiver for good cause
IA	Fine	-	-	-
IL	-	Retail rate impact (2 %)	Compliance waiver	-
KS	Under dvlpmt.	Retail rate impact (1 %)	Penalty waiver	-
MA	ACP	-	-	-
MD	ACP	Revenue impact (1 %). Rate freeze or cap areas	Delay of solar requirement; Compliance waiver	Exemption for industrial sales > 300 GWh
ME	ACP	No new renewable capacity. ACP > 50 % in 3 consec. years	RPS suspension for 1 year	Penalty waiver for demonstrable good faith effort
MI	Purchase REC	Maximum per account charge	Compliance waiver	Extension of RPS goal for 1 year for good cause
MN	Purchase REC; Fine	-	-	Modifications or delay to RPS if in public interest
MO	Fine	Retail rate impact (1 %)	Penalty waiver	-
MT	ACP	Cost cap (comparison with conventional sources)	Compliance waiver	Compliance waiver for unavailability of REC, reasons beyond the control of the utility, reliability
NC	Fine	Maximum per account charge	Compliance waiver	Modifications or delay to RPS if in public interest
NH	ACP	-	-	Modifications or delay to RPS for good cause

State	Penalty mechanism	Financial safety valve: Trigger	Financial safety valve: Action triggered	Other exemptions and waivers
NJ	ACP	-	Delay of solar requirement	-
NM	-	Coops: Gross receipts impact (1 %), IOU: Retail rate impact (staggered, 3 % by 2015).	Compliance waiver and/or exemption from full fuel diversification	Exemption from fuel diversification for technical reasons. Procurement limit for customers > 10 million kWh
NV	Fine	-	-	Compliance waiver for resource unavailability
NY	-	-	-	-
OH	ACP	Cost cap (3 % more than conventional sources)	Compliance waiver	Modification of RPS goal for force majeure. Opt-out option for retail choice customers
OR	Fine	Revenue impact (4 %)	Compliance waiver	Compliance waiver if renewable energy replaces sources other than coal, gas, oil
PA	ACP	-	-	Modification of RPS goal for force majeure
RI	ACP	-	-	Delay or revision of RPS for insufficient resources
TX	ACP	Not specified	REC price cap	Suspension of RPS for reliability reasons. Opt-out for customers at transmission level voltage. Offsets for coops and municipal utilities.
UT	Fine	Cost-effectiveness of renewable resources	Compliance waiver; Penalty waiver	Penalties waived for force majeure
VT	ACP	RPS impairs meeting energy needs at lowest economic and environmental cost	Compliance waiver	RPS will not go into effect if sufficient renewable resources were constructed thanks to capacity requirement (SPEED program)
WA	ACP	Revenue impact rule (4 %)	Compliance waiver	Compliance waiver for events beyond reasonable control of utility, or no load increases.
WI	Fine	Retail rate impact (“unreasonable”)	Delay of RPS goals	Delay of 50 MW capacity goal for events beyond reasonable control. Delay of RPS compliance for reliability, siting/permitting, and transmission issues

Table 3.8: Deterrence mechanisms, financial safety valves and waivers under state RPS

Most states will not allow utilities to pass on the penalty cost to consumers, unless it is the least cost option. Such penalties affect the utility's bottom line. In practice, compliance with state RPS has been well above 90 %, and penalties have only been levied in TX and CT so far (Wiser and Barbose, 2008). As standards continue to tighten, it is possible that enforcement actions will become more common.

While states use sanctions to ensure compliance with RPS, they also want to prevent that certain cost limits are exceeded. After all, the primary goal of a utility is to provide a reliable, affordable energy supply. Consequently, most RPS feature waivers and financial safety valves to prevent economic hardship (Table 3.8). Financial safety valves are a very common feature of RPS and are present in twenty states. Given the role of the electricity supply in industrial production and household consumption, legislators include these provisions to avoid excessive cost increases. They reduce risks related to future price development and availability of renewable energy.

The triggers for compliance waivers and delay or suspension of the RPS schedule are almost always price increases to the consumer. In six states, retail rate impacts are capped at 1-3 % increases. MI and NC have set maximum per account charges that can be applied to each customer's electric utility bill. OR and WA cap revenue impact to the utility at 4 %, while MD caps it at 1 %. In some other states, the cost of renewable resources and the (over)use of ACP serve as triggers.

Furthermore, RPS in many states provide the possibility to claim other waivers, both for penalties and compliance. Force majeure clauses are a common occurrence. Under such clauses, compliance rules are modified or suspended for good cause or circumstances beyond the utility's control. A few states (DE, MD, NM, TX) also provide opt-out clauses or exceptions for high-load or industrial customers. Overall, the existence and extent of waivers can be thought to detract from achieving the desired policy outcome, while the threat of a fine or ACP will provide motivations for compliance.

To the best of my knowledge, no utility has invoked a waiver to date. Given the vague nature of most provisions on waivers, their (successful) use will likely depend on the state's political climate, the relationship between utilities and regulators, and the potential benefit to be gained. As RPS mature and goals become more difficult to attain, applying for a waiver may appear increasingly attractive to utilities.

3.4 Comparing policy design characteristics

The analysis of RPS design elements has shown that there exists immense variability across states in their approaches to increase renewable energy sales. Additionally, individual design aspects have the potential to significantly influence policy implementation and outcomes. In order to move towards a more rigid model for policy comparison, I develop a classification of policy design elements. I also discuss typical patterns of policy design that appear in

RPS across the United States.

3.4.1 Classification of policies

Generalization requires the development of a classification scheme that is applicable to more than one type of policies and promising as a basis for future empirical analysis, given its theoretical foundation. As pointed out by Richards (2000, p. 232), "a useful taxonomy reflects general principles of scientific classification, informing the user about the important similarities and differences among the various items in the classification." I draw on the policy design literature to identify relevant policy dimensions by which to classify RPS. This literature addresses the configurations of a policy, the rules it prescribes, and the implementation and enforcement regime it sets up.

Due to the roots of this field in the political sciences, much research in this area is concerned with explaining policy output, i.e. attempting to identify the processes and causes that lead to a specific type of policy being legislated (Ringquist, 1993a; Varone and Aebischer, 2001). Process-oriented policy output analysis is focused on adoption and policy process (Howlett and Ramesh, 1993; Tews, 2006), most often ignoring diversity in the policy choice. This *ex ante* analysis of policy output is increasingly being supplemented by *ex post* analysis of policy outcomes (Herrick and Sarewitz, 2000) and factors for policy success (Keiser and Meier, 1996). Policy outcomes are traced back to legal rules, the administrative implementation, and strategic reactions by business to regulation. Many studies in this area remain descriptive, listing idiosyncracies of a specific policy or comparing a small number of cases (Popp, 2006). This reflects both the complexity of measuring policy design and outcomes (Jaffe et al., 1995; Newmark, 2005), as well as data availability. For the same reasons, ex-ante economic models of different policy types are more common than empirical policy evaluation.

Policy types refer to classes of policy instruments. The most commonly used dichotomy compares the outcomes of direct regulation or command & control policies against flexible regulation. Command & control policies not only define a target, but also prescribe the strategies and/or technologies to achieve it. Flexible policies set price signals (e.g. tax, subsidy) or quantities (e.g., cap and trade), but leave discretion to the regulated entity as to how to achieve goals or react to price signals. As a general rule, well-designed flexible policies lead to a more efficient allocation of resources than direct regulation (Anderson, 1977; Baumol and Oates, 1975; Dales, 1968; Kneese and Schultze, 1975). Policy instruments shape economic incentives, and therefore influence costs and benefits of environmental policies (Goulder and Parry, 2008).

It is more likely that several variations of one policy type are considered, than completely different policy instruments. Direct regulation is still very common in U.S. environmental policy (Keohane et al., 1998) and many policies mix elements of direct and flexible regulation. The broad dichotomy between direct and flexible regulation is therefore of little help in selecting specific design elements. Consequently, it is necessary to develop a classification that more clearly captures differences within a policy type. I focus on three aspects of policy design: the stringency of goals, the discretion in means and the strength of the penalty regime. These three dimensions are based on the most relevant design characteristics cited in the policy design literature. Furthermore, they capture different aspects of policy design, namely the policy target that firms have to achieve, the permissible compliance pathways they can choose, and the sanctions they face for non-compliance.

Stringency refers to the magnitude of the effort required from the policy target, or the extent to which the goal imposed by the policy is difficult to reach. The stringency of a policy is its most visible characteristic, and often the only aspect of a policy that is described (Bacot and Dawes, 1997; Hamamoto, 2006; MacAvoy, 1987; Ringquist, 1993b). Numerous studies concentrate on stringency as a policy characteristic, presenting evidence of the link between higher pollution control expenditure and innovative activity (Lanjouw and Mody, 1996), investment in technology development (Jaffe and Palmer, 1997; Millock and Sterner, 2004), or pollution levels (Ringquist, 1993b). Stricter policies impose a more substantial constraint (Roediger-Schluga, 2002) and have a signaling effect (Del Brío et al., 2002; Hoffman, 2001).

Discretion in means addresses the amount of flexibility in compliance pathways open to the target of the regulation. The most successful regulations are setting clear and ambitious goals, while leaving firms sufficient time and autonomy to attain them (Majumdar and Marcus, 2001). It is the opportunity to choose - or invent - new means of compliance that is hypothesized to result in more innovation and higher productivity under flexible regulations (Majumdar and Marcus, 2001). Consequently, flexible design elements have been described by many authors as a key element in guaranteeing policy success (Burtraw, 1995; Milliman and Prince, 1989; Nehrt, 1998; Rico, 1995; Shrivastava, 1995; Taylor et al., 2005).

The *penalty regime* refers to all aspects of a policy that are intended to assure compliance by deterrence. Deterrence theory is based on the premise that business firms are rational economic actors, whose compliance with costly regulations will only be compelled by the threat of a costly penalty (Rechtschaffen, 1998). Credible and sufficiently large sanctions can contribute to policy success due to their deterrence effect (Gray and Scholz, 1993), while waivers weaken compliance pressure. Firms also react to institutional pressure, since non-compliance carries a reputational cost (Caplan, 2003; Karpoff et al., 2005).

3.4.2 State rating

I develop a simple rating system that classifies states along these three dimensions (Figure 3.4). For each dimension, I employ the most pertinent factors, coded as binary variables. A larger number of positive ratings denotes a stronger emphasis in the applicable dimension. Most design elements are binary variables, that either exist or not in a given state. For quantitatively expressed design elements, a median split was used.

State	Ultimate goal (% retail sales)	Final year of RPS	Annual % point increase	**Stringency**						**Discretion**				**Penalty regime**			
				Scope	Advanced fossil	Existing hydro	Energy efficiency	Credit multipliers	Existing resources	Eligible resources	Technology quota	Unbundled REC	Regional origin	Fin. safety valve	Force majeure clause	Other waivers	Penalty
RI	16	2020	1.1	+	+	+	+	+	+	+	+	+	+	+	-	+	+
NJ	23	2020	1.6	+	+	+	+	+	+	+	-	+	+	+	+	+	+
OR	25	2024	1.1	+	+	+	+	+	+	+	-	+	+	-	+	-	+
VT	10	2012	0.8	+	+	+	+	+	+	-	+	+	-	-	+	-	+
WI	10	2015	1.3	+	+	+	+	+	+	+	+	-	-	-	-	+	+
MA	22	2020	1.5	-	+	+	+	+	+	+	-	+	+	+	+	+	+
NH	24	2025	1.0	-	+	+	+	+	+	+	-	+	+	+	-	+	+
MN	25	2025	0.8	+	+	+	+	+	-	+	-	+	+	-	-	+	+
NC	13	2021	0.8	+	+	+	-	+	+	+	-	+	+	-	-	+	+
NM	20	2020	1.2	+	+	-	+	+	+	+	-	+	-	-	+	-	-
NY	24	2013	0.9	-	+	+	+	+	+	-	-	-	+	+	+	+	-
MT	15	2015	1.5	-	+	+	+	+	+	-	-	+	-	-	-	+	+
DC	20	2020	1.5	+	+	+	+	-	-	+	-	+	+	+	+	+	+
HI	40	2040	1.0	+	+	-	+	+	-	+	+	+	-	+	-	+	+
MD	22	2022	1.4	+	+	+	+	-	-	+	-	+	+	-	+	-	+
CT	23	2020	1.6	+	+	-	+	+	-	-	-	+	+	+	+	+	+
IA	0.5	1995	n.a.	-	+	+	+	+	-	+	+	-	-	+	+	+	+
MO	15	2025	0.8	+	+	+	+	-	-	-	-	+	+	-	+	+	+
ME	10	2017	1.0	+	+	-	+	-	+	-	-	+	+	-	-	+	+
CA	20	2010	2.7	-	+	+	-	+	+	+	+	-	-	-	+	-	-
DE	20	2020	1.4	-	+	+	-	-	+	+	+	+	+	-	+	-	+
UT	20	2025	1.1	+	-	+	-	-	+	+	+	+	+	-	-	+	+
WA	15	2020	0.8	-	+	-	+	-	+	+	+	+	+	-	-	+	+
MI	10	2015	1.0	+	+	-	+	-	-	+	+	+	-	-	-	+	-
CO	20	2020	1.1	-	+	+	-	-	+	-	-	+	+	-	+	-	+
TX	6	2015	0.1	-	+	-	+	-	+	-	-	+	-	-	+	-	+
PA	18	2021	1.2	-	-	+	-	+	-	+	-	+	+	+	-	+	+
AZ	15	2025	0.8	+	+	-	-	-	-	+	-	-	+	+	-	+	-
OH	25	2024	1.4	+	-	-	-	-	+	+	-	+	-	-	-	-	+
NV	25	2025	1.1	-	+	+	-	-	-	-	-	-	-	+	-	+	+
IL	25	2025	1.3	-	-	-	+	+	-	-	-	-	-	-	+	+	-
KS	20	2020	1.2	-	+	-	-	-	-	-	+	+	+	-	+	+	+

Figure 3.4: Nominal RPS goal and state rating of RPS stringency in goals, discretion in means and penalty regime.

The stringency of goals dimension includes the scope of retail sales and credit multipliers. These measure influence the magnitude of the policy goal negatively, because they define the size of the included sector, and create extra credits for certain resources. Additionally, the eligibility of advanced fossil, energy efficiency, existing hydropower, and of other existing resources are included in the stringency of goal dimension. All of these aspects weaken the goal with regard to its potential to drive new renewable energy deployment, because they allow compliance means other than new non-hydro renewable generation.

Flexible provisions within a direct regulation affect discretion in compliance strategies available to regulated entities, either by restricting the portfolio of compliance pathways, or by mandating, subsidizing or penalizing compliance choices. The discretion in means dimension includes the number of eligible renewable resources, the existence of technology quotas, the permissibility of unbundled REC, and the existence of regional origin rules for REC.

The penalty regime dimension includes the existence of a financial safety valve, of force majeure clauses and of other waivers, and the type of penalty. These measures influence the likelihood that the policy is implemented as intended, because they increase deterrence through sanctions or weaken it by providing exceptions and exemptions.

I juxtapose the state rating with the nominal goal in the final year of the RPS and the averaged annual increase in renewable share, as a measure of goal development over time. The average annual increase reflects only incremental renewable energy share in the state. As evident in Figure 3.4, states with large ultimate renewable goals, and/or large annual percentage point increases do not necessarily rank highly in stringency, discretion and enforcement. IL and OH, for example, both have less than half positive ratings in all dimensions, despite their 25 % stated final goals. Clearly, a strong nominal goal is only one indicator of policy quality, with other design aspects also influencing the factual policy response by utilities.

The state rating also makes apparent that almost every combination of design aspects exists across states. A stronger RPS is not necessarily also flexible, and an RPS that emphasizes discretion may or may not have set up a strong penalty regime. A number of design elements tend to appear together (see correlations in Table 3.9). States that permit energy efficiency gains to count towards RPS compliance are more likely to also allow advanced fossil resources. Every single state that authorizes energy efficiency for compliance also employs credit multipliers. Both of these design aspects decrease the stringency of a RPS, because the required amount of renewable energy is effectively reduced. One outcome of the simultaneous occurrence of these design elements is that more than half the RPS states fall either on the low or the high end of the additive stringency score.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Scope													
2 Advanced fossil	0.05												
3 Existing hydro	−0.11	0.12											
4 Energy efficiency	0.22	0.36^{**}	−0.06										
5 Credit multipliers	−0.02	0.05	0.29	0.36^{**}									
6 Existing resources	−0.09	0.07	0.21	−0.01	0.17								
7 Eligible resources	0.29	−0.07	0.17	−0.06	0.16	0.07							
8 Technology quota	−0.02	0.07	−0.03	−0.08	−0.02	0.06	0.25						
9 Unbundled REC	0.30	0.03	−0.06	0.13	−0.16	0.18	0.09	−0.09					
10 Regional origin	0.10	0.10	0.25	−0.10	−0.16	0.02	0.12	−0.25	0.37^{**}				
11 Fin. safety valve	−0.10	0.10	0.15	0.10	0.29	−0.28	0.15	−0.15	−0.21	0.20			
12 Force maj. clause	−0.20	0.21	0.11	0.18	0.06	−0.01	−0.28	−0.11	−0.04	0.05	−0.05		
13 Other waivers	0.01	−0.03	−0.01	0.18	0.15	-0.38^{**}	−0.01	0.01	−0.16	0.23	0.49^{**}	-0.45^{**}	
14 Penalty	0.06	0.06	0.33^{*}	0.02	−0.10	0.09	−0.01	0.01	0.52^{**}	0.29	0.04	−0.13	0.06

Table 3.9: Correlation table. *p$<$ 0.10; **p$<$ 0.05 (Two-tailed tests)

Stringency	**Discretion**	**Penalty regime**	**States**
+	+	+	DC, MA, NH, NJ, RI
+	-	+	CT, IA, NY
+	+	-	HI, MD, MN, NC, OR
+	-	-	CA, ME, MO, MT, NM, VT, WI
-	+	+	KS, PA
-	+	-	DE, MI, UT, WA
-	-	-	AZ, CO, IL, NV, OH, TX

Table 3.10: Distribution of states across goal stringency, discretion in means and enforcement capacity dimensions. States received a positive overall rating for the dimension, if they achieved positive scores for more than half of all contributing aspects.

In the discretion of means dimension, the presence of more generous regional origin rules tends to be coupled with the option to purchase unbundled REC. It seems that states coupling these two design aspects prioritize absolute increases in renewable energy, as they deemphasize control over origin or delivery of the actual electricity. Interestingly, states that have a penalty in place are also more likely to allow the use of unbundled REC. This could indicate that unbundled REC are intended as a way to facilitate compliance at the margin.[5] The type of fine in these states is often an ACP. With unbundled REC, utilities can easily make up for smaller short-falls.

The distribution pattern of states across dimensions can be seen in Table 3.10. It is clear that there is wide variety in how strongly design aspects in individual states contribute to each dimension. At the extreme ends, five states achieve high ratings in all dimensions, while six states score low in every dimension. Policy outcomes in the latter states will presumably be lower than in the former states. In turn, states with low discretion in means could see goal attainment hampered by higher compliance costs, because the policy design aspects making up this dimension all influence the flexibility of the policy, and accordingly, incentives for innovation and over-compliance. In these more rigid states, policy goal attainment hinges on the capacity of the enforcement regime. Where fines are large enough to stimulate costly compliance, the desired goals could still be achieved, although likely at a high price.

In turn, where sanctions are not in place, and many opportunities exist for circumventing the RPS, it is possible that strict, but inflexible standards will be less successful. There are seven states that have strong goals, but lack both discretion and a strong enforcement regime. In these states, utilities neither have the flexibility to achieve the renewable goal, nor sufficient disincentives against defection (sanctions). Interestingly, of the six states that are reported to have substantially undercomplied with their RPS (Wiser and Barbose,

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[5] In fact, MI and MN explicitly order non-compliant utilities to buy REC to cover the shortfall.

2008), four - AZ, CT, NY, and NV - score low on discretion in means.

Finally, relatively few states that have a weak standard do much to inject flexibility into their RPS or put in place a strong penalty regime. This is hardly surprising, since weak standards can conceivably be achieved with ease, and there is little need for enforcement or flexibility. In addition, this seems to signal low attention by policymakers to the RPS, given that they fail both to supply regulators with tools for enforcement and to accord more discretion to the targets of regulation.

