Including Alternative Resources in State Renewable Portfolio Standards: Current Design and Implementation Experience

Jenny Heeter and Lori Bird

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Technical Report
NREL/TP-6A20-55979
November 2012

Contract No. DE-AC36-08GO28308

Including Alternative Resources in State Renewable Portfolio Standards: Current Design and Implementation Experience

Jenny Heeter and Lori Bird

Prepared under Task No. SAO9.3110

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, Colorado 80401
303-275-3000 • www.nrel.gov

Technical Report
NREL/TP-6A20-55979
November 2012

Contract No. DE-AC36-08GO28308

Available electronically at http://www.osti.gov/bridge

Available for a processing fee to U.S. Department of Energy
and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865.576.8401
fax: 865.576.5728
email: mailto:reports@adonis.osti.gov

Available for sale to the public, in paper, from:

U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/help/ordermethods.aspx

Cover Photos: (left to right) PIX 16416, PIX 17423, PIX 16560, PIX 17613, PIX 17436, PIX 17721

Printed on paper containing at least 50% wastepaper, including 10% post consumer waste.

Acknowledgments

This work was funded by the U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE). The authors wish to thank Steven Lindenberg, Linda Silverman, and the EERE technology programs for their support of this work. For their thoughtful review of the document, the authors thank Justin Barnes, North Carolina Solar Center; Warren Leon, Clean Energy States Alliance; and Jeffrey Logan, Robin Newmark, and Daniel Steinberg of NREL.

Table of Contents

List of Tables

List of Figures

1 Introduction

As of October 2012, 29 states, the District of Columbia, and Puerto Rico have instituted renewable portfolio standards (RPSs). An RPS sets a minimum threshold for how much electricity supply must come from renewable energy in a given year. Each state's RPS is unique, varying in percentage targets, timetables, and eligible resources.

This paper examines state experience with implementing renewable portfolio standards that include energy efficiency, thermal resources, and/or non-renewable energy (such as certain forms of coal, natural gas, or nuclear energy) and explores compliance experience, costs, and how states evaluate, measure, and verify energy efficiency savings and convert thermal energy to an electric equivalent. It aims to gain insights from the experience of states for possible federal clean energy policy as well as to share experience and lessons for state RPS implementation.

Increasingly, new RPS polices have included alternative resources. Alternative resources have included energy efficiency, thermal resources, and, to a lesser extent, non-renewables. Of the last six states to adopt an RPS (Michigan, Missouri, Ohio, Kansas, Indiana, and West Virginia), four (Michigan, Ohio, Indiana, and West Virginia) have included alternative resources, though Indiana's policy is voluntary. Often, policies that include alternative energy sources are referred to as Clean Energy Standards (CESs) or Alternative Energy Portfolio Standards (AEPSs) depending on the objective and included resources. In this paper, we categorize CESs and AEPSs as RPS policies that include alternative resources.

Over time, several states with existing RPSs have expanded or considered expanding eligible resources to include alternative resources. Wisconsin, for example, expanded the state RPS in 2010 to include non-electric sources that displace electricity (such as solar water heating and solar light pipe technology) as well as certain waste resources. In 2012, New Hampshire created a new carve out for thermal resources (S.B. 218).

A number of similar proposals in other states did not pass, but they indicate an interest in including alternative resources in RPS policies. A proposal in Illinois (HB2896) would have included synthetic gas and a proposal in Pennsylvania would have included natural gas in Pennsylvania's Tier II requirement, which currently includes waste coal, distributed generation, demand-side management, large-scale hydro, municipal solid waste, wood pulping and manufacturing byproducts, and integrated gasification combined cycle coal technology.

In addition to state actions to include more clean energy technologies, there has been consideration of a CES at the federal level. In 2011, President Obama announced in his State of the Union address that he wanted to see a CES of 80% by 2035. Under this proposal, clean energy sources would include wind and solar, as well as nuclear, clean coal, and natural gas.[1] Congressional action followed in March 2011, when Senators

[1] President Obama's speech did not define clean coal. Under Senator Bingaman's Clean Energy Standard Act of 2012, coal plants using carbon capture and sequestration technology could participate.

Bingaman and Murkowski circulated a white paper regarding a CES. The document outlined key elements of a standard and posed questions for public comment. President Obama mentioned a CES in his 2012 State of the Union address as well, and in February 2012, Senator Bingaman introduced the Clean Energy Standard Act of 2012, though Bingaman himself expressed uncertainty about whether the bill would gain traction (Restuccia 2012). A recent survey of U.S. citizens designed to determine their willingness to pay for an 80% CES by 2050 found that the average U.S. citizen would be willing to see an electric bill increase of 13% (Aldy et al. 2012), which is greater than some estimates of the proposed policy cost.[2]

Allowing for non-renewable resources in an RPS has the impact of lowering the required amount of renewable energy unless specific tiers or caps are implemented. In some cases, such as previous federal CES proposals, a higher target (e.g. 80%) is specified. Depending on policy structure and economics of other eligible resources, setting a higher target could drive more renewables than an RPS with a lower target.

Nadal (2006) suggests that if a combined approach is used, a floor on renewable energy use should be established. Otherwise, cheaper energy efficiency could dominate. The use of tiers or caps is common in state policy. Another approach, presented in the Clean Energy Standard Act of 2012, sets a "clean energy" target and gives partial credits to natural gas and coal technologies based on their carbon intensity. U.S. Energy Information Administration (EIA) analysis of the bill found that non-hydro renewable generation would increase to 13.3% of generation in 2035, compared to 9.5% of generation in 2035 in the reference scenario and 4.2% of generation in 2010 (EIA 2012).

The following sections of the paper explore state experience with the inclusion of efficiency and non-renewables in RPSs. We focus on how states have designed these policies and provide data on implementation experience to date, including estimates of how much these alternate technologies have been used in meeting policy targets and the relative cost where data are available.

[2] Aldy et al. (2012) cite one study Paul et al. (2011) which found that electric bill increases would be less than 5% for an 80% by 2030 CES. EIA analysis of the Clean Energy Standard Act of 2012 demonstrates that in 2035 household bills would be lower, due to the energy efficiency provisions included in the bill, even though electricity prices would be higher (Sandalow 2012).

2 Policy Background and State Experience

States have various reasons for adopting RPS policies. These include energy system goals, such as diversifying the electricity supply, environmental, economic, technology development, and administrative goals (CESA 2012). Some states may see including energy efficiency as an eligible resource as a way to address energy system and environmental goals, while others have chosen separate policies to ensure that energy efficiency and renewable energy are separately incentivized, thus not competing against each other. Generally if efficiency is included, policies need to include rigorous measurement and verification protocols to ensure achievement of energy and environmental goals.

Other states favor economic goals, such as using local resources. In such cases, those states may prefer to include non-renewables as eligible resources. Including local resources (non-renewables and renewables alike) can also be seen as a way to build public support for an RPS. Also, the inclusion of efficiency or other technologies may be seen as a way of reducing the implementation cost.

Figure 1 shows the states that have adopted an RPS with alternative resources, including various combinations of non-renewables, energy efficiency, combined heat and power (CHP)/cogeneration/waste heat, and solar water heat, solar space heat, and solar thermal process heat. For references to state statutes, see the Appendix.

Figure 1. Technologies covered in state policies

Sources: DSIRE 2012, Barnes 2011

Note: Thermal output will be eligible in New Hampshire as of January 1, 2013.

Each state RPS policy reflects the unique goals and resources of that state. In most cases, separate Energy Efficiency Resource Standard (EERS) policies complement state RPS policies. EERS policies set yearly energy efficiency targets or requirements for utilities. Many EERS policies were passed after states had already established RPS policies; 19 of 24 standalone EERS policies were passed between 2006 and 2010, in contrast, 21 of 30 RPS policies were passed prior to 2006. Having separate efficiency and renewable energy targets can ensure that both efficiency and renewable energy generation are implemented without having them compete against each other.