A casual observer might point out that a few states characterized as having strong policies (e.g., MA) have not seen much renewable deployment in their territory, while a state like TX, with its weak RPS regime, has seen enormous growth in renewables. Clearly, there are other factors besides policy that affect where and how fast new technologies are adopted. It is also important to not confound the state lines with the actual reach of the policy. Utilities in a given RPS state can – and often do – import renewable power for compliance, and consequently, conclusions on the effectiveness of an RPS based only on *in-state* technology adoption are necessarily faulty or at least omissive.

3.5 Discussion and conclusion

The thorough state-by-state analysis of RPS reveals that there is a staggering amount of diversity in these complex policies. Examining RPS under the angle of stringency of goals, discretion in means, and strength of the enforcement regime introduces a measure of comparability, and could also be applied to other types of policies. The three dimensions are commonly cited as central policy design aspects and have been shown to affect policy outcomes in prior research. By combining all three elements, it is possible to describe the policy design aspects that can be expected to have the highest impact on outcomes.

In addition, this chapter analyzes patterns of policy design across states, and shows that combinations of design aspects vary widely, affirming the argument that not all RPS are created equal or implemented in the same way. Studies of RPS to date have not taken into consideration this complexity, using dichotomous measures of policy absence or presence, or other blunt measures such as policy experience and factual goals. It is possible that this has caused scholars to misunderstand the very different *modus operandi* of RPS across states. The detailed analysis of RPS shows that policy design needs to be taken into account when attempting to assess impacts on policy effectiveness or making policy recommendations.

The scope of an RPS is highly relevant, because it determines whether all or only parts of the electric sector have to achieve renewable energy goals. Likewise, which renewable and other resources are eligible for compliance can be expected to affect ease of compliance by utilities. Permitting non-renewable resources or energy efficiency can also water down stated renewable goals. RPS with added minimum quotas or subsidies for certain technologies distort incentives. The treatment of REC is also significant, because this trading mechanism can introduce flexibility. Coordination across states on treatment of REC is important to creating a more uniform market for renewable energy, and provisions on origin, bundling, shelf-life and credit multipliers can facilitate or complicate achieving policy goals. Finally, the existence and type of penalty is relevant for deterrence, and waivers and exceptions can provide opportunities to circumvent the policy. Findings such as these should prove relevant to policymakers as they prepare to adopt or revise a state RPS, increase renewable market integration, or consider a federal renewable target.

The various practical examples discussed in this chapter indicate that these individual design aspects can have large impacts on how the RPS is implemented and on whether stated policy goals are achieved. Often, RPS design is boiled down to a single measure, namely the proportion of renewable energy to be achieved in the final year of the standard. Once other design aspects are taken into account, it appears that the policy goal can in actuality be much lower than stated, because various loopholes exist that weaken it. In addition, the differences in rules that govern compliance pathways affect the extent of discretion conceded to utilities, and could influence both the difficulty and the cost of compliance. Likewise, the penalty regime is important to set appropriate sanctions and encourage compliance.

While providing much needed comparative detail on state RPS, this content analysis remains descriptive. A natural next step is to analyze the impact of different design elements on policy outcomes such as renewable energy sales and capacity, or compliance cost. Another possible area of extension would be to more formally investigate the patterns of state policy design, for instance by using cluster analysis. The simple classification used in this study is limited by its additive design. Individual aspects in each dimension will not necessarily have equally large impacts on policy outcomes and cost effectiveness.

The discussion in this chapter has focused on identifying the aspects of RPS that can be thought to result in the largest policy outcomes and make the RPS the most economically efficient. However, like most policies, the adoption of RPS is driven by more than one interest, and conflicting motivations can exist. For example, policymakers might pursue competing goals, like job creation and localized pollution improvement. Local interest groups often lobby for provisions that support community-owned development or distributed energy, while utilities may be more interested in gaining permission to own large scale wind farms or obtain concessions on building transmission lines connecting load centers with renewable resources. From this vanguard, some design aspects criticized for weakening policy outcomes might appear in a more positive light. For instance, in-state credit multipliers could help create local jobs in installation and maintenance of renewable energy facilities. They can also have benefits for local air quality. Similarly, quotas for solar energy could help the development of a local solar industry.

The conflict between competing policy goals has recently become apparent in CT, where policy makers are considering a revision of the RPS that would halve the goal of 20 % renewable energy by 2020 (Spiegel, 2010). Most of the renewable energy for the RPS has come from out of state, and policymakers envision that RPS funds are redistributed to no interest consumer loans for renewable or energy efficiency products, directly benefitting local citizens (Spiegel, 2010). In the context of the recession gripping the United States since 2008, RPS are also vulnerable to attacks based on their (perceived or real) costs. The economy is dominating 2010 election campaigns, and several prominent candidates in contested Midwest gubernatorial elections resist expanding RPS (Marshall, 2010). As policymakers weigh adopting or revising a RPS, a better understanding of individual design aspects could help them make informed decisions.

Chapter 4

Design matters: policy response to renewable portfolio standards

Policy outcomes are often discussed under the lens of different policy types, notably flexible and direct policies. This chapter develops a more nuanced view of policy types, arguing that many policies incorporate elements of both types and that their full complexity needs to be considered. Employing the example of renewable portfolio standards (RPS), a quantitative analysis of the relationship between policy design and outcomes is conducted. The study presents a novel method to measure RPS outcomes at the level the policy targets.

4.1 Introduction

Policy shapes firm behavior (Marquis and Huang, 2009) and vice versa (Bonardi et al., 2006). It is one of the most important external environments influencing firms' environmental action (Henriques and Sadorsky, 1999). In a recent issue of AMJ, Kochan et al. (2009) called for management research that was more directly relevant to public policy, and policy research that employed insights from management theories to build better public regulation. In the environmental and energy policy arena, this is a particularly pressing issue, due to unprecedented global environmental (Rockström, 2009) and energy challenges (Goldemberg and Johansson, 2004), and the direct and large impact of such regulations on business. Management scholars can contribute to this area by drawing attention to the targets of regulation, private firms, and their response to regulatory environments. Ideally, incentive structures are set up to make use of private sector innovation and competition to achieve policy outcomes. The interest, then, of applying management research to environmental and energy policy questions lies in designing policies to minimize private costs and maximize social benefits, using knowledge of how incentives and rules affect organizational behavior. From a managerial perspective, policy design is an important factor in environmental strategy formulation, because policies set incentives for innovation and can influence the relative competitiveness of rival businesses.

The influence of environmental policy on innovation and technology diffusion has been widely discussed and researched. Much attention has focused on differences between policy types, most notably between direct (or command & control) regulations and market-based, flexible regulation. Market-based, flexible regulation has been theorized as superior to direct regulation, but most analysis consists in theoretical models or qualitative case studies. Little empirical evidence has been accumulated on comparing similar policies among each other. In this chapter, I argue that the internal diversity of policies may mask the difference between outcomes of direct and flexible, market-based policy. Policies rarely fall into a clear-cut policy type; rather, direct regulation often incorporates flexibility and incentives. Consequently, a finer distinction than policy types is needed to account for the complexity of policy. I present hypotheses on the impact of various policy design elements, drawn from policy design theory.

I use the example of renewable portfolio standards (RPS) in U.S. states to analyze the impact of design differences across policies. Not only have these policies become widespread in the past decade, but states show great variety in the characteristics of RPS. Although RPS are a form of direct regulation, many states include a number of market-based and/or flexible elements. Based on the content analysis of RPS statutes and regulatory decisions in chapter 3, I quantify individual design aspects, and develop hypotheses on their influence on firm behavior. In doing so, I turn the attention to differences in policy design at the sub-national level, and outcome measurement at the organizational level. The motivation is twofold. First, by studying differences in policy design across states, I open the door to assessing the effectiveness of individual policy elements, while taking into account the full complexity of a policy. This contributes to the policy design and effectiveness literature. Second, by studying policy outcomes at the organizational level, I measure at the level specified in the RPS. Quantitative measurement of RPS outcomes has generally used statewide generation or even capacity investments. These measures do not include electricity crossing state lines and therefore only measure the effectiveness of the RPS in supporting *in-state* generation or capacity.

In this chapter, I first provide a literature review on the relationship between environmental policy and business response, discussing both the policy and managerial view. I then develop theory and hypotheses on the relationship between policy design elements and policy outcomes, followed by a methods section that presents the empirical setting, sample and data collection strategy, and the operationalization of constructs. Finally, I present and discuss the results of the empirical analysis and discuss its implications for improving the measurement of RPS outcomes.

4.2 Environmental policy and business response

Environmental regulation has traversed multiple phases since its early days. Tracing, and sometimes fostering these developments, the academic literature has provided rich insights into the relationship between environmental policy and business response. Two distinct sets of literature emerge: The first takes a policy-oriented view, focusing on macro-level outcomes of environmental policy and on policy instruments. The second set of literature highlights strategic implications of environmental policy for business, taking a managerial perspective.

4.2.1 The policy view

When environmental policy first came into widespread use in the 1970s, the question asked was seldom how to design such policies effectively. Instead, both the scholarly and public discussion focused on whether to have environmental policies at all. Not all countries put in place environmental protections and some feared that environmental policies would negatively affect international competitiveness. This so-called pollution haven hypothesis is based on the premise that capital flight occurs in highly polluting industries that are most affected by environmental regulations. Ultimately, this is presumed to lead to a race to the bottom with states continuously lowering their environmental standards in order to attract business investment.

There is mixed evidence for this proposition (Press, 2007), with most studies reporting small effects of environmental regulation on location decisions, if at all. For instance, in their study of U.S. specialization in pollution intensive industries, Cole et al. (2005) find only marginally effects of pollution abatement costs, since these industries are also intensive in physical and human capital, making relocation more difficult. Similarly, Jaffe et al. (1995), in their survey of the literature, observe scant evidence of environmental regulation affecting international competitiveness of U.S. industry. In contrast, Bruneau (2005) ascertains that command & control policies can lead to distortions of competition under trade liberalization. He (2006) also finds some support for the pollution haven hypothesis, showing that the strengthening of environmental regulation in China has deterred some foreign direct investment. For the sub-national level, Gray and Shadbegian (1998) compared the impact of different U.S. state regulations of pulp and paper mills on the allocation of investments within the firm, across states, demonstrating that firms shifted productive "investment towards plants facing less stringent abatement requirements."

The creation of entry barriers is the other side of the coin when different levels of environmental regulation exist across countries. Environmental product standards can act as a non-tariff trade barrier when enforced for imports as all well as for domestic products (Busch and Reinhardt, 1999; Drope, 2007), e.g., in the case of maximum contaminant concentrations in consumer products. Close to three quarters of all internationally traded products face environmental trade barriers in at least one country (WEC, 2002). A 1997 study by Vogel and Rugmann (cited in Rugman and Verbeke (1998)) of ten trade disputes around environmental issues between the United States and Canada, observes that in nine of these cases, "environmental regulations were used to obtain shelter."

Over time, once environmental policy became a major element of policy-making, the debate on utility and futility of environmental policy ebbed. Accordingly, a second research stream developed that was concerned with evaluating policy instruments. Instead of the presence of environmental policy per se, this research addresses its design and configuration. At the outset of the modern environmental movement, environmental regulation mostly meant command and control measures (Eisner, 2004). Such measures prescribe the use of best available technologies to solve particular environmental problems, as in the case of the original U.S. Clean Air Act of 1963 and its amendments in the 1970s. On the one hand, direct regulation is straight-forward and easy to implement, and can be less costly to control (Harford, 2000). On the other hand, given the differences in pollution control costs across firms, a uniform standard without trading results in inefficient allocation of resources (Hahn and Stavins, 1991), because marginal pollution abatement costs are not uniform across firms. Command & control provides little flexibility, and thus little incentive for innovation. For instance, Jaffe and Palmer (1997) find that the stringency of direct environmental regulation is not correlated with higher levels of patenting, although it is positively correlated with R&D expenditures. These short-comings of technology based command and control approaches became increasingly evident, particularly as regulators shifted their attention to non-point sources of pollution (Xepapadeas, 1992), which are difficult to control with conventional environmental policy.

The focus turned toward the design of more flexible, market-based policies, that were potentially more effective (Hahn and Stavins, 1991). Theoretical models (Anderson, 1977; Baumol and Oates, 1975; Dales, 1968; Kneese and Schultze, 1975) and empirical studies (Jaffe and Stavins, 1995) show that such policies result in higher productivity and/or innovation over conventional policies. Accordingly, policy makers sought to complement and, in some cases, replace the traditional sanction-based command & control approaches. Regulators began setting performance standards and providing firms the latitude to find the best way to attain them. The search for more flexible regulatory methods led to a paradigm shift toward market-oriented, incentive based approaches, like cap and trade systems and voluntary programs (e.g, Project XL, Climate Leaders, and the Green Chemistry Program). Currently, the EPA (2010) lists 40 voluntary partnership programs working with businesses, communities, state and local governments, and other organizations to achieve environmental goals. Environmental taxes and subsidies are other typical market-based instruments that are now in common use. Finally, environmental regulation has also been complemented by information programs and liability rules (e.g., Superfund).

A number of studies have focused on these new policy instruments, assessing tradeable permit systems (Hagem and Westskog, 1998; Kling, 1994), pollution taxes (Coria, 2009; Parry, 1995; Williams, 2003), and deposit-refund systems (Stavins, 1998b). Identifying the ideal conditions for the success of a specific policy instrument (Cramton and Kerr, 2002), and comparing instruments under set conditions (Montero, 2002; Requate, 1998) has also been a critical endeavor in this stream of research. Overall, the policy-oriented view of environmental regulation is concerned with the macro-social outcomes and the comparison of individual policy instruments.

4.2.2 The managerial perspective

The managerial perspective takes a micro-level view of environmental regulation. It tries to explain why firms react differently to environmental policy and how they formulate strategies towards environmental policy. In this context, policy type and design is also addressed. To understand the managerial perspective, it is important to trace the historical development of corporate environmental behavior.

It traversed multiple phases since its beginnings in the 1960s, as described by Hoffman (2000): Initially, firms treated environmental issues as mere technical problems to be solved on the operational level. Then, with the onset of environmental regulation in the 1970s, the relationship between firms and their natural environment became a matter of compliance. In the following decade, the focus shifted again, this time towards social responsibility, cooperation, and a more active role of businesses in environmental protection. In this process, environmental issues have been increasingly addressed on the managerial level, instead of purely on the operational level. Starting in the late 1980s, many firms began to integrate the environment into strategic planning and adopted a proactive stance. With firms realizing that what was good for the environment was not necessarily bad for business, a new paradigm began to emerge. Environmentally sound business practice was now seen by many as a possible source of competitive advantage, and environmental regulation as a possible driver of innovation and increased productivity (Dechant and Altman, 1994; Orsato, 2006; Porter and van der Linde, 1995a).

A firm's environmental regulatory strategy encompasses both strategies trying to shape future regulation, and those concerned with implementing existing regulation. A number of authors have addressed firm preferences (and active support or opposition) for specific policy instruments. Often, this strategic use of regulation by firms can be understood as rent-seeking (Mitnick, 1981), an activity where firms try to manipulate market regulations in a way that guarantees them profits beyond those to be gained in a competitive market. Pollution abatement regulations can act as entry barriers to new firms, granting rents to incumbents due to the increased capital cost of entry, the increased operational complexity, siting and permitting difficulty and the comparatively tighter regulations applying to new vs. older facilities (Dean and Brown, 1995). For instance, older power plants were grandfathered into the SO_2 trading system, while newly built plants face stricter emissions limits

Buchanan and Tullock (1975) observe that firms have a preference for direct, technology-based regulation over pollution charges, since it represents a more important barrier towards new entrants.

Taking a less negative view, a second perspective on corporate environmental strategy emphasizes that environmental regulation can represent an opportunity for gaining competitive advantage. Firms can make use of environmental regulation as a driver for innovation (Costantini and Crespi, 2008) and for the creation of organizational environmental capabilities that have positive effects on profitability (Aragón-Correa and Sharma, 2003). Since waste indicates the incomplete use of resources, pollution prevention could have productivity effects (Arora and Cason, 1996). Standardizing to high environmental performance in a multi-national firm can be preferable to reverting to the minimum required in each country (Potoski and Prakash, 2004; Rock et al., 2006).

Given the heterogeneity across firms, this second, more positive perspective also emphasizes the organizational characteristics and external conditions under which environmental management pays off. There is evidence that environmental performance is associated with financial performance for certain firm characteristics, such as comparatively clean operations (King and Lenox, 2001). Additionally, stronger integration of environmental management into the firm's strategy is associated with stronger financial performance (Judge and Douglas, 1998). The cost of enforcing environmental regulation is contingent on firm characteristics (Short, 2008).

Researchers have also taken an interest in identifying drivers for environmental behavior, particularly where it goes beyond compliance. External stakeholder pressure (Caplan, 2003; Eesley, 2006; King et al., 2002; Press and Mazmanian, 2006) and attempts to preempt legislation (Maxwell et al., 2000) are important motivators for environmental management. Firms whose environmental impact is more visible (Bowen, 2000) tend to engage in more environmental activities. In general, firms seem to be sensitive to the reputational cost of non-compliance (Caplan, 2003; Karpoff et al., 2005). More recently, scholars have begun to address managerial perceptions as a predictor of firm environmental behavior (Sharma et al., 1999; Henriques and Sadorsky, 1999). For instance, manager's perceptions of environmental issues as an opportunity or a threat predict firm choice of environmental strategy (Sharma, 2000). Furthermore, the perception school of firm environmental behavior has provided insights into managers' reactions to policy types and design (López-Gamero et al., 2009). With this, the literature on environmental policy and firm behavior is coming full circle. Although approaching reactions in terms of perception, not economic incentives, it attests to the fact that both the type and the design of a policy influence firms' reaction.

4.3 Theory and hypotheses: Environmental policy design and policy response

Much research on policy outcomes in the environmental field has centered on the Porter hypothesis, which states that no trade-off exists between environmental protection and competitiveness (Porter, 1991; Porter and van der Linde, 1995a). Adherents of the Porter hypothesis (Ambec and Barla, 2002; Porter and van der Linde, 1995a) maintain that environmental regulation can have private benefits such as innovation which make up for the cost of regulation. Consequently, business firms should be proactive on environmental management under certain conditions. In contrast, traditionalists perceive environmental regulation purely as a cost to firms, meaning that firms' environmental action should not surpass the absolute minimum required of them (Walley and Whitehead, 1994). For instance, in a study drawing wide-spread attention, Gray (1987) observed an association between environmental, health and safety regulation and productivity growth decline. In a similar vein, Rothwell (1980) reviews evidence that environmental regulation in the 1960-70s resulted in some innovation, but not radical technical change. The evidence on the Porter hypothesis remains mixed. Recent comprehensive literature surveys (Ambec and Barla, 2007; Stewart, 1993) and empirical studies (Darnall, 2009; Jaffe and Palmer, 1997; Jaffe et al., 1995) find no clear affirmation of either position. Environmental policies may increase competitiveness and innovativeness for some companies, but will rarely result in a win-win situation for all regulated companies.

Generalized win-win situations set aside, we can assume that the total cost of implementing a regulation, as well as the chances of achieving stated policy goals are closely related to how a policy is designed. Policy design concerns the instruments and incentives contained in a regulatory program that circumscribe the goals of a policy, the implementation rules and permissible means of compliance. It is well known that policy design determines costs and benefits of environmental policies (Goulder and Parry, 2008). In fact, Porter and van der Linde (1995b, p. 110) never contended that all environmental policy leads to win-win situations, but called for effective design of environmental policy:

> *"If environmental standards are to foster the innovation offsets that arise from new technologies and approaches to production, they should adhere to three principles. First, they must create the maximum opportunity for innovation, leaving the approach to innovation to industry and not the standard-setting agency. Second, regulations should foster continuous improvement, rather than locking in any particular technology. Third, the regulatory process should leave as little room as possible for uncertainty at every stage."*

Despite this and other calls for more attention to policy design, most research in this area investigates how decisions about policy are made and what determines the choice of policy instrument (Howlett and Ramesh, 1993). This focus on legislative processes, implementation and enforcement reflects the academic roots of this field in policy analysis and political science. Recognizing the equal importance of policy outcomes, researchers have started to focus on what types of design aspects make a policy more likely to succeed (Keiser and Meier, 1996), and on evaluating policies ex post (Ringquist, 1993b). Most commonly, such research has addressed individual policy instruments. Policy outcomes refer to the "consequences for society, intended and unintended that stem from governmental action and inaction" (Anderson & Smallwood, 1980, cited in: Ringquist (1993a, p.93)). Policy outcome researchers distinguish between effectiveness and efficiency of a policy. Effectiveness addresses whether the policy is meeting its goal, and efficiency assesses the cost of a policy, often in comparison to other tools (Harrington et al., 2004).