Table 1 provides an overview of state policies that include alternative resources. Seven RPS states – Delaware, Kansas, Missouri, Montana, New Jersey, Oregon, and Texas – do not include any of these technologies.

Table 1: Overview of State Policies

State	Energy Efficiency included in RPS	Separate EERS	Non-renewables included in RPS	Some form of non-electric solar thermal included in RPS*
Arizona		X		X
California		X		
Colorado		X		
Connecticut	X	X		X
Hawaii	X	X		X
Illinois		X		
Indiana (goal)	X	X	X	Not yet determined
Iowa		X		
Maine				X
Maryland		X		X
Massachusetts		X		
Michigan	X	X	X	X
Minnesota		X		
Nevada	X			X
New Hampshire				X
New Mexico		X		
New York		X		X
North Carolina	X			X
Ohio	X	X	X	X
Pennsylvania	X	X	X	X
Rhode Island		X		
Washington		X		X
Washington, D.C.				X
West Virginia	X		X	X
Wisconsin		X		X

* See Table 7 for which types of thermal technologies are eligible in each state.

Sources: ACEEE 2011, DSIRE 2012

All states that allow energy efficiency to contribute to an RPS, except West Virginia, use either a separate tier or cap on the amount of energy efficiency that can be used. Similarly, the amount of non-renewable energy (such as natural gas or certain types of coal resources) is capped in most policies: in Michigan, no more than 10% of the total requirement can be met with advanced clean energy credits; in Ohio, half of the total requirement must come from renewables; Pennsylvania established a separate tier for non-renewable resources. Only in West Virginia is there no maximum amount of non-renewable energy that can be used, though natural gas cannot be used to meet more than 10% of the total requirement.

Some federal RPS proposals have used a similar mechanism. For example, the American Energy and Security Act ("Waxman-Markey"), which passed the U.S. House of Representatives in 2009, allowed 25% of the standard to be met with energy efficiency (up to 40% if requested by a state). Senator Bingaman's American Clean Energy Leadership Act, introduced in 2009, took a similar approach.

At least one state that has allowed both efficiency and renewables to meet its RPS has shifted away from this approach. Hawaii instituted an RPS policy in 2004, and modified it in 2006 to include energy efficiency. The policy currently caps the energy efficiency contribution to the RPS at 25%. In 2015, energy efficiency will no longer be eligible for the RPS; instead, utilities will need to meet separate EERS requirements.

2.1 Inclusion of Non-Renewables in RPS

Four states have standards that allow for the inclusion of non-renewable resources, such as certain types of coal, natural gas, or nuclear energy.[3] Table 2 provides an overview of the various types of polices states have implemented.

Table 2: State CES Policy Overview

RPS + EE + Non-RE	Date Enacted	First Implementation Year	Restriction on Non-RE Use
Michigan	2008	2012	Advanced Clean Energy Credits and energy efficiency cannot be more than 10% of requirement combined.
Ohio	2009	2009 (renewables), 2025 (non-renewables)	A minimum 12.5% of 2024 requirement must be from RE. The other 12.5% can come from eligible non-RE.
Pennsylvania	2004	2007	A separate tier (Tier II) for non-RE exists; represents 10% of standard in 2021.
West Virginia	2009	2015	Natural gas cannot be used to meet more than 10% of the requirement.

CES policies all include some type of non-renewable resource, though eligible technologies vary (Table 3). Eligible coal technologies, for example, are restricted in Michigan to only coal-fired facilities that can capture and sequester 85% of CO_2 emissions. But West Virginia allows several types of coal technology, including advanced coal technology, IGCC technology, and new and existing waste coal (Table 3). West Virginia is also the only state that allows natural gas to contribute to its CES, though it is limited to 10% of the CES target.

[3] This paper does not address the use of fuel cells, which are allowed in some state RPSs, even if running on natural gas. For more on these issues, see CESA 2011.

Table 3. Eligible Non-Renewable Resources

	Coal	Other Non-Renewables	Nuclear	Natural Gas	Hydro (not included as RE)
Pennsylvania	New and existing waste coal; Integrated Gasification Combined Cycle (IGCC) technology	Wood pulping and manufacturing byproducts			Large scale hydro
Ohio	Clean coal	Fuel cells that generate electricity; advanced solid waste conversion technologies	Generation III advanced nuclear power		
Michigan	Coal-fired facilities that capture and sequester 85% of CO_2 emissions	Gasification			
West Virginia	New and existing waste coal; IGCC technology; advanced coal technology; fuel produced by coal gasification or liquification facility	Coal bed methane; tire-derived fuel; synthetic gas		Natural gas	Pumped storage hydro

Note: For detailed definitions of eligible resources, see state statutes: Pennsylvania 73 P.S. § 1648.1 et seq., Ohio ORC 4928.01(34), Michigan MCL § 460.1001 et seq., West Virginia W. Va. Code and §24-2F-1 et seq.

Experience with implementing policies that incorporate alternative clean energy sources has been limited; most of these policies were adopted in recent years and have not yet reached or are just beginning to reach their initial compliance years. Pennsylvania and Ohio began implementing their standards in 2007 and 2009, respectively. Ohio's CES is operating, but because there are no intermediate targets for the non-renewable portion of the RPS, there has been no activity in meeting the non-renewable requirements (Siegfried 2011). In Michigan and West Virginia, compliance periods begin in 2012 and 2015, respectively, so there is no implementation experience yet.

In Pennsylvania, utilities have been able to meet nearly all of the Tier I targets for renewables and Tier II targets for non-renewables (PA PUC 2011).[4] The Pennsylvania targets in reporting year 2010 (June 1, 2009 to May 31, 2010) were 2.5% for Tier I (renewable) and 4.2% for Tier II (waste coal, distributed generation, demand-side management, large-scale hydro, demand-side management, municipal solid waste, wood pulping and manufacturing byproducts, and integrated gasification combined cycle coal technology). Most utilities were able to meet Tier I and Tier II targets, and at a low price.

[4] In 2010, alternative compliance payments were made for 10 MWh of Tier I and Tier II obligations, out of an obligation of more than 2.2 million MWh.

In Ohio, state RPS legislation specifies annual targets for the renewable portion of the target, but no annual targets are specified for the non-renewable portion. Thus, while progress has been made towards the renewable portion, utilities have made little or no progress in achieving compliance with the non-renewable energy requirement.

Ohio's standard classifies CHP as non-renewable, but CHP is not being utilized. Senate Bill 315 would re-classify CHP as renewable, which could increase the incentive for CHP deployment by allowing it to satisfy RPS requirements. However, some parties have expressed concern that reclassifying CHP as a renewable could disadvantage future wind development in the state. The Sierra Club has suggested leaving CHP in its current classification, but to establish incremental targets for non-renewable portions of the RPS; the American Wind Energy Association also supports this approach, but has taken the position that adding CHP to the in-state (main tier) requirement and increasing its size would be more politically feasible (Haugen 2012). A separate law, passed in April 2012, allowed one particular CHP facility to count toward the renewable portion of the RPS.

In West Virginia, utilities filed compliance plans in January 2011. American Electric Power and Allegheny Power provide 99% of retail sales to the state, and their compliance plans indicate that no new renewable generation capacity would be required through 2025 (RAP and C2ES 2011). American Electric Power intends to use wind from existing power purchase agreements, company owned hydroelectric and pumped storage facility generation, existing and planned natural gas generation, advanced coal technology, energy efficiency and demand response programs, and existing coal generation that uses supercritical technology (PSC WV 2011a). Allegheny Power has stated that it plans to use existing facilities, but may use existing supercritical units and new energy efficiency and demand-side management programs if needed[5] (PSC WV 2011b).