The relationship between environmental policy design and outcomes has primarily been examined under the lens of contrasting policy types. The most commonly used dichotomy compares the outcomes of direct regulation or command & control policies against market-based, flexible regulation. Command & control policies not only define a target, but also prescribe the strategies and/or technologies to achieve it. Flexible policies set price signals or quantities, but leave much discretion to the regulated entity as to how to achieve goals or react to price signals. Such policies have been called, in turn, "market-based" (Stavins, 1998a), "open, flexible instruments" (Eskeland and Jimenez, 1991) or "innovative approaches involving incentives" (Holling and Meffe, 1996). They include policy instruments such as taxes, quota setting and tradable permits. Economic theory tells us that market-based policies can shape firm behavior at a lower cost than direct regulation (Anderson, 1977; Baumol and Oates, 1975; Dales, 1968; Kneese and Schultze, 1975).

Although insightful for initial decisions on policy type, contrasting such broad policy types has few practical implications for designing specific policies. It also leaves open the question of how policies of a common type compare amongst each other. Even within market-based or direct policies, there exist different degrees of prescription or flexibility, which may affect their outcomes in unexpected ways. Environmental regulations are often complex, and policies that seem similar at the surface may use completely different combinations of policy instruments. In addition, policy instruments generally do not get selected for their optimality in economic efficiency terms, but for various other political, institutional or psychological reasons (Sterner, 2003). In fact, although economists prefer market-based policies, direct regulation has remained the most commonly used tool in U.S. environmental policy (Keohane et al., 1998). Many environmental policies combine some elements of both flexible and direct regulation.

Little is known on how design differences between similar policies affect their comparative outcomes. As noted by Porter and van der Linde (1995b) and Goulder and Parry (2008), the make-up of a policy instrument can play an important role. Instruments that qualify for the same label may in fact harbor vast differences in design and implementation.

For instance, Sweden and France both impose a tax on nitrogen oxides (NO_x). Although the instruments appear similar at first sight, the Swedish policy provides much stronger incentives for overcompliance, thanks to automatic cycling back of funds to firms for pollution abatement, and the use of real-time measurement that gives firms feedback on plant fine tuning (Millock and Sterner, 2004). State regulations on confined animal feeding operations define effluent quotas from these facilities, but large differences exist across U.S. states in the stringency, scope and prescription of these regulations (Koski, 2007). Examples like these indicate the need to assess policy design in greater detail.

Despite the complexity and variety in environmental policy design, many studies of policy impact on firm behavior have employed the passage of a policy as the single significant event changing firms' behavior (Bohn and Lant, 2009; McAvoy, 1979; Menz and Vachon, 2006). Where scholars have sought to assess the impact of regulatory stringency on innovation or productiveness, they have often used a single measure, such as pollution control expenditures (Bacot and Dawes, 1997; Hamamoto, 2006; MacAvoy, 1987) or have relied on survey-based measurement (Darnall, 2009). Single measure reflections of policy are necessarily biased (Lester, 1980) and survey-based measures raise the question of the accuracy of perceptive measures.

Studies that give more room to policy design characteristics often do so in a descriptive manner or compare few cases (Popp, 2006). In some instances, this is due to the small number of available cases, or the difficulty of measuring policy differences (Newmark, 2005). Due to the diversity in requirements, it is also quite challenging to comparatively assess environmental policy outcomes across several countries. According to Jaffe et al. (1995, p. 134), it "is extremely difficult to compare [the U.S.] compliance cost burden with that borne by competing firms in other countries." Assessments across several geographic regions therefore have to find a way to address differences in policy design.

In view of these challenges, a meaningful assessment of environmental policies and associated outcomes needs to more fully analyze the complexity of individual policies, while providing more than anecdotal evidence on the relationship between policy characteristics and outcomes. In the following subsections, I discuss common design aspects of environmental policies and develop hypotheses on their effect on policy outcomes. Environmental policy outcomes can take various forms (e.g., number of inspections and size of fines, pollution reduction, pollution expenditure, permit validity etc.). I focus on policy response, namely the reaction by the target of the policy to the stated goal.

4.3.1 Stringency of goals

The stringency or strength of a policy is the most commonly cited design element that is thought to affect policy response. Stringency refers to the magnitude of the effort that is required from the policy target, or the extent to which the goal imposed by the policy is difficult to reach.

Numerous studies analyze relationships between rising stringency and increased compliance or more favorable policy outcomes. The effects of stringency on innovative activity represent an important area of research. Porter and van der Linde (1995a, p. 100) portend that, "while the cost of compliance may rise with stringency, then, the potential for innovation offsets may rise even faster." A number of empirical studies have supported the existence of a relationship between higher compliance costs and expenditures and increased innovation. Lanjouw and Mody (1996) present evidence that higher pollution control expenditure - as a measure of policy stringency - is associated with more patenting activity in developed as well as developing countries. Jaffe and Palmer (1997), not finding an association with higher patenting activity, show that larger pollution control expenditures have a positive effect on R&D spending.

Stronger policy requirements necessitate more than just incremental improvement and can therefore foster radical technical change or investment in more expensive pollution control equipment (Millock and Sterner, 2004), which in turn fosters larger decreases in emission levels. Shortened implementation cycles set incentives for larger and earlier investments in new technology development (Krozer and Nentjes, 2008). Managi et al. (2005) raise the possibility that this effect is more pronounced for flexible than direct policies.

Stricter policies have also been said to increase diffusion of available technologies because they impose a more substantial constraint (Roediger-Schluga, 2002). Diffusion effects may explain increased productivity better than invention (Managi et al., 2005). Firms may be motivated to innovate internally or adopt innovations made by others (competitors or suppliers), when exposed to a more stringent policy. A direct effect of stronger regulation on pollution levels is demonstrated by Ringquist (1993b). In his study on air pollution control, he shows that regulatory program strength (i.e., stronger requirements for pollution control) is significantly negatively correlated with SO_2 and NO_x emission levels at the state level.

Perceptions and signaling also play an important role in firm response to stricter environmental policy. Del Brío et al. (2002) show that the more demanding a policy was perceived, the higher the importance attached to the environmental issue. This may indicate that the strength of an environmental policy has a certain signaling effect and increases institutional pressure (Hoffman, 2001). A stringent policy can be thought to send the message that policymakers and regulators put great emphasis on this area, and are willing to enforce compliance. This signaling goes beyond just compliance with the policy at hand. Participation in a voluntary program for carbon dioxide emission reductions (Climate Challenge Program) was higher among utilities in states with stronger regulatory pressure (Welch et al., 2000), an effect that is theorized to stem from utilities' attempts to shift regulatory pressure.

Based on the literature on innovation and diffusion effects of environmental regulation, as well as on institutional pressure, the policy response can be expected to be more pronounced when a policy imposes stricter requirements. At the most basic level, the stated goal or requirement imposed on a firm should have the following effect:

> **Hypothesis 1A:** All else equal, policy response will be higher for organizations exposed to a policy design incorporating a stricter stated goal.

It is important to look beyond the stated goal, because accounting or measurement rules can weaken it. In some cases, permits or credits are subject to accounting rules that weight their importance. Especially were weighting is used for commonly occurring characteristics, this can starkly influence the stringency of the goal.

> **Hypothesis 1B:** All else equal, policy response will be lower for organizations exposed to a policy design that creates exceptions to the goal by weighting.

Policy design influences stringency of goals in other ways, too. For instance, policies often exclude certain populations from compliance. It makes a difference whether all or only two-thirds of all companies in a sector are under the scope of the policy. In addition, the design of the compliance schedule and opportunities for banking and borrowing influence goal stringency over time. Although important, these aspects of stringency are not included in this study. Scope cannot be included, because outcomes are measured at the organizational level, and policy effect on excluded organizations cannot be assessed. Banking is not included because this analysis covers only a single point in time; a u-shaped effect could be expected in this case.

4.3.2 Discretion in means

The stringency of a policy is often its most visible characteristic. Frequently, it is also the only characteristics that is being tested for its relationship to policy outcomes (Bacot and Dawes, 1997; Hamamoto, 2006; MacAvoy, 1987; Ringquist, 1993b). This unduely reduces the complexity of a policy. As pointed out by Koski (2007, p. 408), "stringency measures yield virtually no information regarding how complex a regulation is, the breadth of requirements and target groups it creates, and the amount of flexibility allowed in interpretation of rules for compliance and enforcement." It is therefore indicated to explore other aspects of policy design.

As described above, economic theory predicts that flexible and market-based instruments are generally more efficient than direct regulation, and provide larger incentives for innovation. Notwithstanding few examples of purely market-based regulation, many environmental policies incorporate flexible elements. Compared to direct regulation, flexible or market-based policies are thought more likely to convey international competitive advantage (Porter, 1990, 1991; Shrivastava, 1995) and first-mover advantage (Nehrt, 1998). Flexible policies have also been hailed as fostering innovation (Porter and van der Linde, 1995b; Taylor et al., 2005) and increasing productivity (Majumdar and Marcus, 2001). It is thought that these policies encourage innovation, because they do not force firms to apply a uniform best-available-technology (BAT), which removes all incentives for inventing more efficient ways to reduce pollution. Instead, compliance with environmental regulation becomes another field of competition among firms, spurring experimentation, invention, and diffusion of innovations. These policies can even provide incentives for overcompliance, because firms can for example sell excess pollution permits.

Examining the effect of policy type on the invention as well as the diffusion of pollution control technologies, Milliman and Prince (1989, p. 260) find that "direct controls, emission subsidies, and free permits, relative to emission taxes and auctioned permits, are often inferior with respect to promoting abatement technological change." This view is supported by empirical studies on the Acid Rain program, the first major market-based environmental policy in the United States. Rico (1995) and Burtraw (1995) find a reduction in compliance cost in the SO_2 trading program of roughly 50 % over conventional command & control approaches. Under high uncertainty, learning effects are one of the reasons why discretionary environmental policy can be superior to direct regulation (Tarui and Polasky, 2005).

The characteristics and effects of archetypical flexible policies described here are also applicable to flexible elements in direct regulation. Such flexible elements can increase discretion in means. As a general characteristic, Majumdar and Marcus (2001) found that the most successful regulations are setting clear and ambitious goals, while leaving firms sufficient time and autonomy to attain them. It is the opportunity to choose - or invent - new means of compliance that is hypothesized to result in more innovation and higher productivity under flexible regulations (Majumdar and Marcus, 2001). Flexible provisions within a direct regulation can affect discretion in compliance strategies available to regulated entities, either by restricting the portfolio of compliance pathways, or by mandating, subsidizing or penalizing certain compliance choices.

As a general rule, more discretion in means affects policy response positively. Trading is a common mechanism that increases the number of compliance choices available to regulated entities. It leads to effective allocation of resources, because pollution is reduced where marginal compliance cost is the lowest. It also provides incentives for over-compliance, since excess permits can be sold.

> **Hypothesis 2A:** All else equal, policy response will be higher for organizations exposed to a policy design incorporating a trading mechanism.

The scope of trading is another important measure of discretion. Where regulated entities can source permits or credits from influences the ease of compliance.

> **Hypothesis 2B:** All else equal, policy response will be higher for organizations exposed to a policy design allowing broader market access in the sourcing of traded permits or credits.

4.3.3 Penalty regime

The strength of the penalty regime is the third critical dimension in achieving policy goals. Gollop and Roberts (1983, p. 662) point out that it is not sufficient to measure regulatory intensity based on the legal standard alone, because this “fails to account for permitted variances, a firm’s simple failure to comply with the standard, and, most important, the extent to which the standard actually constrains [the firm].”

A multitude of studies exist on the role of deterrence in environmental policy outcomes. Deterrence theory is based on the premise that business firms are profit driven, and that only the threat of a costly penalty will induce them to change their behavior (Rechtschaffen, 1998). According to Gray and Scholz (1993), the deterrence effect of credible and sufficiently large sanctions can contribute to effective policy implementation. However, the increase in fine size is generally not proportionate to the decrease in violations (Lafrancois, 2009; Stafford, 2002). Institutional pressure and reputational effects explain that on average, firms overcomply even when the threat of inspection is low. Besides the monetary cost, there is a reputational cost to non-compliance (Caplan, 2003; Karpoff et al., 2005) that firms are sensitive to.

The type of penalty imposed is significant, too, because it can address different motivational drivers for responding to a policy. Economic cost-benefit calculations are not the only factor entering into a company’s compliance decision, but normative aspects (i.e., feeling of duty to comply) and reputational risks also figure prominently (Caplan, 2003; Gunningham et al., 2005). Depending on the type of penalty imposed, these non-economic drivers can be emphasized or become less important. Conventionally, environmental regulation has relied on monetary fines to sanction non-compliance. Generally, non-compliant firms have to pay the fine, but still have to take action to achieve compliance. Therefore, for fines, both reputational and economic incentives for compliance exist.

This is not the case for the alternative compliance payment (ACP), a relatively new compliance instrument. Although not favored for pollution control,[1] it has recently found use in renewable portfolio standards. If a company is not able to procure renewable energy credits below the ACP price, it can simply pay the ACP, and is considered in compliance. As a side-effect, there is no reputational risk associated with non-compliance. In addition, an ACP effectively caps the compliance risk a company is exposed to, by setting a price ceiling. In the process, it also removes incentives for over-compliance, since a small short-fall does not present a risk of incurring a fine, because such a short-fall can easily be made up through an ACP. This effect should be especially pronounced when there is uncertainty about actual emissions levels or the production of environmental goods.[2] Under an ACP,

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[1] There are moral issues associated with selling the right to pollute, particularly if it could create pollution hot spots.

[2] For instance, a renewable energy goal has intrinsic uncertainty, because at the outset of the compliance period, neither the total energy sales the goal is based on are known, nor is the amount of available certificates known, since it depends on external factors such as weather. Price information appears difficult to come by,

erring on the safe side is not necessary anymore.

> **Hypothesis 3:** All else equal, policy response will be higher for organizations exposed to a policy design incorporating a penalty, than for organizations exposed to an alternative compliance payment, or no penalty at all.

4.4 Methods

4.4.1 Empirical setting

To test the hypotheses formulated in section 4.3, I examine policy design in the context of renewable energies policies in American states, exploring the relationship between the design of renewable portfolio standards (RPS) and the policy response by the regulated entities. RPS are the most widely used policy instrument to encourage the development of renewable resources in the United States. Aside from the federal production tax incentive for renewable energy, they remain the preeminent driver of renewable capacity deployment. At the core, an RPS defines requirements for the quantity of renewable energy to be sold or produced in a given year within a geographic area. The requirement can be set at the consumer, distributor or generator level. In practice, it is most commonly defined in terms of retail electric sales. Consequently, it falls to electric distributors to ensure compliance with these policies. Historically, RPS therefore represent an extension of state regulation of the electric utility sector. Thirty-five U.S. states and D.C. had an RPS system in place in 2009.

As laid out in detail in chapter 3, these policies are widely disparate, not only in the strength of the goals they set, but also in the design of the policy itself. As such, they represent a unique policy experiment and an ideal testing ground for investigating the effect of policy design.

4.4.2 Sample and data collection

In my analysis, I focus on investor-owned utilities, since they represent two thirds of electricity sales in the United States (EIA, 2008a). Additionally, smaller consumer-owned utilities, and non-regulated utilities are often excluded from these policies or subject to special provisions (Fischlein et al., 2009). For these organizations, comparability of policies would not have been guaranteed.

At the end of 2009, a total of 35 states (and D.C.) had a renewable standard of some form. As renewable goals are voluntary in ND, SD and VA, utilities in these states were excluded from the analysis. ME, UT and VT have set a far out goal with no intermediate

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as most utilities engage in bilateral confidential contracting with renewable energy credit brokers (Berry, 2002) and markets are small and segmented. The elevated transaction costs therefore subtract from the efficiency of a trading system that is a far cry from a commodity market (Gillenwater, 2008a).

reports required. Utilities in these three states could not be included, because intermittent reporting is not required and no information was available on utility renewable sales. RPS are enacted, but not yet in effect in KS, MO, NC, and WA (as of 2009). These four states were also excluded, leaving 26 states and D.C. In one state with an existing RPS, DE, reports were confidential. For all other states with a mandatory and effective RPS, I collected data for at least one investor-owned utility selling electricity in the state.

To obtain data on utility renewable sales and RPS compliance, I searched for utilities' RPS compliance reports, integrated resource plans and annual reports. Due to the relative newness of RPS policies and the time-lag between compliance period and reporting, complete data was available for only a single year. The cross-sectional design of this study limits the conclusions that can be drawn from it.

Data for compliance year 2007-2008 was collected between January and March 2010. I first searched each state's public utility commission (PUC) web-site and all RPS related case filings in the electronic docket system. Some states maintain dedicated web-sites with information on the renewable portfolio standards. I also contacted individual utilities for information.

Data availability depended strongly on the individual state. While data was collected for all utilities in some states, information proofed more difficult to obtain in states without a central reporting web-site. For some utilities, annual reports or integrated resource plans contained information on gross renewable generation and purchases, but no information was available on how these resources were distributed across states within the utility's service territory. For others, while RPS reports were available in the PUC dockets, information was blacked out. These utilities had to be excluded from the analysis.

Overall, a total of 250 documents were collected and searched for information on renewable energy capacity, generation and purchases, as well as renewable energy credit purchases. Information was obtained for a total of 77 out of 118 investor-owned utilities in states with mandatory and effective RPS. A non-response bias test between excluded and included utilities revealed no significant differences in mean sales, customer numbers, or revenue.

4.4.3 Dependent variable

The stated goal of every RPS is to increase the amount of renewable energy sold in a state.[3] Therefore, it seems appropriate to measure policy response in terms of the share of renewable energy sales reported by each utility in a given state. Measuring organizational policy response state by state and using reported RPS data addresses two problems common to prior research: First, it accounts for renewable energy crossing state lines, because it measures renewable sales, not generation or capacity. Second, it accounts for the attribution

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[3] A small number of states have capacity requirements. In MI and MN, these requirements can be counted towards the primary sales goal. TX has a capacity goal, but for purposes of recording compliance, utilities utilize REC and associated capacity factors. IA is the only state with a pure capacity goal.

of renewable energy credits, because it uses reported compliance data.

Initial research on RPS outcomes investigated effects on capacity additions for all renewables (Kneifel, 2008) or for wind power (Menz, 2005). While the development of new renewable generation sites is one potential effect of RPS, it does not correspond to the stated policy goal of increasing renewable *sales*. Additionally, the highly divergent capacity factors of renewable resources are not reflected in this measure. Two states with the same amount of new capacity could have very different levels of renewable generation if one of them relied on intermittent resources, e.g., wind, and the other one relied on a source with a higher capacity factor, such as geothermal or biomass. Recognizing the limitations of measuring RPS outcomes in terms of capacity, Carley (2009) and Yin and Powers (2010) measure it as the percentage of renewable *generation* in the state.

Although an improvement over the capacity studies, all of these researchers measure RPS outcomes at the state level, using publicly available data from the Energy Information Administration (EIA). It is important to note that the vast majority of RPS do not specify that renewable energy has to be generated in-state. In 1996, roughly three quarters of all electricity in the United States was traded wholesale before reaching consumers (EIA, 1998), and there is little reason to believe this has changed significantly. Electricity often crosses state borders (Jiusto, 2006). This can lead to grossly inaccurate representations of renewable energy's role in the electric power system. A case in point is CA, which - based on generation - produces close to 12 % of its electricity from renewable energy (EIA, 2009c), making it one of the 'cleanest' states in the country. In reality, CA imports about 18 % of the electricity consumed in the state (Jiusto, 2006), and much of this power stems from fossil fuel plants. In a different example, a number of Minnesota power companies import large amounts of wind energy from North Dakota to comply with the RPS.[4] Therefore, CA's actual electricity consumption appears to be dirtier than in-state generation numbers suggest, while MN's appears to be cleaner. Measurement at the state level will miss these effects.

Fremeth (2009) so far is the only researcher incorporating purchases in measuring renewable share, employing combined renewable generation and purchases as the outcome variable. Including purchases represents an important step towards accurate representation of renewable power sales. Nevertheless, Fremeth's primary interest is in measuring environmental performance of a firm, which can span several states. The data contains no information on the attribution of renewable energy across states, let alone whether renewable energy credits were acquired in conjunction with the physical power, or resold. Although renewable energy credits (REC) are often sold bundled with electricity, this is not always the case. Additionally, where contracts between utilities and renewable generators predate an RPS, rules on the attribution of REC vary. Some public utility commissions (PUC) have

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[4] North Dakota has an excellent wind resource and the transmission line between the load centers in the Minneapolis/St.Paul area and Fargo, ND is less congested than the main line reaching the prime Minnesota windy areas in the Southwestern corner of the state.

ruled that unless specified in the contract REC remain with the generator, meaning that they are free to sell REC elsewhere, and utilities have to amend their contracts to obtain both the physical electricity and the environmental credit.

Given these challenges, I propose a different approach. I measure RPS outcome as the policy response by utilities, namely the amount of renewable energy credits (REC) reported for compliance in a given year, as a proportion of total sales by the utility in the state. Sales data was obtained from EIA (2008a). Data on REC claimed for compliance were obtained from the sources described in section 4.4.2.

The drawback of this approach is data availability. Multiple year data was available for only a handful of utilities, given the newness of RPS in many states, as well as the lag in reporting. Therefore, this study can only assess association between policy design and outcomes. The cross-sectional design of this study permits no causal predictions. Despite the limitations of the research design, it is important to develop more accurate measures for RPS outcomes. From a methodological stand-point, previous studies of RPS outcomes (Carley, 2009; Kneifel, 2008; Menz and Vachon, 2006; Yin and Powers, 2010), while making great strides, also present critical flaws, in that they measure policy outcomes as generation or capacity at the state level. The present study therefore can be understood as an attempt to develop an improved measure of RPS outcomes, which could be used in longitudinal analysis once additional data becomes available.

4.4.4 Independent variables

The main predictors in this study are policy design variables at the state level that were developed based on a content analysis of state regulatory texts. I collected all relevant state statutes, regulatory codes and administrative rules for the states that have a mandatory renewable portfolio standards. I reviewed both the legislative texts and the regulatory rulings associated with them, because it is administrative codes that often determine the rules of implementation (Koski, 2006). For instance, a number of RPS do not specify rules for REC trading or list only big milestones in their compliance schedules. It is often left to the public utility commission to clarify such aspects.

Overall, I analyzed 72 documents, totaling 1854 pages, for policy design aspects using the NVivo 8 qualitative analysis tool. This software enables applying predefined codes to a text. Codes refer to individual design elements. The list of codes was developed based on a review of the relevant literature that qualitatively describes important elements of RPS (Berry and Jaccard, 2002; Cory and Swezey, 2007; Doris et al., 2009; Espey, 2001; Wiser et al., 2007). Codes address the treatment of renewable energy credits and trading, rules on enforcement and penalties, goals and timelines, eligible sources and technologies, and technology quotas and subsidies.

The immense variation across states in these design aspects is described in detail in chapter 3. Not all design aspects discussed in the previous chapter are included in the analysis, because the size of the data set is limited. In addition, a small number of aspects are not applicable at the measurement level used. The scope of the policy, i.e., the percentage of utility sales covered, will only be apparent when measuring at the state, and not at the organizational level. Some design aspects can be thought more likely to influence policy outcome, while others will affect price. For instance, some aspects are likely to influence cost of the standard, rather than renewable sales, e.g., with technology quota, utilities have to spend more money on solar or other technologies, but the amounts required are very small and are unlikely to affect overall renewable sales. Other design aspects are likely to unfold their potential only in more advanced stages of the RPS policy, e.g., waivers have not been used at all so far.

For the purposes of this quantitative study, the included policy design variables are expressed as dummies, where 1 = presence of the design characteristic. The policy goal is operationalized as the current year goal stated in the regulatory text or policy. This specification of the variable (GOAL) is more relevant to current year policy response than the final goal of the policy, which is often many years away. In addition, end years vary widely, making normalization difficult.[5]

I include the existence of accounting rules affecting policy stringency as a measure of exceptions to the policy goal. For RPS, many states have diverse rules for counting a MWh of renewable generation (see section 3.3.6 for a description). Based on the type of renewable resource, or based on where it was generated or the technology was fabricated, a single MWh of renewable generation may receive multiple credits. The variable MULTIPLIER captures the presence of this design element in a state.

The trading mechanism for RPS is called a renewable energy credit (REC). Only where this credit can be traded without the associated energy can the trading mechanism unfold its full potential. Such credits are called "unbundled." Generally, power purchase contracts are long term, while spot market transactions do not include information such as the power source. Therefore, in the absence of unbundled credit trading, there is little flexibility to purchasing renewable energy. The variable capturing this policy design aspect is termed UNBUNDLED. It takes a value of 1 for states allowing unbundled REC for compliance with the RPS, and a value of 0 for states that permit only bundled purchases or require utilities to generate renewable power themselves.

The variable REC_ORIGIN captures the breadth of market access in the trading mechanism. It refers to rules affecting the geographic sourcing of renewable energy. A small number of states require renewable energy to be produced in-state to count towards compliance. Others use a regional origin formula, or place no restriction on the origin of the REC. The variable takes a value of 0 for states with the most restrictive rules, which allow only in-state origin.

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[5] I tested a specification of the policy goal as the average annual increase between the first and last year of the standard, but this specification was not a significant predictor. As a measure of increase in difficulty over time, this variable would probably be more interesting to look at in a longitudinal study.

Penalties in RPS can take the form of an alternative compliance payment or a fine. The variables Fine and ACP take a value of 1 for each state where this design element is present.

4.4.5 Control variables

I considered a variety of state and organizational level control variables, to account for other possible influences on policy response. Their selection is primarily based on the previous RPS literature (Doris et al., 2009; Kneifel, 2008; Menz and Vachon, 2006; Yin and Powers, 2010). The first control variable is needed due to the specification of the dependent variable, which does not distinguish between existing and new resources. RPS sometimes specify a maximum age for renewable generating facilities, because they want to incent new capacity development. Renewable energy produced at facilities older than the cut-off date cannot be used towards compliance. Given that policy makers tend to choose policy goals that are feasible for firms (Barrett, 1991), it is likely that states with RPS allowing existing resources set higher goals, and that utilities also achieve these goals. I control for this effect by including a dummy variable Existing, taking a value of 1 for states in which existing resources are eligible.[6]

Prior studies of renewable energy deployment have found effects of renewable energy policies other than renewable portfolio standards (Menz and Vachon, 2006; Yin and Powers, 2010). I therefore included these policies as control variables. These policy variables are based on policy information collected by DSIRE (2009). Each variable takes the form of a dummy variable, with 1 equaling the presence of the policy.[7]

The first policy control variable is Green_Power. Under a required green power option, utilities are mandated to offer a voluntary renewable energy purchasing program to their customers. This generally takes the form of customers being offered to voluntarily buy a set amount of renewable energy (e.g., in 100 kWh blocks) each month and pay a small surcharge on their bill. Prior studies have found a strong effect of this policy on renewable energy deployment (Menz and Vachon, 2006; Yin and Powers, 2010). Electricity sales under these mandates generally cannot be counted towards compliance with the RPS. In fact, many of the compliance reports examined for this study listed green power mandates separately, and the MWh reported under this policy were not included in the outcome variable. Even though this precludes a direct effect, utilities can use surplus generation from green power programs towards RPS compliance, warranting inclusion of this variable. In addition, there

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[6] Arguably, this variable could be included as a main effect. As explained in section 3.3.3, permitting existing resources to count towards RPS compliance can be expected to result in less *new* renewable deployment and means that the goal is less difficult to achieve. The dependent variable used in this study - policy outcomes - does not distinguish between new and old resources, meaning that I actually expect to see a higher policy response in the states allowing existing resources, although stringency is reduced.

[7] Although appearing in nationwide studies of determinants of renewable generation, interconnection and net metering rules were not included in the analysis, because theses rules exist in every state in my sample, with the exception of Rhode Island.

are possible synergy effects, when utilities gain experience in renewable generation, or build partnerships with independent generators.

The combination with an energy efficiency policy could also affect RPS outcomes. It is conceivable that reductions in retail sales caused by such a policy result in a lower barrier for achieving the - generally proportionate - renewable energy goal. Energy efficiency regulation was therefore included as a control variable (EFFICIENCY), and was counted as existent if the state had a public benefit fund or system benefits charge for energy efficiency, or an energy efficiency standard. Public benefit funds targeted at renewable energy were also included as a separate control variable (PBF). A final policy control variable concerned the deregulation status of the state's electricity system (DEREGULATED). It has been argued that deregulated states will see more renewable generation, and this variable has been significant in other work (Fremeth, 2009; Delmas et al., 2007) on renewable energy deployment. This variable is based on EIA (2010e) data.

In addition to policy control variables, there are other characteristics at the state level that could influence renewable power deployment. The retail price of electricity determines the relative cost of renewable power, and was shown to have a significant influence on in-state renewable deployment by Carley (2009). The PRICE variable is operationalized as cent per kWh retail price in the compliance year, and taken from EIA (2010d). Another state level variable is CO_2PERCAP, the tons CO_2 emitted per capita. It is an indicator of the resource mix used in the state. This variable was calculated based on state emissions (EIA, 2010c) and population (U.S. Census Bureau, 2008). I also test a different specification of carbon emissions, namely absolute tons of carbon emitted (CO_2).

Finally, I tested a small number of organizational level variables, to control for organizational size. These variables are in-state sales (SALES), revenues (REVENUE) and customer accounts (CUSTOMERS), and are taken from EIA (2010a).

4.5 Data analysis and results

This section presents and discusses the results of the empirical analysis.

4.5.1 Data exploration and transformation of the dependent variable

Descriptive statistics for all control variables and main effect variables are presented in Table 4.1. Due to the large number of potential control variables, and the small size of my data set, I regressed each control variable against the outcome variable individually first, and only included variables in the model that proved significant in the univariate regression. There is no theoretical reason to include every control variable, and doing so would result in over-fitting. The control variables retained were GREEN_POWER, DEREGULATED, and CO_2. Correlations for all main effect predictors and the selected control variables can be found in Table 4.2. None of the predictors are correlated excessively high.

Variable	**Min.**	**Max.**	**Mean**	**Std. Dev.**
Goal	0	33.10	4.75	5.34
Multiplier	0	1	0.29	0.45
Unbundled	0	1	0.60	0.49
REC_Origin	0	1	0.49	0.50
Fine	0	1	0.35	0.48
ACP	0	1	0.32	0.47
Existing	0	1	0.39	0.49
Green_Power	0	1	0.13	0.34
Efficiency	0	1	0.94	0.25
PBF	0	1	0.74	0.44
Deregulated	0	1	0.65	0.48
Price	6.89	21.3	11.4	3.6
CO_2 (million tons)	.1	230.0	50.1	49.1
CO_2perCap (tons per capita)	.14	20.5	7.1	4.6
Revenue (thousand US $)	17	11,632	1,380	2,169
Sales (MWh)	305	93,577,094	14,073,756	20,179,846
Customers	19	5,190,973	653,993	1,026,121

Table 4.1: Descriptive statistics for predictors and control variables

		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	Goal									
2	Multiplier	−.29*								
3	Unbundled	−.27*	.17							
4	REC_Origin	−.16	.07	.23*						
5	Fine	.09	−.28*	−.17	−.18					
6	ACP	−.10	.11	.57**	.26*	−.51**				
7	Existing	−.31**	.44**	.17	.17	−.09	−.04			
8	Green_Power	−.03	−.07	.24*	−.23*	−.04	.06	−.23*		
9	Deregulated	−.31**	.28*	.40**	.40**	−.77**	.51**	.09	.04	
10	CO_2	−.14	.41**	.00	−.28*	−.25*	.15	−.03	−.16	.18

Table 4.2: Correlation table for predictors and selected control variables. **$p < 0.01$; *$p < 0.05$ (Two-tailed tests)

Data exploration also included examining the dependent variable and the residuals. The dependent variable ranges from 0 % to 36 %, with a median of 2.7 %, and a mean of 5.1 %. The distribution of the dependent variable can be described as exponential. Initial data exploration revealed significant kurtosis and skewness. The Kolmogorov-Smirnov test indicated non-normality, with $D(77) = 0.266, p < 0.01$. Based on the residual analysis, a transformation of the dependent variable is necessary to avoid biased estimates. Other researchers in this area (Carley, 2009; Yin and Powers, 2010) have used a log-transformation. This is problematic, because it eliminates all values that equal zero and very small values remain outliers.

The problem could be remediated by adding a small constant to each value, or replacing all zeros with a very small value. Due to the properties of the data set, which is clustered toward zero, this solution is not optimal. For very small constants (e.g., 0.01), values that were originally zero and dropped from the analysis will act as influential outliers after the log transformation. Adding a larger value (e.g., 0.5) is also problematic, because of its relative size compared to the range of the dependent variable. Osborne (2002) argues that "the size of the constant and the place on the number line that the constant moves the distribution to can influence the effect of any subsequent data transformations." For these reasons, I decided against adding a constant to all values or replacing zeros with a small constant.

The dependent variable is also expressed as a proportion, and the log transformation is not recommended for this type of data. Proportions often result in severely skewed distributions, especially when they are clustered between 0 % and 20 %, and log transformation is not advisable in this case (Osborne, 2002). For proportions with values clustered close to zero or 1, the angular or arcsine transformation is recommended (Kutner et al., 2005; Wheater and Cook, 2000). For each data point, this transformation finds the angle whose sine is equal to the square-root, expressed as the radian. Both transformations perform well in reigning in non-normality and non-equal variance, and no significant differences in fit or in conformance with linear regression conditions were apparent from the residual analysis.[8] Given that the log-transformation has found much use in this field, I present alternative models using both of the two transformations. In the spirit of advancing measurement method for RPS outcomes, care has to be taken of using appropriate data transformations.

4.5.2 Model specification

I test the predictions developed in section 4.3 using a multivariate linear regression model with ordinary least squares (OLS) estimation. As laid out above, I will present alternative models using both a $\log_{10}$ and an arcsine square-root transformation of the dependent

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[8] For both transformations, the Durbin Watson test statistic approached 2, indicating independent error terms. Tolerance and VIF values revealed no multicollinearity. There were no influential cases: Cook's distance values did not exceed a value of 2 in either model, and no case had a leverage value of more than three times the average leverage value.

variable. These models are expressed as:

$$\log_{10} Y_i = \beta_0 + \boldsymbol{\beta}_1' \mathbf{X}_{1,i} + \boldsymbol{\beta}_2' \mathbf{X}_{2,i} + \epsilon \tag{4.1}$$

and

$$\arcsin \sqrt{Y_i} = \breve{\beta}_0 + \breve{\boldsymbol{\beta}}_1' \mathbf{X}_{1,i} + \breve{\boldsymbol{\beta}}_2' \mathbf{X}_{2,i} + \breve{\epsilon} \tag{4.2}$$

where Y_i is the policy outcome for organization i, $\mathbf{X}_{1,i}$ is a vector of policy design elements, $\mathbf{X}_{2,i}$ is a vector of control variables, β and $\breve{\beta}$ denote the corresponding regression coefficients, and ϵ and $\breve{\epsilon}$ represent the error terms.

4.5.3 Results

Results of the main effect model are presented in Table 4.3, and the model with controls added is presented in Table 4.4. Coefficients are transformed back for the log transformation, and indicate a multiplicative relationship, with back-transformed coefficients < 1 indicating negative and those > 1 indicating positive relationships. By convention, coefficients in a arcsine square-root transformed model are not back-transformed; only directionality of relationship is interpreted.

Both models explain a large proportion of the variance with either transformation method, with an adjusted R^2 of 0.60 for the log-transformed model including control variables, and an adjusted R^2 of 0.53 for the arcsine square-root transformed model including control variables. There is considerable overlap in the statistically significant variables between the log transformed model and the arsine square-root transformed model. Furthermore, the directionality of relationships is consistent across both types of transformations.

I find that hypothesis H1a is supported, indicating that a more stringent policy goal is positively related to the policy response at the organizational level. This result is hardly surprising, since stricter policies should result in higher levels of compliance. In the current stage of RPS deployment, the relationship is linear. Possibly, as goals get more difficult to achieve down the line, a u-shaped relationship between goal strength and outcomes could appear. RPS policies in most states are very recent and goals are ramped up slowly.

More interesting is the relationship between the existence of credit multipliers and policy response. The results support hypothesis H1b, which held that a policy design creating exceptions to the goal is associated with a lower policy response. Evidently, utilities are taking advantage of multipliers to produce the types of renewable energy that earn additional credit, or to produce renewable energy in-state for extra credit.

	$\log_{10} y$ (n=74)			$\arcsin \sqrt{y}$ (n=77)	
	β	SE	Back transf.	$\check{\beta}$	SE
(Constant)	$.337^{*}$	.183		$.175^{***}$	.038
Goal	$.039^{***}$	.011	1.095	$.010^{***}$	.002
Multiplier	$-.546^{***}$	.130	0.284	$-.059^{**}$	.027
Unbundled	$.542^{***}$	.145	3.481	$.084^{***}$	.030
REC_Origin	$-.233^{**}$	.090	0.585	$-.055^{***}$	.018
Fine	$.399^{***}$	.138	2.508	$.094^{***}$	.029
ACP	$-.277$	.167	0.529	$-.040$	.034
Adj. R2	**.52**			**.47**	

Table 4.3: Multivariate linear regression results: Main effects. Dependent variable: organizational proportion of renewable energy sales. $^{***}p< 0.01$; $^{**}p< 0.05$; $^{*}p< 0.10$.

	$\log_{10} y$ (n=74)			$\arcsin \sqrt{y}$ (n=77)	
	β	SE	Back transf.	$\check{\beta}$	SE
(Constant)	$.764^{***}$	.265		$.215^{***}$	.057
Goal	$.033^{***}$	.011	1.08	$.010^{***}$	.002
Multiplier	$-.443^{***}$	.140	0.36	$-.059^{*}$	.030
Unbundled	$.480^{***}$	.150	3.02	$.063^{**}$	.032
REC_Origin	$-.261^{***}$	.088	0.55	$-.056^{***}$	.019
Fine	.156	.191	1.43	.062	.041
ACP	$-.151$	.159	0.71	$-.013$	.033
Existing	.093	.129	1.24	$.050^{*}$	.028
Green_Power	$.321^{*}$	.173	2.10	$.074^{**}$	.036
Deregulated	$-.345^{*}$	.190	0.45	$-.052$	.041
CO_2	$-.003^{**}$	.001	0.99	.000	.000
Adj. R2	**0.60**			**0.53**	

Table 4.4: Multivariate linear regression results with controls. $^{***}p< 0.01$; $^{**}p< 0.05$; $^{*}p< 0.10$.

The relationships between the outcome variable and the variables related to discretion in means offer some unexpected results. The policy design elements that affect discretion of means are both significantly associated with policy response. Hypothesis H2a states that permitting unbundled REC (UNBUNDLED) will result in a higher policy response. The predicted relationship is supported, indicating that the flexibility introduced with the trading mechanism plays a significant role in driving reaction to the policy. In contrast, the association between the geographic origin (REC_ORIGIN) and policy response, while significant, is contrary to the anticipated relationship. Hypothesis H2b predicted that policy response is higher were geographic variability in the trading mechanism is permitted, but the results show a negative relationship between less restrictive REC procurement rules and policy response.

Possibly, not allowing REC procurement from out of state acts as a signal of policy strength, akin to a more stringent policy that signals the 'seriousness' of regulators (Del Brío et al., 2002; Hoffman, 2001; Welch et al., 2000). Another, more likely explanation is of geographic nature. Of the the 38 cases exposed to a policy design not restricting REC origin to the state, 27 are located in North-Eastern states (CT, DC, MA, MD, NH, NJ, NY, PA, RI). Possibly, the inclusion of this provision simply reflects a greater need for it. The East Coast is a geographic region with fewer renewable resources, higher population density, complicated siting and permitting rules, and pronounced opposition to wind power on aesthetic grounds (Bohn and Lant, 2009; Fischlein et al., 2010). At the same time, almost every state in this region has an RPS, intensifying the competition for REC. Indeed, renewable energy demand outstrips supply in NY, the Mid-Atlantic states and New England (Bird et al., 2009). There is little transparency on REC pricing for the compliance market, but selective broker data reported by NREL (Bird et al., 2009) shows that REC prices have sometimes topped US$ 40 per MWh in MA, CT, and RI, but sell for no more than US$ 10 to 15 in Texas.[9] There is a distinct possibility that geography confounds the relationship between unrestricted REC origin and policy response. The findings in this study do not necessarily disprove the flexibility effect of allowing unrestricted REC trading. Currently, there is little cross-regional trading of REC, and it is possible that an impact could be seen of allowing free national trading of REC. Unfortunately, the data set used in this study is too small to allow for testing interactions between regional effects and other variables. The findings neither support nor disconfirm the theory, but further research is needed to elucidate this issue.