2.2 Inclusion of Energy Efficiency in RPS

Eight states include energy efficiency as an eligible resource in their RPS policies. Each state that allows for non-renewable contributions (Michigan, Ohio, Pennsylvania, West Virginia) also allows for energy efficiency. In addition, Connecticut, Hawaii, Nevada, and North Carolina allow energy efficiency (but not non-renewables) to contribute to RPS targets (Table 4), but cap the contribution that energy efficiency can make to RPS compliance.[6]

It should be noted that some states with an RPS that includes only renewable energy sources have a separate EERS.[7] While EERS policies can stand alone, they do impact RPS implementation. If a state's RPS target requires a percentage of total electricity sales to come from renewable energy, reducing the amount of total electricity sales through an EERS will subsequently reduce the amount of renewable energy needed for compliance.

---

[5] Ownership of credits from three PURPA facilities is being disputed at the West Virginia Public Service Commission.

[6] Cooperative and municipal utilities in North Carolina are exempted from the cap on energy efficiency; there is no limit to how much energy efficiency they could use to meet RPS compliance.

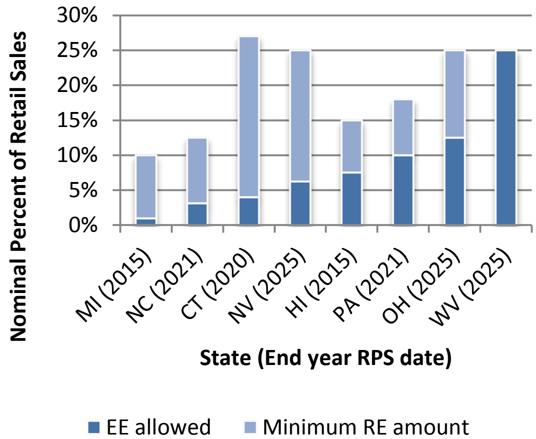
While some literature (Brown et al. 2007, Nadal 2006) compares combined and separate EERSs, this paper focuses on state experience with combined efficiency and renewable standards—when energy efficiency is incorporated into an RPS policy. In both policy cases, the issue of evaluation, measurement, and verification of energy efficiency is critical.

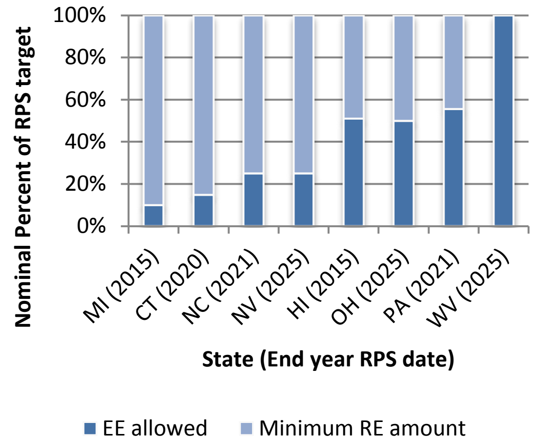
Table 4. RPS States Allowing Energy Efficiency

RPS + EE	Date Enacted	Year Implemented	Restriction on EE Use
Connecticut	1998	2006	Separate tier for EE, represents ~29% of RPS in 2010, ~15% in 2020.
Hawaii	2001	2010	≤50% of RPS through 2015
Nevada	1997	2005	≤25% of RPS
North Carolina	2007	2012*	≤25% of RPS (IOUs); Coops and municipals have no restriction.
States that also allow non-RE			
Michigan	2008	2012	Advanced Clean Energy Credits and energy efficiency combined cannot exceed 10% of requirement
Ohio	2009	2009 (renewables) 2025 (non-renewables)	≤50% of RPS
Pennsylvania	2004	2007	Separate tier for EE, represents ~63% of RPS in 2010, ~55% of RPS in 2021.
West Virginia	2009	2015	No restriction.

* 2010 for solar carve-out.

Including energy efficiency in an RPS target will lower the effective amount of renewable energy that must be procured if energy efficiency is not capped. With the exception of West Virginia, states that allow energy efficiency cap the level of energy efficiency. Capping the level of energy efficiency at a certain percentage ensures that both renewable energy and energy efficiency are utilized and provides a level of certainty to market participants. Figures 2a and 2b show that energy efficiency limits range from 10% to about 50% of the RPS target. West Virginia puts no limit on the amount of RPS-qualifying energy efficiency.