The hypothesized positive association between the threat of a fine (FINE) and policy response (H3) holds up only in the main effect model. The effect on policy response of facing an alternative compliance payment (ACP) is marginally significant and negative when employing the log transformation, and not significant when employing the arcsine

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[9] In personal communication with utility managers in CA and MN, the higher price of REC on the East Coast was also mentioned, unprompted.

square-root transformation. In the main effect model, this is the only difference between the two types of transformations. The two dummy variables for fine and ACP are both highly correlated with the deregulation status (see table 4.2). States that have a fine tend to be traditionally regulated, while deregulated states are more likely to use an ACP.

Interestingly, the positive association between a fine and a higher policy response in the main effect model is opposite than proposed by Lafrancois (2009), who models the influence of enforcement type on renewable investment under an RPS. She predicts that a penalty based on the size of the infraction is more effective in driving compliance than a lump-sum payment. This results from the uncertainty inherent in renewable energy generation (intermittency, no large-quantity storage). While interesting, this model overlooks that in all states that currently have penalties based on the size of the infraction, these are *alternative* compliance payments (ACP), meaning that utilities are deemed in compliance when paying an ACP. So whenever the price of a REC is in excess of the ACP, the firm will choose to pay the ACP. Therefore, the ACP acts not so much as a penalty, but as a price cap. In contrast, fines are lump sums that do not relieve companies of their mandate, meaning they still have to procure the shortfall of renewable power the next year. Consequently, the risk associated with non-compliance is much higher in a state that imposes fines, and a fine should provide a larger incentive to over-comply than ACP. This effect shows up in the main effect model, but does not hold up once control variables are introduced.

The only other difference in main effects between the main effect model and the model with controls concerns credit multipliers. In the arcsine square-root model, the effect of multipliers is only marginally significant once controls are introduced.

While the models with controls are fairly consistent as to main effects, the results for the control variables diverge in part. The first control variable concerns the association between policy response and allowing renewable energy from existing resources to count towards compliance. The prediction that allowing existing resources would result in a higher policy response is not supported in either model.[10] This can be interpreted in two ways. Either it means that even the availability of existing resources for compliance does not incite utilities to a higher policy response, or simply that states allowing the use of existing resources do not adjust their goals upwards to reflect this fact. In fact, the correlation table (Table 4.2) shows that there is a small, but highly significant negative relationship ($R = -0.3, p < 0.01$) between allowing existing resources and the current year goal. This points to the latter explanation. Accordingly, were it possible to just measure *new* renewable sales (or increases over the prior year), it is likely that there would be a significant negative effect of allowing existing resources.

The effect of GREEN_POWER is significant in the log-tranformed model, and marginally significant in the arcsine square-root transformed model. This finding is consistent with

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[10] EXISTING is marginally significant in both the main effect and the controls model using arcsine square-root transformation.

other studies of factors driving renewable energy deployment (Menz and Vachon, 2006; Yin and Powers, 2010). Thanks to the specification of the dependent variable, it can be interpreted to stem from synergistic effects existing between green pricing programs and RPS policy response. REC reported for mandatory green pricing programs generally cannot be counted towards RPS compliance, and they were not included in the outcome variable. While a direct effect can therefore be excluded, there seems to be an indirect effect of having both programs. It is possible that utilities learn from experience in building and operating renewable facilities or entering into contracts with independent renewable power producers. Additionally, the price premium utilities can charge on green pricing programs may help to bring additional projects online, and increase the overall availability of renewable energy in the local market.

The remainder of the control variables do not consistently show up as significant in both models. Deregulation (DEREGULATED) is marginally significant in the log model and not significant in the arcsine square-root model. This is contrary to results by Delmas et al. (2007), Fremeth (2009) and Kneifel (2008); all of whom report higher use of renewable power in deregulated states. Possibly, this can be explained by the fact that their models covered all states, with or without an RPS, while my study looks only at RPS states. Among these states, their seems to be no significant difference in RPS outcomes between deregulated and regulated states.

While the log model detects a significant, negative effect of higher absolute CO_2 emissions (CO_2), this variable is not significant in the arcsine square-root model. Interestingly, a different specification of carbon emissions that was weighted for population was not significant. Total CO_2 emissions – and therefore absolute global warming impact – seem to be associated with a lower RPS policy response, but per capita emissions are not. States with large absolute emissions tend to have lower organizational responses to RPS, indicating perhaps that the capability to switch to renewable resources is not as high in these large, high impact states.

Overall, the conclusions drawn from the arcsine square-root and log transformed models are similar where main effects are concerned (Table 4.5). It can be said with reasonable confidence that goal strength (GOAL), unbundled REC (UNBUNDLED) and in-state origin (REC_ORIGIN) are associated with reported policy outcomes, although the relationship is inverse than predicted for REC_ORIGIN. The results are not clear-cut for credit multipliers, which is only marginally significant in the arcsine square-root model. Neither a fine nor an ACP are associated with outcomes once controls are inserted into the model. Several differences exist in the effects of control variables. The log model has a slightly better fit, with more of the variance explained by the predictors than in the arcsine square-root models. Possibly, this is an artefact of the transformation used, but all in all, both transformations appear reasonable.

Variable	**Predicted rel.**	$\log_{10} y$	$\arcsin \sqrt{y}$
Goal	↑ policy response	Supported	
Multiplier	↓ policy response	Supported	Marginally sign.
Unbundled	↑ policy response	Supported	
REC_Origin	↓ policy response	Significant, but inverse relationship	
Fine	↑ policy response	Not supported	
ACP	↑ policy response	Not supported	
Controls:			
Existing	↑ policy response	Not supported	Marginally sign.
Green_Power	↑ policy response	Marginally sign.	Significant
Deregulated	↑ policy response	Marginally sign.	Not significant
CO_2	↓ policy response	Significant	Not significant

Table 4.5: Comparison of alternative models

Situating the present study in the context of prior research on RPS outcomes, a few interesting commonalities and differences come to light. None of the studies that have examined the effect of RPS policy presence at the state level find a significant effect on renewable capacity (Kneifel, 2008; Menz and Vachon, 2006)[11] or generation (Carley, 2009) *in the state*. I argue that the failure to find an effect is caused by the level of measurement. Renewable energy and REC are traded across state-lines quite frequently, and measurement at the state level cannot account for this.

Remarkably, once analysis begins to account for variations in RPS design, associations appear between RPS policy and renewable generation even at the state level. The two studies that examine RPS stringency (Fremeth, 2009; Yin and Powers, 2010) both find an effect of stronger goals on renewable generation among those utilities or states, respectively, that have an RPS. This is in line with the findings in the present study. Nevertheless, even in these cases, measurement at the state level leads to some counter-intuitive findings. For instance, Yin and Powers (2010) report that allowing REC trading leads to a .3 % increase in renewable generation for each 1 % increase in the RPS goal, while in the absence of this design feature, generation increases by 1.01 %. Consequently, free trading in REC leads to comparatively less renewable generation in the state. This effect can be measured directly thanks to the specification of the dependent variable used in the present paper, where the association between unbundled REC and renewable generation is positive.

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[11] Kneifel (2008) finds an effect of capacity requirements, but not of generation requirements.

4.5.4 Limitations

The limitations of this study are mainly related to its research design. Data availability limited the study period to a one year time frame. Due to the cross-sectional nature of the study, it is not possible to infer causality. Future research should build models based on multi-year data, which would allow for causal prediction. Using a longitudinal data set, it would also be possible to include additional control variables, particularly at the organizational level. A larger, multi-year data-set would also enable the testing of interaction terms. It is conceivable that there are trade-offs between certain aspects, or reinforcing effects.

It is also important to realize that the present study provides a snapshot in time and investigates RPS outcomes early in their deployment. As RPS policies mature, it is conceivable that the strength or nature of some relationships will change or that variables will become significant that were of little importance in earlier periods. For instance, as goals become ever more stringent, a non-linear relationship could come to bear between stringency of the goal and policy response. Additionally, if goals become too difficult (or expensive) to achieve, utilities could make use of waivers and exceptions in RPS policies to gain permission to lower their policy response. Particularly, variables such as banking can have a time dependent influence on RPS outcome. As more data becomes available, it may become possible to model these complex relationships. With regard to the temporal context, it is also important to note that not all RPS goals increase steadily over time. Stepwise increases in some states could result in 'lumpy' deployment patterns, that could be different from those in states with steady increases in goals over time. Again, banking will alter these deployment patterns.

The outcome variable used in this study (reported renewable energy sales) tracks only one important characteristic of policy success, namely renewable sales proportion. It cannot assess impacts on the distribution of renewable energy sales across fuels. A few utilities report resource specific data, but currently, their numbers are not large enough to permit for a more detailed analysis. Design elements such as technology quotas and subsidies or credit multipliers can be expected to affect resource composition. There is also uncertainty related to technology deployment pathways as advanced renewable technologies become available. The research design used in this study focuses on policy design and controls for a small number of state level variables. Obviously, there are other variables – both of technical and of economic nature – that influence technology deployment trajectories.

In chapter 3, I have also discussed potential cost impacts of RPS. Measuring the cost effectiveness of RPS would require more information on the pricing of REC, which is currently not available. Of the RPS compliance reports I collected, about a third had some information on REC pricing. Reporting methods, however, are not standardized, and data is incomplete. For example, some utilities report only solar REC prices, but not the prices of other renewable energy. Nevertheless, the variable provides an advance in measurement methods over previous research, by assessing RPS outcomes at the level the policy targets, renewable sales proportion.

4.6 Discussion and conclusion

The present study has investigated the association between policy design elements and policy response. In doing so, it has provided some evidence that more stringent goals are associated with higher policy response, as is increased discretion in means. Results are not clear cut for the effect of a fine, which looses significance once controls are introduced.

The results demonstrate that assessing policies in more detail than is currently being done is essential to understanding their relationship with policy outcomes. Additionally, the simplified comparison between direct and flexible regulation does not necessarily hold up when examining policy design, and could mask differences in policy outcomes. The policies assessed in this study - renewable portfolio standards - clearly vary in the strength of their goals and in enforcement, as well as in the amount of flexibility they grant.

This study contributes to the theoretical development of the policy design field, by identifying relationships and testing associations between policy design elements and outcomes. Keeping in mind the limitations of the data set, it provides some support for theoretical models that predict superiority of flexible over direct regulation, since the majority of flexible design elements tested in this study are positively related to policy outcomes. More importantly, the study offers empirical contributions to the understanding of renewable portfolio standards, a key strategy for increasing renewable electricity consumption and decreasing carbon emissions. Specifically, it offers a pathway towards more accurate measurement of RPS outcomes and design complexity. Half of all prior studies on RPS outcomes have found no association between RPS and increased renewable capacity or generation, simply because they were measuring at the wrong level and/or disregarding policy complexity.

The present study accounts for the full complexity of RPS, in contrast to prior work that has mostly used dichotomous measures of policy presence/absence. It also improves upon prior measurement methods in this area, by measuring policy outcome at the organizational level. Thanks to an innovative dataset based on RPS compliance reports, this measurement can account both for electricity purchases crossing state lines, as well as the attribution of renewable energy credits. I measure policy outcomes directly, while other studies have used in-state generation or capacity as proxies of RPS outcomes.

Examining policy design and outcomes at the organizational level opens up other fruitful areas of investigation. For instance, dissimilar organizations may react differently to policy design aspects. Organizational level analysis of policy design outcomes could integrate theories of organizational behavior to gain insights on how organizational structures and characteristics respond to certain types of incentives. Another interesting research question concerns managerial perception. It has been shown that perception of environmental issues shapes the choice of environmental strategies (Sharma, 2000; Sharma et al., 1999). In a similar vein, perceptions of policy uncertainty can influence how firms react to policies, both in the timing and the choice of strategies (Fuss et al., 2009; Meijer et al., 2007). Given these findings, it would be interesting to explore whether perceptions of policies interact with design aspects to influence the choice of compliance strategy and the likelihood of compliance.

In sum, the complexity of policy design should be taken into account when examining the impact of policies on business firms. Policy analysis can provide insights into the complex characteristics of policies, while drawing from management literature to illuminate how firms react to policies. Together, they can open up new avenues for research, with the kinds of practical implications much needed to address pressing environmental issues.

Chapter 5

The effect of policy scope and interactions among renewable and energy efficiency policies

With kind permission by my co-authors, this chapter is adapted from: Fischlein, M., T. M. Smith, and E. J. Wilson (2009). Carbon emissions and management scenarios for consumer-owned utilities. *Environmental Science & Policy* 12, 778-790.

Environmental regulation primarily targets the most visible sources of pollution: large, industrial emitters. But just like small and medium enterprises (SME) employ about 50 % of all workers in the economy, small sources add up to important environmental impacts. Consequently, the scope of a policy can have a strong influence on its overall impact. Environmental regulation of the U.S. electricity sector is a case in point, because it focuses selectively on just the largest utilities. This study estimates the impact of extending prominent environmental regulations in the electricity sector – energy efficiency and renewable energy standards – to include all types of utilities. It also analyzes interactions between these policies.

5.1 Introduction

The electricity systems contributes roughly 40 % to U.S. greenhouse gas emissions, making it the largest emitter of all sectors and a key target for meaningful emission reductions (Pacala and Socolow, 2004). While carbon cap-and-trade efforts are emerging regionally and nationally in the United States, the most widely used approaches to curb carbon emissions in the electric utility sector are to increase the amount of renewable generation and to reduce energy demand growth through efficiency programs. These proven policies represent core carbon mitigation strategies for the electricity sector. However, with few exceptions, regulatory efforts in this area have targeted large, investor-owned utilities, often excluding municipal utilities, rural electricity cooperatives, and district power providers.

These energy service providers are collectively referred to as consumer owned utilities (COU) due to their non-profit and customer empowering models of governance. They hold a unique set of organizational challenges when implementing carbon management policies, from their relatively small size and limited access to resources to their complex ownership models and often dispersed rural focus. Yet, their broad presence across the nation (COU operate in all U.S. states) and their significant share of the electricity market (amounting to more than a quarter of retail sales) underscore their importance.

While significant strides in U.S. climate change legislation in the electricity sector have been made in recent years, mainly driven by the states (Rabe, 2004), COU have largely been ignored by these provisions. Almost all state energy efficiency policies exempt COU or grant them exceptions, as do almost half of all state renewable portfolio standards (DSIRE, 2009). The policy realm's inattention to COU is compounded by the general lack of available data on COU. Indeed, the majority of current research efforts, while offering important contributions, explicitly or implicitly focus solely on the investor-owned sector (Eto and Vine, 1996; Fershee, 2008; Loughran and Kulick, 2004; Wiser et al., 1998). Creating policies that reward building renewable and energy efficiency capacity in these organizations is compounded by the difficulty in assessing the carbon impact of COU. The vast majority of these organizations do not own or operate all of the necessary generation to satisfy the loads they serve. However, with state renewable policies mandating shares in sales, rather than in generation, and utility-run energy efficiency programs at the distribution level being the preponderant model of deployment, addressing COU is a reasonable future pathway of policy extension for many states. As a point source, electric generation represents a relatively straightforward target for pollution regulation, as opposed to mobile sources, where regulation faces significant information costs (Cabe and Herriges, 1992; Segerson, 1988). A small number of COU already run innovative and high performing energy efficiency (Flanigan and Hadley, 1994) or renewable energy programs (Dracker and De Laquil III, 1996), demonstrating that capacity for these carbon mitigation strategies exists.

In this chapter, I address the growing relevance of COU within the context of climate change. First, I examine the role of COU within the context of the U.S. electricity industry. Second, I provide an overview of the policy landscape and the present state of energy efficiency and renewable generation among COU. Third, I estimate the carbon intensity of electricity sales from the COU sector, incorporating both generation and purchased power on a state-by-state basis. Fourth, I analyze the implications of several carbon management scenarios for COU through the year 2030. Finally, conclusions and recommendations are provided for greenhouse gas reduction strategies for the COU sector at both the state and federal levels.

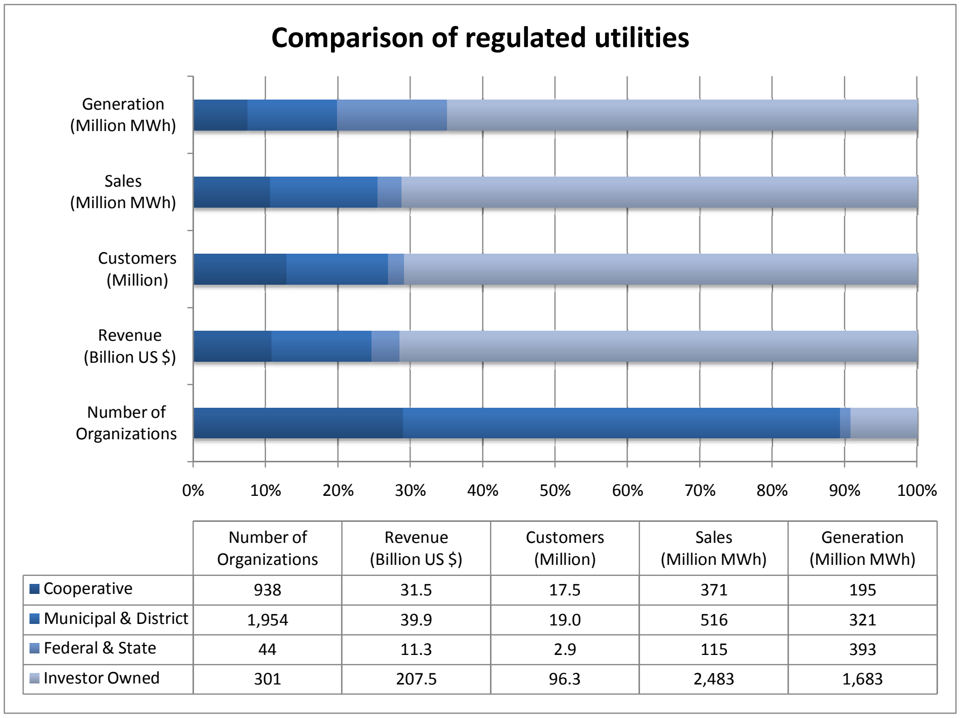
5.2 Growing relevance of consumer-owned utilities under climate change

5.2.1 Consumer-owned utilities in the U.S. energy system

COU are comprised of rural electric cooperatives and municipal and district utilities. In contrast to investor-owned utilities, COU governance relies on direct customer control. Cooperatives fall into two categories: distribution and generation and transmission (G&T) units. Sixty-six G&T cooperatives provide power for more than 800 distribution units in the U.S., often operating under long-term exclusive power purchasing contracts. Municipal and district utilities are owned by the government and under direct customer control, while state and federally owned utilities do not have direct customer control and are therefore excluded from this study.

COU often have some generation capacity of their own, but generally enter into long-term contracts with municipal marketing authorities, investor-owned utilities and power marketers. Currently, there are 1,852 municipal utilities and 102 district utilities nationwide. Overall, COU are significantly smaller than investor-owned utilities, which, on average, sell more than 25 times the amount of power as the average COU. Despite the small size of individual COU, taken together, they are large suppliers of electricity. In 2006, they accounted for 25.5 % of end consumer electricity sales and serviced 26.9 % of all customer accounts (Figure 5.1). In the same year, they generated more than 500 TWh, accounting for close to 20 % of power production by regulated utilities. In addition, COU have tremendous reach across the United States. Municipal utilities are found in every state but Hawaii and cooperatives supply over 75 % of the U.S. land area with power.

In view of the geographic reach of COU and their large customer-base, excluding them from carbon reduction policies places greater burdens on investor-owned utilities and their customers, who have to shoulder a disproportionate share of the costs associated with the transition to cleaner electric power. Exclusion of COU from such policies is aided by their historical position within policy and political institutions. COU largely govern themselves, often based on the notion that their direct ownership and governance structures can guarantee fair rate-making even under monopoly conditions. They set their own rates in all but a few states. In fact, fewer than twenty state commissions regulate cooperatives (Greer, 2003) and most do not have jurisdiction over municipal utilities either (APPA, 2005; Bachrach et al., 2004). Only seven states have full rate regulation authority over municipal utilities, with another seven states regulating utility rates under specific conditions (APPA, 2005). Additionally, large swaths of regulation address solely the generation level, particularly where emissions are concerned, and many regulations exclude small sources. Finally, the geographical pervasiveness of COU provides them with considerable political clout. Electoral districts of many state senators and federal members of Congress overlap with their service territories and board members of COU are often part of the local elite.