Figures 2a and 2b. Energy efficiency maximum percentage of RPS target allowed

We examined the amount of energy efficiency used to meet RPS targets, where data were available, and found that utilities are typically using as much energy efficiency as allowed (Figure 3). This indicates that specifying the maximum amount of energy efficiency is an important policy component. Over time, the amount of energy efficiency used to contribute to RPS polices has increased, as targets are increasing and additional states are beginning their first compliance years.

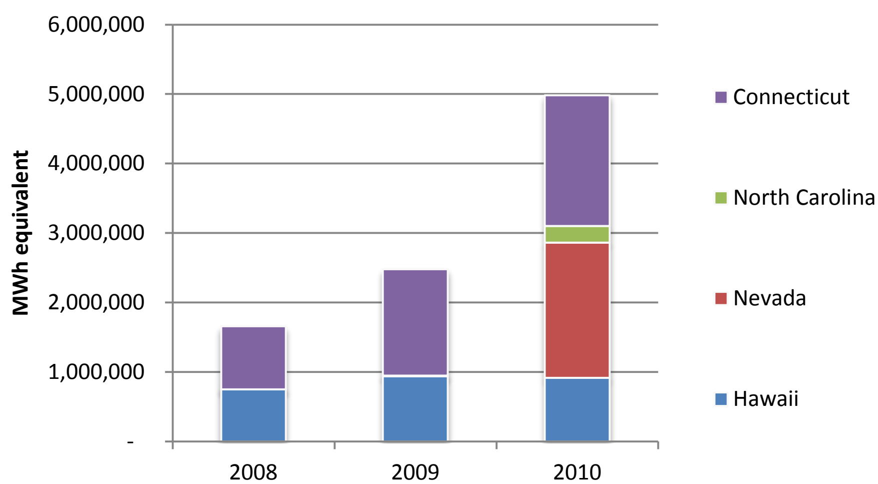


Figure 3. Amount of energy efficiency used by states in RPS policies

Sources: Hawaii Public Utilities Commission 2011, NEPOOL-GIS 2012, NV PUC 2011, NC-RETS 2012

Hawaii, Nevada, and Pennsylvania all met or exceeded their maximum allowed amount of energy efficiency and/or non-renewables (Table 5). In Connecticut, no compliance report has been issued, however, data from the NEPOOL-GIS system (the credit tracking system for the Northeast) show that approximately 20% of the certificates issued were from energy efficiency, compared to an allowable amount of approximately 29%. It is possible that Connecticut utilities have sufficient carry-over to reach the maximum threshold for energy efficiency use. In 2010, Connecticut generated the equivalent of 1.9 million MWh from conservation and load management and CHP facilities.

Nevada used the equivalent of 1.9 million MWh of energy efficiency, and Hawaii used more than the equivalent of 0.9 million MWh of energy efficiency. In Hawaii and Nevada, utilities have been allowed to carry over excess energy efficiency for use in future compliance years. North Carolina has not yet begun compliance; however, some utilities in the state began generating energy efficiency credits in 2010. Pennsylvania's Tier II has been growing over time, reaching 1.4 million MWh in 2010.

Table 5. Amount of Energy Efficiency or Alternative Energy Used for Compliance in 2010

State	Amount of Alternative Energy in 2010 (MWh)	Total RPS Compliance Obligation in 2010 (MWh)	Percent of RPS Target from Alternative Energy
Connecticut[a]	1,882,000 MWh	10,005,000 MWh	~20% of total registered certificates (less than allowable ~29%)
Hawaii[b]	916,420 MWh	1,001,000 MWh	~92% of target (exceeded allowable 50%)
Nevada	1,944,000 MWh	3,382,000 MWh	~57% of target (exceeded allowable 25%)
Pennsylvania	1,387,000 MWh (non-RE)	2,218,000 MWh	~63% of target (matched allowable)

[a] Connecticut has not issued a compliance report. However, certificates registered in NEPOOL GIS provide a preliminary estimate of the magnitude of EE being used.
[b] HECO includes 788,249 MWh of energy efficiency that was installed before 2010.

In 2006, the state of Washington passed an RPS that includes an energy efficiency target that is separate from the renewable target. In contrast to other state policies, which set specific targets for the amount of energy efficiency required, Washington requires qualifying utilities to pursue all available conservation that is cost-effective, reliable, and feasible. The Washington Utilities and Transportation Commission (WUTC) oversees utilities' energy conservation efforts, reviewing the development of conservation potential assessments, conservation savings, and the cost effectiveness of conservation acquisition. WUTC conservation estimates for 2011 are detailed in Table 6.

Table 6. 2011 Annual Conservation Plan for WA Utilities

Company	aMW*	Electric Budget (Million $)
Avista	6.9	15.0
Pacific Power & Light	4.2	8.6
Puget Sound Energy	38.8	90.8
Total	**49.9**	**114.4**

* aMW is an "average MW" – a measure of continuous capacity equivalent (i.e., operating at a 100% capacity factor).

Source: Washington Utilities and Transportation Commission 2012

Overall, available data from states indicates that efficiency is generally being fully utilized to meet targets up to the level of the cap. In some cases, excess efficiency has been implemented and can be banked for use in future years. For this reason, the level of the cap on efficiency is an important element of the policy design of a CES. Another important consideration is the type of efficiency that can be included and how well it is measured and verified (discussed in more detail in section 3.3).

2.3 Inclusion of Thermal Technologies in RPS

All 29 RPS states and Washington, D.C. allow for solar thermal electric, such as concentrating solar power, to contribute, but fewer states allow for purely thermal resources. Because solar thermal electric technologies produce electricity rather than thermal energy, their integration into an RPS policy is straightforward. States determine metering requirements for thermal, then use a conversion factor to calculate an electrical equivalent (kWh) from thermal energy (Btus).

Purely thermal technologies are allowed to some extent in RPS polices. Solar water heat is allowed by 10 jurisdictions, and solar space heat and solar thermal process heat are allowed by 7 jurisdictions (Table 7). Finally, combined heat and power (CHP), cogeneration, or energy recovery is eligible in 13 states, though some states place restrictions on what types are eligible. For example, in Arizona, only thermal energy produced by a qualifying renewable resource, which also offsets electricity use, is eligible.

Table 7: Eligible Thermal Resources

	Solar water heat	Solar space heat	Solar thermal process heat	CHP/ Cogeneration/ Waste heat
Arizona	D	D	D	D,R
Connecticut				X
Washington, D.C.	X	X	X	
Hawaii	D	D	D	D,R
Maine				X
Maryland	X			
Michigan				X
Nevada	X	X	X	X
New Hampshire[a]	X			
New York	X			D
North Carolina	X	X	X	X
Ohio				D
Pennsylvania[b]	X	X	X	X
Washington				X
West Virginia				X
Wisconsin	D	D	D	D,R

Notes:
D = thermal energy which displaces electricity generally qualifies
R = only renewable heat qualifies
[a] Thermal output will be eligible in New Hampshire as of January 1, 2013.
[b] In Pennsylvania, solar resources that do not produce electricity fall under Tier II – Demand Side Management.

Sources: Barnes 2011, DSIRE 2012

Solar thermal resources are being used to meet compliance primarily in Hawaii, North Carolina, and Washington, D.C., though even in those jurisdictions, use is limited.

In the PJM territory, which covers the Mid-Atlantic region of the U.S., as of January 2012, 285 solar thermal projects were registered, with a generation capacity equivalent of 1.5 MW. Solar thermal projects are located primarily in the District of Columbia, Maryland, North Carolina, Pennsylvania, Virginia, and West Virginia.

As of May 7, 2012, in North Carolina, 67 solar thermal projects (equivalent to 9 MW) were registered, compared to 154 solar PV projects (57 MW). In 2011, about 5,100 MWh of solar thermal credits were issued in the state's tracking system, compared to more than 52,500 MWh of solar PV, and a total of 2.1 million MWh of renewable credits (NC-RETS 2012).