	Number of Organizations	Revenue (Billion US $)	Customers (Million)	Sales (Million MWh)	Generation (Million MWh)
■ Cooperative	938	31.5	17.5	371	195
■ Municipal & District	1,954	39.9	19.0	516	321
■ Federal & State	44	11.3	2.9	115	393
■ Investor Owned	301	207.5	96.3	2,483	1,683

Figure 5.1: Comparison of cumulative revenue, consumers, sales and generation across regulated utilities, 2006. Source: EIA, 2010a. Figure reproduced from Fischlein et al. (2009).

The widespread practice of excluding COU from regulations may become more problematic in light of new climate change mitigation approaches. It has been suggested that a carbon cap and trade system might be best situated at the distribution level to stimulate end-use efficiency in direct contact with customers, and to avoid windfall gains for generators (RAP, 2006). More generally, market based pollution control systems necessitate the inclusion of all types of providers. As described by Bushnell et al. (2008, p. 175), regionalized policy regimes can result in both leakage ("physical relocation of the [. . .] economic activity") and reshuffling (changes in "who buys from whom"), effectively eliminating any gains from environmental policies. While the concept of leakage has primarily been conceptualized geographically (Cowart, 2006), leakage can also result from the exclusion of industry sectors (Paltsev, 2001). Where renewable mandates or a potential carbon cap and trade system is concerned, this may lead to power purchase reshuffling at the wholesale or end sale level. As a result, COU might switch to dirtier fuels or purchase electricity from dirtier sources. This phenomenon may already be emerging. Despite a recent bout of project cancellations, COU still propose 20 % capacity growth from coal, compared to 4.9 % for investor-owned utilities.[1] A large number of coal plants are also being proposed

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[1] Based on a comparison of proposed capacity additions from coal between 2003 and 2009 (DOE/NETL, 2005; Sierra Club, 2009) and 2006 nameplate capacity for all fuels (EIA, 2007a), investor owned utilities plan to increase their capacity by 4.9 %, where municipal and district utilities propose to add 10.5 % additional

by independent power providers, a major source of purchases for COU. In short, both generation and purchases by COU are at risk of becoming significantly more carbon intensive. On top of production shifts, in deregulated states, price advantages associated with cheaper dirtier fuels might lead to consumer shifts.

5.2.2 Present policy efforts for carbon management: energy efficiency regulations and renewable portfolio standards at the state level

The most prominent strategies levied to reduce carbon emissions from electric utilities are energy efficiency and renewable generation programs. Utility-based energy efficiency programs encourage or require active intervention by a utility to influence the shape or the amplitude of its load curve through demand side measures (Gellings and Chamberlin, 1988). They mandate utilities to attain either a spending or energy savings goal. In response to deregulation, systems benefit charges have also been introduced to provide funds for services that had so far been assumed by utilities (Heiman and Solomon, 2004). This surcharge is levied on customer bills to finance energy efficiency programs, R&D, education programs, renewable energy, etc. Renewable portfolio standards specify goals for renewable electricity generation, usually expressed as a percentage of electricity sales or absolute capacity. Goals vary in the quantity of renewable generation and the time horizon they prescribe. Many state RPS systems mandate a 15-25 % renewable share of total capacity (Table 5.1).

Initially motivated by concerns about pollution control and resource management, policies supporting renewable generation and energy efficiency have come to represent key pathways for reducing greenhouse gas emissions in the electricity sector. Over the past 25 years, utilities have gained considerable experience with implementing these policies. Utility-centered strategies for carbon management benefit from positive public perception and fit the American model of private implementation of public goals, contributing to their political feasibility. In a significant number of U.S. states, these strategies are at the core of utility sector carbon management. U.S. energy regulation is largely in the domain of the states (Rabe, 2008), and carbon management in this sector is driven by state action.

Presently, there are no federal policies on utility-based energy efficiency or renewable generation goals (Byrne et al., 2007), although the federal government grants the Production Tax Credit and R&D subsidies. While the federal government may move to act on climate change in the near future, state action is likely to remain relevant since federal action often determines a minimum requirement with individual states being allowed to set more rigorous policy.

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capacity and cooperatives plan to add 33 %. While at the time of publication IOU have 31 coal plants in all stages from initial proposal to approval and COUs have 30 such plants, relative to current capacity, COU are adding new coal generation at a rate four times that of IOU.

State	**COU sales**		**Demand growth[1]**	**Renewable portfolio standard**			**Energy efficiency regulation**	
	GWh	**%**		**COU status**	**Goal**	**Timeline**	**COU status**	**Mechanism or goal**
AK	5 683	93	2.4	-	-	-	-	-
AL	28 116	33	2.5	-	-	-	-	-
AR	17 965	44	3.3	-	-	-	-	-
AZ	30 805	41	3.7	not included	15%	2025	included	Systems benefits charge
CA	62 371	24	1.3	exceptions	20%	2010	included	1% per year
CO	19 863	38	3	exceptions	20%	2020	not included	1% per year
CT	2 086	6	1.3	included	23%	2020	not included	1% per year
DE	2 844	14	2.2	exceptions	20%	2019	not included	Efficiency utility, bonds
FL	53 665	24	2.8	not included			-	-
GA	50 458	37	3.2	-	-	-	-	-
HI	452	4	1.4	not included	20%	2020	included	Systems benefits charge
IA	10 333	21	2.5	not included	105 MW	-	-	-
ID	2 981	18	1.6	-	-	-	-	-
IL	11 984	13	1.7	not included	25%	2025	not included	2008: 0.2%, 2012: 1%, 2015: 2%
IN	19 511	22	2.3	-	-	-	not included	2008: 0.2%, 2009: 0.4%, 2015: 2%
KS	11 523	37	2.4	-	-	-	-	-
KY	32 542	51	2.5	-	-	-	-	-
LA	12 467	24	1.3	-	-	-	-	
MA	7 870	21	1.3	not included	15%	2020	not included	Systems benefits charge
MD	4 882	5	1.6	included	20%	2022	-	-
ME	169	92	0.1	included	10%	2017	included	Efficiency utility, systems benefits charge
MI	11 872	12	1.7	included	10%[2]	2015	not included	2009: 0.3%, 2012:1%
MN	22 764	32	2.2	exceptions	25%	2025	included	1.5% per year
MO	24 411	21	2.7	not included	15%	2021	-	-
MS	21 350	49	2.4	-	-	-	-	-
MT	3 615	37	0.2	not included	15%	2015	included	Systems benefits charge
NC	30 708	20	2.2	exceptions	12.50%	2021	not included	2012: 0.75%, rising to 5% in 2021
ND	5 885	70	3.1	voluntary	10%	2015	-	-
NE	26 888	100	2.7	-	-	-	-	-
NH	922	9	1.3	included	23.80%	2025	included	Systems benefits charge

State	COU sales		Demand	Renewable portfolio standard			Energy efficiency regulation	
	GWh	%	growth[1]	COU status	Goal	Timeline	COU status	Mechanism or goal
NJ	1 368	3	1.5	not included	22.50%	2021	not included	Systems benefits charge
NM	6 936	47	2.8	exceptions	20%	2020	not included	5% decrease from 2005-2014, 10% by 2020
NV	2 307	7	4.7	not included	25%	2025	not included	Efficiency eligible under RPS
NY	4 842	4	0.8	not included	24%	2013	not included	15% decrease from 2008-2015
OH	17 440	6	0.7	not included	25%	2025	not included	2014: 1%, 2% 2019-2025
OK	13 532	35	1.5	-	-	-	-	-
OR	13 965	16	0.7	exceptions	25%	2025	not included	Efficiency utility, systems benefits charge
PA	3 996	3	1.6	not included	18%	2020	included	2011: 1% of 09/10 sales, 2013: 3%
RI	52	1	1.3	not included	16%	2020	not included	Systems benefits charge
SC	18 720	36	2.3	-	-	-	-	-
SD	4 531	61	3	voluntary	10%	2015	-	-
TN	92 949	74	1.9	-	-	-	-	-
TX	82 046	24	2.1	exceptions	5.9 GW	2015	included	15% of load growth by 2009, 20% by 2010
UT	5 611	100	3.5	voluntary	20%	2025	-	-
VA	13 885	13	2.5	voluntary	15%	2025	-	-
VT	1 324	23	1.3	included	20%	2017	not included	Efficiency utility, 1.7% in 2007
WA	49 568	61	-0.4	exceptions	15%	2020	included	All cost-effective efficiency
WI	11 368	15	2.2	included	10%	2015	included	Efficiency utility, systems benefits charge
WV	135	58	2.3	-	-	-	-	-
WY	5 556	86	1.6	-	-	-	-	-

Table 5.1: COU sales and policy status by state, 2006. Source: (DSIRE, 2009) and Pew Center on Global Climate Change, 2008 (policy status), EIA 2007b (sales), 2007c (demand growth). Table reproduced from Fischlein et al. (2009).

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[1] Average annual growth 1990-2007

[2] Additional requirement: 1100 MW absolute capacity.

Current deliberations at the federal level apply only to very large utilities and target renewable energy levels substantially lower than many state policies. For instance, under the House approved *American Clean Energy and Security Act of 2009* (H.R. 2454), a national renewable mandate of 15 % by 2025 would only apply to utilities selling more than 4 million kWh. This would result in the exclusion of all but the 23 largest COU. State-level carbon mitigation policies are therefore likely to retain their importance, and their architecture provides valuable information on the future design and effectiveness of different approaches.

With regard to state-level energy efficiency policies, most of the requirements only apply to investor-owned utilities. As of 2007, among the 27 states with utility-administered energy efficiency programs or public benefits funds, sixteen completely exclude COU (Table 5.1). With regard to the coverage of COU under state renewable portfolio standards (RPS), out of 30 states with mandatory renewable portfolio standards in 2007, only seven fully include COU, and another nine include them with exceptions or special provisions. Some states, while not explicitly differentiating between provider types, link targets to size or exclude the smallest utilities. This often results in exemption or exceptions for high percentages of COU. Finally, some states leave the decision to participate in these policies to COU or exempt them from binding targets.

5.2.3 Energy efficiency and renewable energy efforts in consumer-owned utilities

The electric utility industry spent \$1.9 billion in 2005 for energy efficiency (EIA, 2006a), and reported energy savings of 54 TWh in 2004, accounting for 1.4 % of total retail sales (EIA, 2006b). Close to half of all investor-owned utilities reported efficiency programs of some form in 2005, but only 11 % of municipal utilities and 21 % of cooperatives reported implementing these programs (EIA, 2006b). Since only larger utilities report on these programs, these numbers may underestimate actual usage of efficiency programs by COU. Industry sources suggest that close to half of all COU run some type of energy efficiency program (Moline, 1992; NRECA, 2007). The evidence on cost-efficiency of COU-run energy efficiency programs is mixed. Comparable nationwide data is not available and few states require comprehensive reporting of costs and savings. For the state of Minnesota, lifetime costs per kWh were found to range from 7.5 cents to 28 cents (OLA, 2005). A recent study of energy efficiency in California public utilities found an average lifetime cost of .032 cent per kWh, a figure almost on par with the costs incurred by investor-owned utilities (CMUA, 2006) and significantly below those in Minnesota. One possible explanation for these divergent assessments is that California counts a number of very large COU, with longstanding experience in energy efficiency. These numbers compare to a range from 0.8 cents to 22.9 cents per kWh reported in a recent review of the relevant literature on investor-owned utilities (Gillingham et al., 2006). Over all, this may indicate that smaller organizations face unique hurdles in initiating cost-effective energy efficiency programs, although anecdotal evidence suggests that some COU have the capacity and political will to run far-reaching and successful energy efficiency programs (Flanigan and Hadley, 1994).

Similar to other regulated utilities, investment in renewable generation technology has been slow among COU. In 2006, electric utilities generated ten thousand GWh of non-hydro renewable electricity (EIA, 2007b). This represents a mere 10.4 % of all renewable energy generated in the United States, bearing witness to the fact that many electric utilities buy from independent generators instead of engaging in renewable generation themselves. Data on generation for each electric provider type are lacking, making it difficult to assess the U.S. share of renewable electricity generation by COU. However, capacity data suggest that renewable energy is not a significant factor in COU fuel mix, with 0.5 % capacity reported among municipal utilities and 0.2 % among cooperatives (EIA, 2007a). While overall renewable capacity is small, significant individual efforts by COU suggest they could increase renewable generation and sales in the future. Municipal utilities, in particular, have been among the first proponents of renewable energy commercialization (Dracker and De Laquil III, 1996) and many have established ambitious renewable energy targets (APPA, 2008).

5.3 Not all kilowatt-hours are created (or sold) equally

The electric generation mix determines the carbon intensity of a kilowatt-hour, and the contribution of COU to U.S. greenhouse gas production is considerable. Cooperatives, in particular, are greenhouse gas emissions intensive, with 82 % of their electricity generated from coal plants (EIA, 2007d). Coal's share of total electricity generation is more than a third higher among cooperatives than among other electric utilities.[2] Not surprisingly, cooperatives' coal-intensive fuel mix translates into above-average carbon emissions. They discharged at least 120 million tons of CO_2 in 2005 (EPA, 2007).[3] On average, U.S. generating plants emitted 630 kg of CO_2 per MWh generated, where cooperatives emitted 850 kg (EPA, 2007). Carbon intensity of cooperatives' generation is exacerbated by the disproportionate system losses occurring in low density areas. The median line loss for distribution-level cooperatives was 6.6 % in 2003, with additional system losses of 3 % at the generation and distribution level (APPA, 2005), while average combined losses amounted to 5.8 % nationwide the same year (World Bank, 2004).

Municipal and district utilities, in contrast, run natural gas fired-plants and hydropower plants for 20 % and 22 % of their own generation, respectively (EIA, 2007d), with coal accounting for only 49 % of owned generation, making them appear much less carbon intensive. However, the manner in which data on these organizations are collected by government makes summarizing carbon intensity for municipal and district utilities exceedingly difficult.

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[2] These numbers do not account for purchases on the wholesale market, but solely for actual generation.

[3] EPA's EGRID data base contains information only for units larger than 25 MW. Emissions data is available for roughly 65 % of generation by cooperatives.

Accurate evaluation of their emissions is hampered for two primary reasons: 1) many of these facilities are small and excluded from reporting requirements, with emissions data available for only about 40 % of total generation,[4] and 2) many COU purchase a significant portion of their electricity, of which the source is not known.

Based solely on generation, municipal utilities appear quite different from cooperatives in their carbon impacts. However, given that existing policies focus on distribution, it seems relevant to investigate the carbon impact of retail sales. When analyzing retail sales, this difference is substantially reduced due to the large amount of power purchased by COU. For example, in Oklahoma and Wisconsin, generation by municipal utilities appears quite clean, with Oklahoma's generation primarily produced from natural gas (82 %) and Wisconsin relying on coal for only 31 % of their generation. However, in both cases, municipal utilities purchased over 90 % of their electricity. Regional grids for both states, which, one might reasonably assume, reflect the carbon intensity of power purchases, have significantly higher coal dependencies. Similarly, cooperatives in Kansas and Mississippi appear very coal intensive (95 % and 86 %, respectively), however, 44 % and 82 % of cooperatives' retail sales in these states are derived from purchased power from less coal intensive regional grids (64 % and 59 % coal, respectively).

These examples illustrate the importance of examining carbon impacts at the sales level, where purchased power is included. While significant differences undoubtedly remain between ownership models, with regard to state-level renewable and energy efficiency policies, municipal, cooperative and district utilities tend to be included (or excluded) together. Thus, in the following section, I estimate the carbon intensity of electricity sales across the COU sector, in aggregate and on a state-by-state basis.

5.3.1 Methods

Where a kilowatt-hour is produced affects its carbon intensity. This is important to the examination of carbon management policies, as carbon intensity of COU sales varies significantly across the United States. The lack of emission data for COU complicates any reliable assessment of their carbon impact. This is compounded by the fact that generation owned by COU makes up only a part of the electricity sold. Based on the trend of state renewable policies mandating shares in sales, rather than in generation, and utility-run energy efficiency programs requiring spending and savings targets at the retail level, carbon impacts must be examined at both the source of generation and also at the retail sales level.

Yet, the carbon impacts of purchases are not well understood, particularly when COU are involved, since individual utility supply data are not readily available and cross-state transfers of electricity play a role that is not well documented (Jiusto, 2006). Due to the relatively large amount of power sold by COU that is either purchased or for which fuel

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[4] Based on a comparison of emissions data in the EGRID system (EPA, 2007) and generation numbers reported to the EIA EIA (2008a).

mix data is not available (64 % of sales in 2006 (EIA, 2010a, 2007d)), carbon emissions associated with their sales have to be estimated.

I develop an estimation method using fuel input, fuel mix and carbon factors. I begin by obtaining available fuel input data for COU generation, then estimate the fuel mix of the remaining sales by deducting generation from retail sales and applying the fuel mix of the state's respective regional grid (North-American Electric Reliability Corporation region) to obtain fuel input for purchases. While this method introduces some uncertainty in the final estimate, regional fuel mix is the best available proxy for the fuel mix of COU purchases. A similar method is used by carbon credit certification systems (e.g., green-e) to calculate the carbon benefits of renewable generation. Finally, I use fuel-specific carbon factors to calculate the CO_2 emissions E (to CO_2) of electricity sold by all COU in a state:

$$E = \sum_f c_f i_f \tag{5.1}$$

where c_f (to CO_2 / MMbtu) denotes the carbon factor of fuel f, and i_f (MMbtu) denotes the total fuel input corresponding to the COU sales.

The carbon intensity is then computed as the ratio of carbon emissions and total COU sales S (MWh)

$$I = \frac{E}{S} \tag{5.2}$$

The main difficulty lies in determining the fuel input i_f, since it comprises contributions from both generation g and purchases p, i.e.,

$$i_f = i_{f,g} + i_{f,p} \tag{5.3}$$

Whereas the fuel input from generation is known (EIA, 2007d), the fuel input associated with purchases is not, and has to be estimated. To arrive at an estimate, I consider COU sales as the sum of generation and purchases

$$S = g + p \tag{5.4}$$

and assume that (1) the fuel mix per MWh of all COU purchases p equals the regional (non-COU) fuel mix, and (2) the fuel intensity for these purchases equals the regional fuel intensity. Regional fuel mix $\bar{m}_f$ can be computed as the ratio of regional (non-COU) generation $\bar{g}_f$ (MWh) from fuel f over total regional generation $\bar{g}$

$$\bar{m}_f = \frac{\bar{g}_f}{\bar{g}} \tag{5.5}$$

Similarly, the average regional fuel intensity $\bar{t}_f$ (MMbtu/MWh) can be computed as the ratio of fuel input $\bar{i}_{f,g}$ (MMbtu) over regional generation $\bar{g}_f$ using fuel f

$$\bar{t}_f = \frac{\bar{i}_{f,g}}{\bar{g}_f} \tag{5.6}$$

Based on these assumptions, the fuel input $i_{f,p}$ associated with COU purchases equals

$$i_{f,p} = \bar{t}_f \bar{m}_f p \tag{5.7}$$

This value can now be used as a proxy in computing the total fuel input corresponding to COU sales using equation (5.3), which then allows me to compute total CO_2 emissions and carbon intensity using equations (5.1)-(5.2).

The following data sources were used to compile the data set. Utilities were matched across data sets using federal utility ID numbers.

- Owner type: EIA (2007a). Annual Electric Generator Report.
- Generation by fuel (MWh), fuel input (MMBtu per MWh): EIA (2007d). Power Plant Databases.
- Retail sales: EIA (2008a). Annual Electric Power Industry Database.
- Carbon factors: EIA (2008c). Fuel and Energy Source Codes and Emission Coefficients.
- Electricity demand growth (national projection): EIA (2008b). Electricity Projections
- Electricity demand growth (historical state rates): EIA (2007b). Electric Power Annual

Fuels considered in the analysis were coal (sub-bituminous, bituminous and lignite coal), natural gas, hydropower, nuclear, fuel oils (residual and distillate fuel oil), and non-hydro renewable energy (geothermal, biomass, wind). Emission factors were unavailable for petroleum coke, coal-based synfuel, waste coal, and landfill gas. These fuels, amounting to 3.27 % of COU generation and 2.75 % of all generation across the United States, were therefore excluded from the analysis. An additional nineteen fuels were negligible in terms of their share in total generation for both COU (0.18 %) and total U.S. electricity generation (0.67 %), and were also excluded.

5.3.2 Carbon emissions and intensity of consumer-owned utility sales

The state-by state estimates for carbon emissions and carbon intensity of electricity sold by COU in 2006 are reported in Table 5.2. The table also displays the fuel mix of COU sales in each state, weighted for purchases and generation.

	Fuel mix weighted by generation and purchases						Estimated carbon emissions	
State	**Coal**	**Natural gas**	**Nuclear**	**Hydro**	**Renewable**	**Fuel oils**	**tons**	**tons/MWh**
WA	8%	11%	3%	77%	2%	0%	3 363 129	0.07
CA	14%	41%	4%	37%	4%	0%	16 080 487	0.26
VT	11%	26%	22%	16%	21%	3%	344 016	0.26
ID	25%	25%	8%	38%	4%	0%	982 433	0.33
CT	15%	36%	30%	13%	2%	4%	752 723	0.36
MA	15%	38%	28%	13%	1%	5%	2 854 766	0.36
ME	15%	36%	30%	13%	2%	4%	61 007	0.36
NH	15%	36%	30%	13%	2%	4%	333 615	0.36
RI	15%	36%	30%	13%	2%	4%	18 693	0.36
NY	17%	35%	28%	13%	1%	4%	1 833 929	0.38
OR	29%	28%	9%	31%	4%	0%	5 739 556	0.41
MT	30%	29%	9%	29%	4%	0%	1 569 802	0.43
NV	30%	29%	9%	29%	4%	0%	1 001 642	0.43
AK	4%	71%	0%	15%	0%	11%	3 197 284	0.56
AR	52%	17%	23%	5%	1%	1%	10 456 577	0.58
NM	41%	28%	6%	21%	2%	0%	4 059 306	0.59
HI	8%	0%	0%	1%	1%	90%	275 818	0.61
PA	63%	6%	28%	3%	0%	0%	2 518 265	0.63
VA	57%	15%	24%	2%	1%	0%	8 750 128	0.63
GA	57%	16%	25%	1%	1%	0%	32 163 724	0.64
LA	58%	13%	25%	2%	1%	0%	8 095 097	0.65
NC	58%	13%	25%	2%	1%	0%	20 034 717	0.65
SC	58%	13%	25%	2%	1%	0%	12 228 608	0.65
TN	58%	13%	25%	2%	1%	0%	60 745 486	0.65
AL	62%	15%	21%	2%	1%	0%	18 606 593	0.66
DE	64%	6%	29%	1%	0%	0%	1 868 907	0.66
MD	64%	6%	29%	1%	0%	0%	3 204 137	0.66
WV	64%	6%	29%	1%	0%	0%	88 588	0.66
MS	62%	13%	22%	2%	1%	0%	14 326 707	0.67
NJ	65%	5%	27%	1%	0%	1%	920 653	0.67
FL	52%	37%	6%	0%	0%	5%	36 930 371	0.69

State	Coal	Natural gas	Nuclear	Hydro	Renewable	Fuel oils	tons	tons/MWh
OH	66%	5%	25%	3%	0%	0%	12 082 511	0.69
NE	67%	2%	29%	1%	1%	0%	18 731 561	0.7
TX	42%	49%	8%	0%	1%	0%	57 134 533	0.7
IL	68%	10%	19%	2%	0%	0%	8 661 617	0.72
KY	75%	8%	15%	1%	0%	0%	24 037 188	0.74
OK	55%	40%	2%	0%	1%	0%	10 205 206	0.75
IN	80%	3%	16%	0%	0%	0%	14 971 888	0.77
SD	73%	5%	14%	4%	3%	0%	3 763 602	0.83
MI	76%	5%	18%	1%	0%	0%	9 973 411	0.84
AZ	82%	17%	0%	1%	0%	0%	26 752 985	0.87
CO	83%	14%	0%	2%	0%	0%	17 562 793	0.88
KS	76%	19%	2%	0%	1%	0%	10 196 564	0.88
MN	71%	8%	13%	4%	3%	0%	20 165 716	0.89
UT	99%	0%	0%	1%	0%	0%	5 039 077	0.9
IA	79%	4%	11%	3%	2%	0%	9 634 607	0.93
MO	89%	7%	1%	3%	0%	0%	23 013 560	0.94
WI	85%	3%	6%	3%	1%	0%	10 676 810	0.94
WY	97%	0%	0%	2%	0%	0%	5 455 304	0.98
ND	99%	0%	0%	0%	0%	0%	6 295 241	1.07

Table 5.2: Weighted fuel mix, retail sales and carbon emissions for COU, 2006. Source: EIA 2008c, 2007a,d. Table reproduced from Fischlein et al. (2009).

In total, 2006 electricity sales by COU are responsible for approximately 568 million tons of carbon emissions, equal to about a quarter of emissions generated by the electric power sector (EIA, 2008d) and 10 % of all U.S. CO_2 emissions (EIA, 2008b). This is roughly equivalent to the 2005 CO_2 emissions of the United Kingdom, the 7th largest CO_2 emitter in the world (World Resources Institute, 2008). Carbon emissions associated with COU sales also surpass energy-related greenhouse gas emissions of the U.S. chemical industry by 80 %, are two and a half times that of steel industry emissions and five times as large as paper industry emissions (Schipper, 2006).

Not only are these emissions too large to be systematically ignored by state or emerging federal policy, they are also of similar carbon intensity to the U.S. electric utility average. Overall, COU sales produced 0.64 tons of carbon dioxide emissions for every MWh sold in 2006, compared to 0.66 tons/MWh for the electric power sector in 2005, the last year for which carbon emission data is available (EIA, 2007b).

While average carbon intensity is not significantly different from the industry as a whole, the state by state analysis illuminates geographic differences. Tremendous variation exists among COU across states, both in carbon intensity and in the share of electricity sold within each state (Figure 5.2). The variation of carbon intensity across the states is dramatic, ranging from .068 tons CO_2/MWh in the state of Washington, where municipal utilities serve a third of all electricity demand, to 1.07 tons CO_2/MWh in North Dakota, where cooperatives sold 70 % of all electricity in 2006.

Within this context, it becomes apparent that a kWh saved or displaced in the most carbon intensive state is – from a greenhouse gas reduction perspective – worth more than a kWh in a less carbon intensive one. For example, approximately a ton of CO_2 is emitted for every MWh sold by COU in North Dakota, making it four times as carbon intensive as electricity produced in California. Thus, a California energy efficiency program targeting COU would need to save 4 kWh for every one saved in North Dakota. Dependent on the importance of the COU sector, RPS and energy efficiency policy standards could conceivably reduce greenhouse gases more in some states, and less in others. Sixteen states can be classified as having a high share of COU sales, which are also relatively carbon intensive (accounting for 42 % of all COU emissions). Only fifteen states can be classified as having COU sales that are both relatively minor (share of state energy sales below the median) and relatively clean (carbon intensity factor below the state median). Nonetheless, even these states will need to lower carbon emissions in order to achieve necessary levels of emissions reductions.

Overall, the 31 states that have no mandates for COU account for roughly 60 % of total COU retail sales (525 thousand GWh) and represent close to two-thirds of COU associated carbon emissions (365 million tons). This results in an average carbon intensity factor of 0.696 tons/MWh, higher than both the overall COU state average and the national utility average. In contrast, only seven states have enacted both renewable portfolio standards and

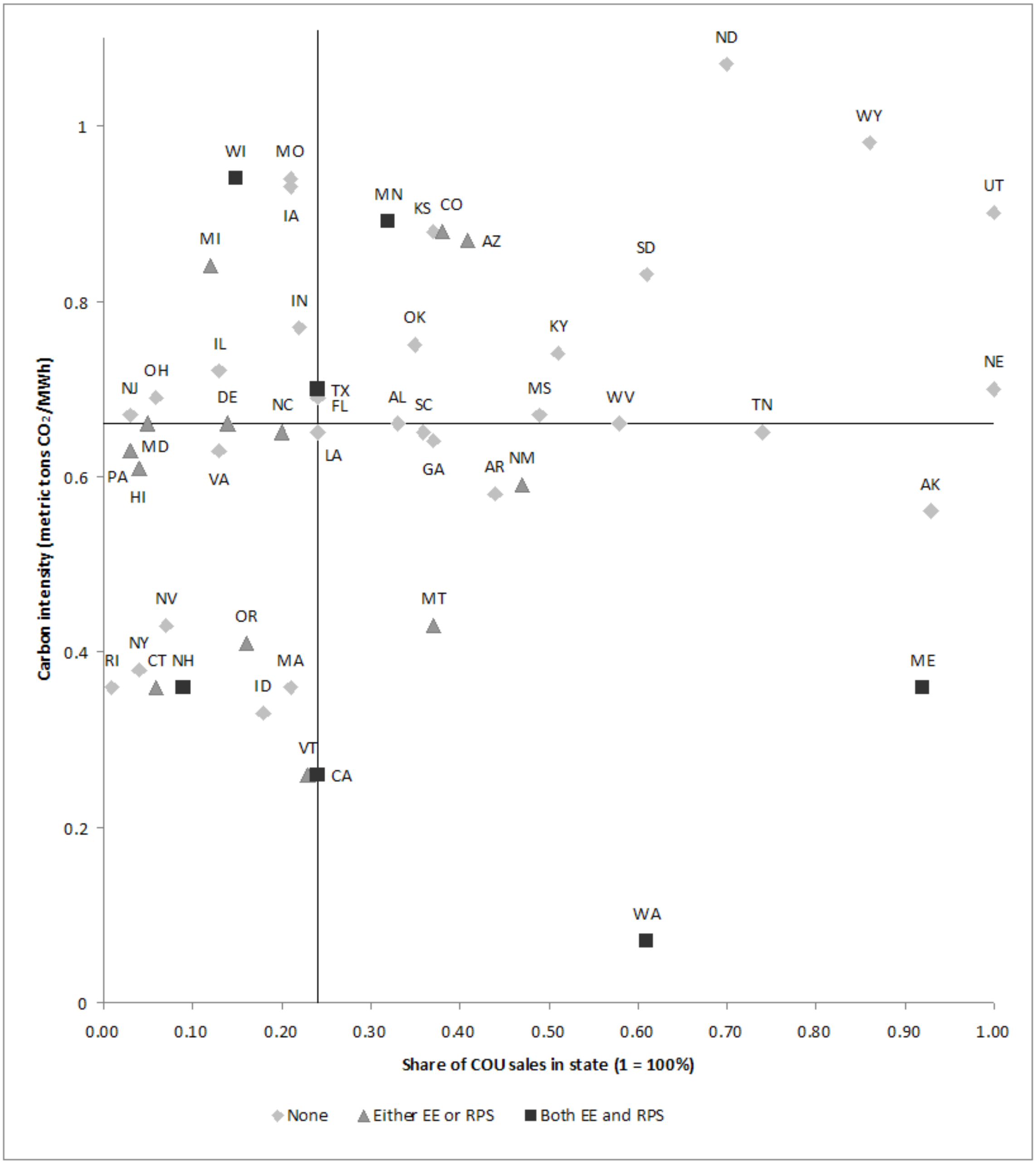

Figure 5.2: State by state carbon intensity and sales share of COU, 2006. Quadrants represent median splits on both variables. Figure reproduced from Fischlein et al. (2009).

energy efficiency legislation which include COU. While these states represent slightly more than a quarter of COU sales, their sales are significantly less carbon intensive - creating only 0.470 tons of CO_2 for every MWh sold. Significantly, only two states with relatively dirty COU sales - Minnesota and Wisconsin - count among this group.

In sum, with few exceptions, state-level policies that include COU are not situated in the states with the dirtiest COU sales, and/or the highest absolute COU sales. As a result, their current impact on COU emissions is limited. Broader, and potentially strategic inclusion of COU in these and other greenhouse gas reduction regulations could have a more significant effect. From a climate perspective, the importance of including COU varies significantly by state. Conversely, in states where COU hold a small share of the market, or where its fuel mix is relatively clean, state governments may be less inclined to spend the resources or political capital required to include COU, or require higher levels of compliance within existing policies, though it may be easier, politically, to do so.

5.3.3 Carbon scenarios: including consumer-owned utilities in renewable energy and energy efficiency policies

The long-term goal of any climate policy must be stabilization of atmospheric concentrations of greenhouse gases (IPCC, 2007). As CO_2 and other greenhouse gases are long-lived in the atmosphere, stabilization of atmospheric concentrations will require greenhouse gas emissions reductions of roughly 80 % by 2050 (Pacala and Socolow, 2004). While it is important to recognize the geographical distribution of COU carbon intensity, future emissions from COU should be analyzed within the context of a larger climate policy including both utility-based energy efficiency and renewable portfolio policies. Here, I develop a series of scenarios, incorporating COU load share and carbon intensity, state electric generation data, and electric sector growth to examine the implications of adopting varying degrees of energy efficiency and renewable energy policies for COU across all states. I estimate a business-as-usual case, as well as combinations of weak and strong renewable policies (15 % and 25 % renewables by 2030, respectively) and weak and strong energy efficiency policies (0.5 % and 1 % annual demand savings).

In developing the scenarios, I made several simplifying assumptions: 1) I assume no significant changes to fuel mix in the business as usual scenarios and the scenarios that include only energy efficiency; 2) I tie electricity demand growth to an EIA (2008b) projection of 1.1 % annual demand growth up to 2030; 3) all renewable generation scenarios assume renewables replacing coal power, with natural gas slightly increasing to counterbalance intermittency (+3 % in 2030). This last assumption represents the most favorable scenario from a carbon policy perspective, since replacement of the most carbon intensive fuels by renewables results in the largest emissions savings.

The national scenarios are based on three possible developments for conservation and three possible developments for renewable portfolio standards, resulting in nine scenarios.

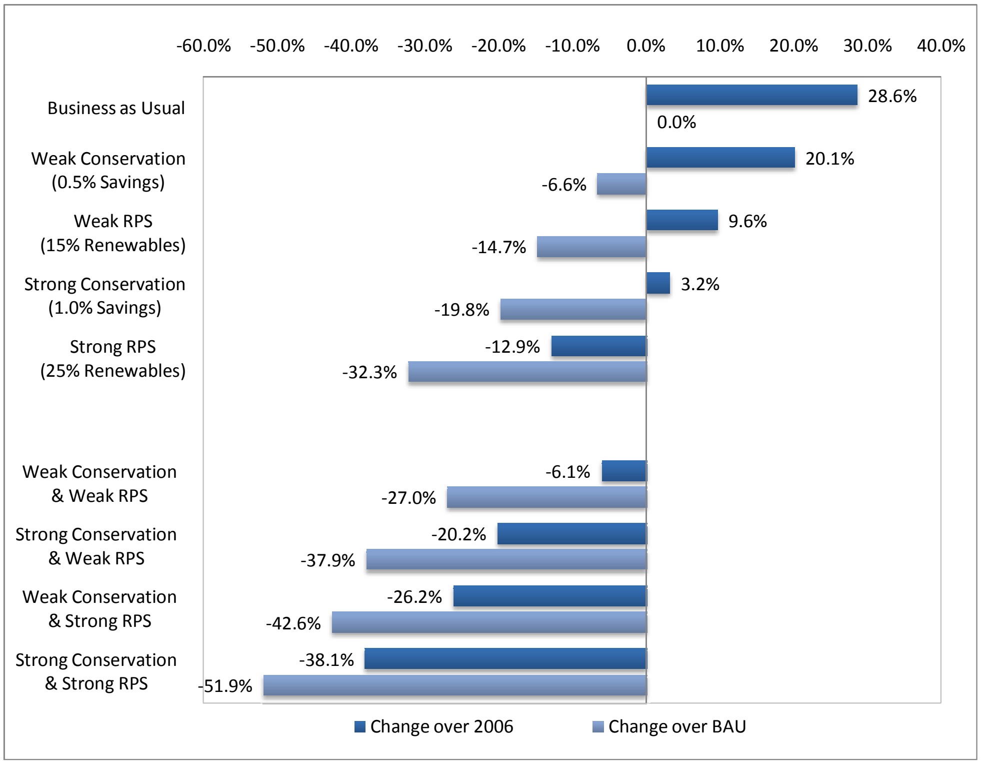

Figure 5.3: Carbon emission scenarios for COU, under different energy efficiency (EE) policies and renewable portfolio standards (RPS). The upper part of the figure shows effects of single policies at different stringency. The lower part shows effects of combined energy efficiency and renewable energy policies. Figure reproduced from Fischlein et al. (2009).

The reference case for conservation assumes a projected national growth rate of 1.1 % up to 2030. Based on typical conservation goals drawn from existing state regulations, 0.5 % and 1 % annual demand savings represent the low and high end of conservation efforts. I deduct these savings from the base growth rate to obtain the low and high energy efficiency scenarios. The reference case for renewable portfolio standards assumes business as usual, i.e., shares of renewable generation are unchanged in 2030. For the weak and strong renewable portfolio standard scenarios, I rely on typical goals set by existing RPS around the country: 15 % renewables in the weak RPS case and 25 % renewables in the high RPS case.

Percent change in carbon emissions associated with the COU sector meeting each policy scenario is presented in Figure 5.3. The business-as-usual scenario projects carbon emissions to be nearly 29 % larger in 2030 (730 million tons) than current 2006 levels (568 million tons). While each policy scenario in isolation provides reductions over business as usual, carbon emissions increase from 2006 levels under all but the most aggressive renewable portfolio standard. Under a strong renewable portfolio standard, without additional energy efficiency improvements, 2030 carbon emissions are estimated to reach 495 million tons, a 12.9 % reduction (73 million tons) over 2006 levels.

When renewable and energy efficiency policies are combined, carbon reductions become more meaningful. By adding energy efficiency to a strong renewable portfolio, the savings approach the deep emissions reductions necessary for atmospheric stabilization of greenhouse gases. Carbon reductions in 2030 more than double with the addition of a weak energy efficiency policy. Carbon emissions under this scenario are estimated to be 453 million tons in 2030. Coupling a strong RPS policy with a strong energy efficiency target results in 2030 estimated reductions of 216 million tons, less than two thirds of 2006 emissions.

Indeed, pursuing all available policies will be necessary for meaningful greenhouse gas reductions, particularly given the sensitivity of the above estimates to fuel substitution pathways and projected demand growth. I first explored the impact of a fuel substitution pathway where renewables replace natural gas instead of coal. Under this assumption, only the combination of strong renewable and strong energy efficiency policies would result in emissions reduction (16 % over 2006 levels). In all other renewables scenarios, emissions would increase, between 5 % and 28 % over 2006 levels. Structuring fuel replacement pathways therefore has to be an important part of renewable policies.

I also explored the impact of different demand growth rates. The EIA projection used in the analysis likely reflects some demand savings, meaning that the energy efficiency scenarios may underestimate actual demand growth. Based on historical data since 1990, electricity demand grew at an annualized rate of 1.92 percent (EIA, 2007b). A recalculation of the scenarios at this rate of growth results in 2030 business-as-usual carbon emissions of 1.047 billion tons, an 85 % increase over 2006 emissions. Even more striking is that under this demand growth assumption, only the most stringent RPS and energy efficiency policies examined provide any carbon emissions reduction in 2030 below 2006 levels, and only a meager 8.1 %. This demonstrates that the success of an RPS policy depends heavily on whether new renewable generation displaces current carbon intense sources, or simply satisfies new demand.

At the individual state level, the importance of pursuing a dual path of energy efficiency and renewable energy strategies for reducing carbon emissions varies greatly – driven primarily by the demand growth rate and the carbon-intensity of electricity sales. Between 1990 and 2007, annualized state-level electricity demand growth ranged from Washington's -.4 % to Nevada's 4.3 % (refer to Table 5.2). Notably, energy efficiency and RPS policies are not generally applied in states with high growth rates. Only eight states with above median growth rates have at least one of the policies. Four of the seven states that implement both policies for COU are both relatively clean and slow growing, meaning that the impact of these policies is likely small. I calculate the impacts of strong energy efficiency and strong RPS policy scenarios in four U.S. states – Arkansas, Massachusetts, North Dakota, and Wyoming (see Figure 5.4). The reference case for conservation assumes historical state growth rates for electricity demand calculated for the period 1990-2006 and extrapolates these rates up to 2030. These states provide examples of "high versus low carbon intensity"

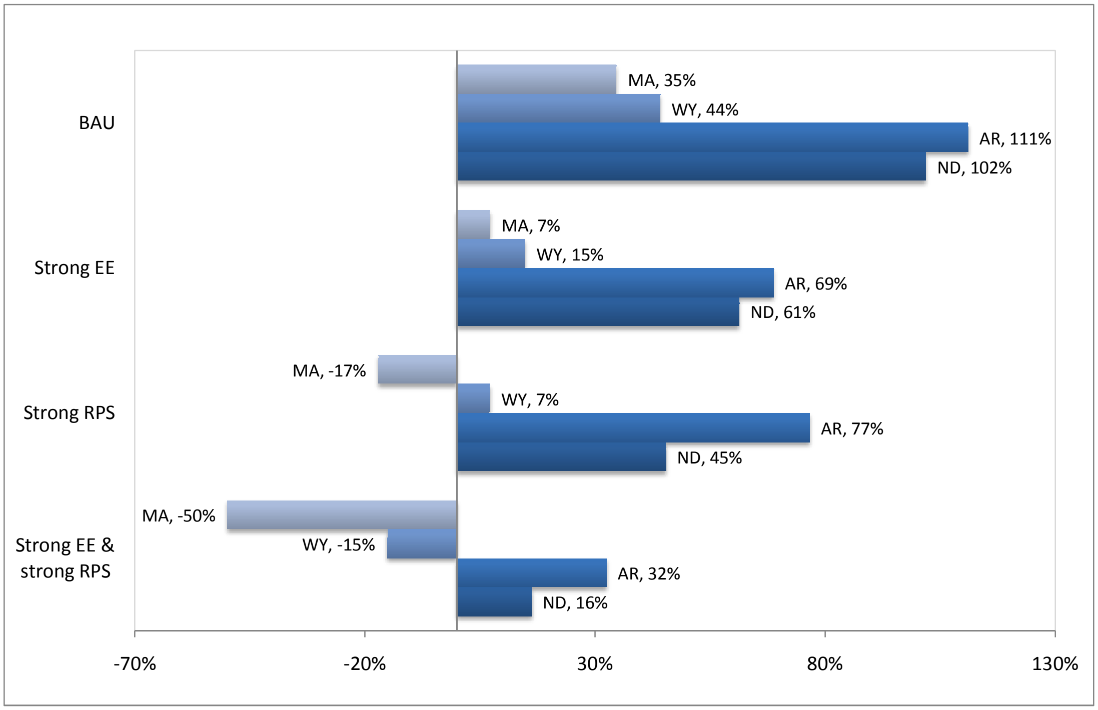

Figure 5.4: State comparisons of carbon emissions scenarios for COU (Change over 2006 base year). Fast demand growth: ND, AR. Slow demand growth: MA, WY. High carbon intensity: ND, WY. Low carbon intensity: AR, MA. Figure reproduced from Fischlein et al. (2009).

and "high versus low demand growth," for comparison. All COU in these states currently operate without energy efficiency or RPS mandates.

Under these conditions, even a combination of strong efficiency and renewable policies reduces emissions below 2006 levels in only the slow-growing states of Massachusetts and Wyoming, while fast-growing Arkansas and North Dakota continue to see emissions increases. As one might expect, where growth is low, additional renewable capacity can replace fossil fuel sources, as opposed to servicing new demand. In states with fast growing electricity demand, slowing growth rates through energy efficiency is an important first step towards keeping carbon emissions in check. In dirty states, RPS gains from replacing dirtier fossil fuels are potentially larger. In Wyoming and North Dakota, where COU sell highly carbon intensive power, implementing an RPS alone reduces emissions more than implementing only a strong energy efficiency policy. Arkansas and Massachusetts, with their relatively clean electricity sales, provide fewer absolute greenhouse gas emissions reductions for each kilowatt-hour saved or displaced, and the electric demand growth rate determines which policy in isolation is more effective. Slow-growing Massachusetts, for example, benefits more from an RPS, while emissions reduction potential is greater for energy efficiency in Arkansas, which is both clean and fast-growing.

Implementing these policies in fast-growing states, while most likely not contributing to absolute reductions over 2006, remains crucial to reduce overall sector CO_2 emissions. In fact, the state case studies suggest that reductions over business-as-usual trajectories may be larger in many high growth states. For example, North Dakota's emission reductions over business as usual projections are expected to be larger than those of Wyoming. Policy efficacy will certainly depend on potential interactions between growth rate, current carbon intensities and the pathways by which fuel sources are displaced or electricity sales are avoided. As new climate policies develop within states and at the national level, interaction among these policies will present new challenges. If the sector as a whole is to contribute significantly to greenhouse gas stabilization, energy efficiency goals must play a more prominent role in order to make the most of renewable energy's carbon reduction potential.

5.4 Discussion and Conclusion

As renewable and energy efficiency policies target distribution-level improvements, it is increasingly important to examine carbon impacts of retail sales. What does not get measured does not get managed. Therefore, the first order of business should be to include COU more completely in greenhouse gas reporting initiatives, and to track the origin of electric retail sales to accurately assess the most important levers for emissions reductions. This places greater emphasis on the role of COU in carbon management strategies. When thinking about carbon dioxide reduction from COU retail sales, it is helpful to differentiate between states where COU are particularly active, where their current generated and purchased power is particularly carbon intensive, and where electricity demand growth is particularly high. In short, where COU are located affects their carbon intensity and the absolute greenhouse gas reduction from any state or federal policy. Depending on COU location and power purchases, incorporating COU into state policies may result in small or large emissions reductions, but also creates models, and ultimately political pressure, for future federal action.

I estimate that the COU sector's electricity sales are similar in carbon intensity to the U.S. average. Thus, the 25 % share of retail sales held by COU accounts for roughly an equal share of total utility carbon emissions. While these estimates are not without their limitations given the static nature of the analysis and the uncertainties surrounding fuel mix developments (e.g., technical change, future role of nuclear energy, emergence of new generation technologies, disposition and substitution of existing capacity), this analysis represents an important first step towards assessing the carbon impact of this significant sector. It highlights the tremendous variation in COU carbon emissions (ranging from 19 thousand tons to 61 million tons) and intensity (ranging from .07 tons/MWh to 1.07 tons/MWh) across states. I aggregate these findings in calculating carbon scenarios associated with typical RPS and utility-based energy efficiency targets at the national level. Importantly, at an annualized growth rate of between 1 % and 2 %, a combination of only the most rigorous RPS and energy efficiency policies in practice today (applied across the entire COU sector) can begin to approach the deep reductions necessary to contribute meaningfully to climatic stabilization. Finally, I further explore these policy scenarios by examining their impact on four states without RPS or utility-based energy efficiency policies in place, specifically highlighting the urgent need to reduce demand growth from historic levels.

This analysis highlights that current state-level policies that include COU are not situated in the states with the dirtiest COU sales, the highest absolute COU sales, or the highest growth rates, limiting existing policy experience and effectiveness. The relative importance of these factors may require different policy approaches for COU, across ownership types and states. COU face obstacles unique to the universe of public power (Wilson et al., 2008). Their governance structure and small size play a role in the low penetration of utility-based energy efficiency and renewable generation, as does their special legal status when compared to investor-owned utilities. COU can have an interest in energy savings and alternative energy sources, as demonstrated by a growing number of COU running such programs. Nonetheless, many of them do not engage in these activities, in part because they are ruled by the imperative of least-cost electricity and may not have sufficiently factored the cost of carbon emissions into their future policy calculations. COU also have not faced the same pressures as investor-owned utilities. As they set their own rates, they have largely been insulated from rate case pressure and litigation from the environmental community. Absent these external drivers, few COU have pursued these policies on their own.

Despite these disincentives, the non-profit and customer-ownership model of these organizations seems reconcilable with the goal of carbon mitigation. To this end, programs must be tailored to COU in order to facilitate their engagement. Most importantly, this requires adapting policies to the realities of limited resource availability and know-how in small COU. Such modifications could affect how the federal Production Tax Incentives and rate making structures are implemented. At the state level, an important step toward engaging COU in carbon management is to provide the necessary information and financial incentives for their full participation, encourage aggregation of several utilities often adamant to conserve local control over their funds, develop training programs administered by state agencies or utility associations, and link new facility siting to renewable energy or energy efficiency requirements. COU demonstrate how even small individual actors within larger sectors of the economy can become important under a climate policy. Including COU in future greenhouse gas reduction policies will require a careful rethinking of traditional governance and regulatory structures for the electric sector, as well as restructuring of existing policies.

Chapter 6

Conclusion

This dissertation has attempted to elucidate the importance of policy design and scope. Underlying the three essays is the idea that policy design matters, and that evaluating individual policy characteristics more carefully and accurately is essential to understanding their effect on policy outcomes. Using as their empirical setting sustainable energy policies in the American states, with a focus on renewable portfolio standards (RPS), the three essays offer a method to classify policy characteristics, a quantitative study of policy outcomes, and a prospective estimation of the impact of policy scope extension.

The first essay (Chapter 3) provides a wealth of detail on RPS rules across U.S. states and situates them within the larger context of renewable energy markets. The in-depth content analysis is complemented by the development of a policy classification scheme that abstracts from the empirical setting and could also be applied to other types of policies. Examining RPS design under the angle of stringency of goals, discretion in means, and strength of the enforcement regime introduces a measure of comparability. The policy design literature identifies these three dimensions as central design aspects and they have been shown to affect policy outcomes in prior research. By combining all three elements, it is possible to describe the policy design aspects that can be expected to have the highest impact on outcomes.

From an empirical standpoint, the state-by-state comparison reveals that RPS are far more varied than apparent at first glance. Indeed, some of the states with the largest renewable goals introduce so many weakening measures that the factual goal appears to be much lower than stated. The differences in rules that govern compliance pathways affect the extent of discretion conceded to utilities, impacting both the difficulty and the cost of compliance. Likewise, the penalty regime is important to set appropriate sanctions and encourage compliance. In particular, this chapter highlights that a rigid focus on percentage goals and monolithic measures of policy strength detracts from understanding the actual impact of including certain design features in a policy.

Chapter 4 underlines this argument, by quantitatively relating the RPS design characteristics to organizational response. This section introduces the idea that it is not sufficient to characterize policy in terms of large policy types, i.e., flexible vs. direct regulation, but that most policies incorporate elements of both. The results show that both more stringent goals and, to some extent, increased discretion in means are associated with higher reported policy response. The results also demonstrate that assessing policies in more detail than is currently being done is essential to understanding their relationship with policy outcomes. The simplified comparison between direct and flexible regulation masks differences in policy outcomes. The policies assessed in this study - renewable portfolio standards - clearly vary in the strength of their goals and in enforcement, as well as in the amount of flexibility that is permitted.

This essay contributes to the theoretical development of the policy design field, by identifying and testing relationships between policy design elements and outcomes. It provides some support for theoretical models that predict superiority of flexible over direct regulation, since the majority of flexible design elements tested in this study are positively related to policy outcomes. However, the cross-sectional nature of the study limits the theoretical conclusions that can be drawn from it, as well as its practical implications. Nevertheless, this study develops a novel, more accurate way of measuring RPS outcomes and underlines the importance of policy design. The research design used is innovative, in that it accounts for the full complexity of RPS, in contrast to prior work that has mostly used dichotomous measures of policy presence or absence. It also improves upon prior measurement methods in this area, by measuring policy outcome at the organizational level. Thanks to an innovative data set based on RPS compliance reports, this method can account both for cross-state line electricity purchases and the attribution of renewable energy credits, providing an improvement over prior studies of RPS outcomes and a pathway for future analysis of this policy field.

The third essay in this dissertation (Chapter 5) focuses on a single design attribute, policy scope. In contrast to the first two chapters, this study is prospective in nature, developing future policy scenarios and assessing their potential impact on carbon emissions. It deals with a sector currently excluded from most state sustainable energy policies: consumer-owned utilities. To remediate the complete lack of emissions data on consumer-owned utilities, I develop a method to estimate their carbon intensity based on fuel mix of generation and purchases. In parallel with the previous chapter, I highlight the importance of calculating policy outcomes at the retail level. These entities receive little attention, but according to my estimates, their retail electricity sales produce a significant amount of greenhouse gases, roughly a quarter of all emissions from the electric utility sector.

The state-by-state estimation also permits to draw conclusions on regional carbon intensity and the potential for greenhouse gas reductions from any policy newly including these actors, which vary greatly across states. I aggregate these findings to develop future policy scenarios at the national level, calculating the evolution of carbon emissions associated with typical RPS and utility-based energy efficiency targets. I find that the electricity consumption growth rate is a key factor. Where consumption grows between 1 % and 2 % annually, even the most rigorous policies in practice today (applied across the entire COU sector) only begin to approach the deep emissions reductions necessary. Finally, I further explore these policy scenarios by examining their impact on four states without RPS or utility-based energy efficiency policies in place, again highlighting the urgent need to reduce demand growth from historic levels.

To the energy policy researcher, the myriad of state and local programs for sustainable energy extend both a challenge and an opportunity: a challenge, because the patchwork of policies, their mutual interactions and design intricacies make them a highly complex field of study; an opportunity, because policy experimentation at the sub-national level provides natural experiments that permit to hone in on the causal relationships between policy characteristics and outcomes, and deduce valuable lessons for future state and federal policies. In particular, this dissertation has presented evidence that policymakers, in the rush to move a policy proposition beyond the hurdle of adoption, would do well to pay more attention to individual policy characteristics. As with so many things, the devil is in the details.

Policymakers can design many aspects into a policy that make compliance easier, less costly or more flexible, while not compromising the overall goal. In turn, including certain design elements can be counter-productive to achieving the stated goal of a policy (in the case of RPS, to increase renewable energy sales), although it may serve other purposes. This dissertation has presented ample evidence of competing policy goals apparent in the design characteristics chosen by some states. Some design aspects that may provoke criticism when focusing on the central goal of a policy can appear in a very different light when considering alternative policy goals. Policymakers need to carefully consider which goals should take precedence, in order to avoid conflicting messages and counterproductive policy design. Additionally, the findings of this dissertation suggest that a policy can never be considered in isolation, because it may interact in unexpected ways with other policies and programs.

Likewise, managers should pay attention to policy design not only in the policy adoption stage, but also during its implementation. Flexible provisions, in particular, increase the discretion available to business organizations, and may provide opportunities to lower the cost of a policy. Business also has an interest in influencing implementation rules to provide a maximum of coordination among disparate state rules. Although the electricity sector is unique in that most states do not permit retail competition, policy design is also interesting from a competitive and reputational standpoint. Utilities can gain from certain provisions that rely on and improve direct relationships with customers and suppliers, e.g., distributed energy, solar panel installation.

The line of inquiry presented in this dissertation could be pursued to assess policy outcomes of other relevant energy and environmental policies, including international comparison. Additional analysis could focus on alternative measures of policy effectiveness, such as price development of tradable instruments. In addition, the patchwork of state policies in the renewable energy arena not only raises the question of their effectiveness in forcing technology deployment at the macro-level, but also of how implementation takes place at the micro-level.

Consequently, exploring the effect of policy design on the use of market instruments at the firm level represents a possible research area. Flexible environmental policies often give little guidance on how to achieve a target (i.e., for emissions) and organizational decisions about compliance pathways are not well understood although they determine the ultimate cost of policies to the consumer. Electric utility companies face a strategic decision under uncertainty when assembling their compliance mechanism. Developing renewable generation resources entails long term, capital intensive investments, requiring the development of capabilities outside the core competence of many utilities. In turn, buying renewable energy credits (REC) to satisfy state requirements for renewable energy may expose the utility to price volatility and other uncertainties associated with the REC market. Understanding the determinants of this compliance choice – and ultimately, boundary choice – has important implications for managers.

Examining policy design and outcomes at the organizational level opens up other fruitful areas of investigation. For instance, dissimilar organizations may react differently to policy design aspects. Organizational level analysis of policy design outcomes could integrate theories of organizational behavior to gain insights on how organizational structures and characteristics respond to certain types of incentives. Another interesting research question concerns managerial perception. It has been shown that perception of environmental issues shapes the choice of environmental strategies (Sharma, 2000; Sharma et al., 1999). In a similar vein, perceptions of policy uncertainty can influence how firms react to policies, both in the timing and the choice of strategies (Fuss et al., 2009; Meijer et al., 2007). Given these findings, it seems promising to explore whether perceptions of policies interact with design aspects to influence the choice of compliance strategy and the likelihood of compliance.

Another opportunity for future research involves a closer look at the institutions and functioning of renewable energy markets, including regional trading schemes for renewable energy credits. Renewable energy markets are small and segmented, and their functioning is further complicated by interactions with other policies. In particular, it is vital to understand the impacts of counting renewable energy towards future carbon emission reduction mechanisms.

Together, the three essays presented in this dissertation highlight the importance of examining policies in more detail, and of giving the utmost attention to policy design. They also draw attention to research design, and underline the importance of measuring policy outcomes at the level the policy targets. Overall, this policy research attempts to create an evidence-driven underpinning upon which future policy debates can build. It provides important insights on the outcomes associated with design elements and the complexity of deployment pathways. Policy design needs to be taken into account when attempting to assess possible impacts on policy effectiveness or making recommendations for adopting a policy.

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Appendix A

Glossary and Acronyms

Care has been taken in this dissertation to minimize the use of jargon and acronyms, but this cannot always be achieved. This appendix defines jargon terms in a glossary, and contains a table of acronyms and their meaning.

A.1 Glossary

- **Co-generation** – The combined production of heat (steam) and electrical power
- **Command & control** – An environmental policy that uses regulation (e.g., permits, quotas) instead of financial incentives
- **Distributed energy** – Small electric power sources that are operated and dispatched in a dispersed or decentralized manner
- **Feed-in tariff** – A renewable energy incentive policy that guarantues a premium payment on every unit of renewable energy produced
- **Flexible regulation** – A regulation that leaves discretion to businesses in achieving the goals of the regulation
- **Incentive-based regulation** – A regulation that employs market incentives to achieve its goals
- **Mandatory green pricing** – A policy that requires utilities to offer renewable energy to their customers on a voluntary basis
- **Production tax credit** – A federal incentive program that offers a tax credit for each unit of every unit of renewable energy produced
- **Public benefits fund** – A state fund that supports renewable energy, energy efficiency, and low-income energy assistance, often alimented by a surcharge (see *System benefits charge*) on electricity

- **Renewable portfolio standard** – A policy that specifies a goal for renewable electricity generation, usually expressed as a percentage of electricity sales (MWh) or as an absolute capacity goal (MW)
- **Renewable energy credit** – A certificate that incorporates the environmental benefits of renewable generation, and allows it to be traded separately from the physical unit of electricity
- **Second tier resource** – A renewable resource that can only be used for compliance with the renewable portfolio standard in restricted quantities
- **System benefits charge** – A small surcharge on electricity prices that aliments public benefits funds (see *Public benefits fund*)

A.2 Acronyms

Acronym	**Meaning**
ACP	Alternative Compliance Payment
CO_2	Carbon dioxide
BAT	Best Available Technology
DOE	U.S. Department of Energy
EIA	Energy Information Administration
EPA	Environmental Protection Agency
ERCOT	Electric Reliability Council of Texas
FERC	Federal Energy Regulatory Commission
GWh	Giga Watt-hour
kWh	kilo Watt-hour
MIRECS	Michigan Renewable Energy Certification System
MISO	Midwest Independent Transmission System Operator
MMBtu	Million British thermal units
M-RETS	Midwest Renewable Energy Tracking System
MW	Mega Watt
MWh	Mega Watt-hour
NARR	North American Renewables Registry
NEPOOL-GIS	New England Power Pool Generation Information System
NERC	North-American Electric Reliability Corporation
NGO	Non-Governmental Organization
NMISA	Northern Maine Independent System Administrator

Acronym	**Meaning**
NYISO	New York Independent System Operator
NYSERDA	New York State Energy Research and Development Authority
NO_x	Nitrogen oxide
PJM	Pennsylvania, New Jersey and Maryland Power Pool
PJM-GATS	Pennsylvania, New Jersey and Maryland Power Pool - Generation Attribute Tracking System
PTC	Production Tax Credit
PUC	Public Utility Commission
PURPA	Public Utility Regulatory Policies Act of 1978
RGGI	Regional Greenhouse Gas Initiative
RPS	Renewable Portfolio Standard
REC	Renewable Energy Credit
SME	Small and Medium Enterprises
SO_2	Sulfur dioxide
TWh	Terra-Watt-hour
WECC	Western Electricity Coordinating Council
WREGIS	Western Renewable Energy Generation Information System

Table A.1: Acronyms