In 2010, Hawaii was the second largest state market for solar water heating, with 285 thousand square feet installed (SEIA/GTM 2011). Hawaiian Electric Company (HECO), the state's largest utility, breaks down the amount of solar water heating that has been used to meet the RPS in its annual compliance reports. HECO claimed 172,056 MWh of solar water heating, primarily through a rebate offered by the Hawaii Energy Efficiency Program, representing 9% of the renewable or efficiency MWhs that HECO generated in 2010 (Figure 4).

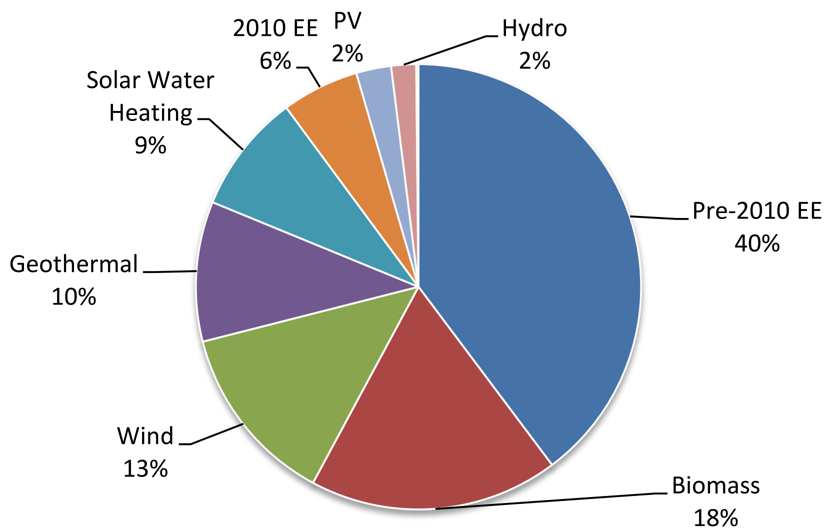


Figure 4. RPS MWh claimed in Hawaii by source, 2010

Source: HECO 2011

Connecticut provides the only publically available data on how sources such as CHP or cogeneration have been used to meet RPSs. Connecticut has a separate RPS tier (Tier III) for CHP and conservation and load management. Originally, some stakeholders expressed concern over the ability for CHP to swamp Tier III obligations, leaving little room for conservation and load management programs. In 2008, Tier III obligations were 607,598 MWh (CT DPUC 2011), with one eligible CHP facility estimated to produce 175,000 MWh per year (Friedman et al. 2008). In fact, in 2008, about 14% of the credits issued through NEPOOL GIS for Connecticut's Tier III standard were from CHP, though it is unclear how many facilities these credits are from.[8] In 2009 and 2010, the CHP share of Total Tier III credits increased to 35% and 34%, respectively (NEPOOL-GIS 2012). The conversion of thermal energy to an electrical equivalent is discussed in Section 3.4.

Overall, available state data shows limited adoption of thermal technologies to meet RPS targets where they are eligible, although several states have documented some use of solar thermal projects.[9] Limited data on the use of CHP exists, but it has been shown to meet about one-third of the energy efficiency tier in Connecticut (NEPOOL-GIS 2012); states including CHP in a separate tier may want to evaluate the mix of CHP and other forms of energy efficiency.

---

[8] NEPOOL GIS tracks the number of credits issued each calendar year. These credits may or may not be used for compliance in the year that they were created. For example, in 2008, only 610,000 credits were required for Tier III, but more than 900,000 Tier III credits were issued.

9 In the future, New Hampshire's thermal tier, which begins in 2013, will support a large amount of biomass thermal resources.

3 Impacts of Including Additional Resources in an RPS

Including non-renewable, energy efficiency, and/or thermal resources in an RPS does not come without challenges. While costs may be less than for renewable electricity, for energy efficiency particularly, evaluation, measurement, and verification are important, as the level of savings must be estimated rather than read from a meter, as with renewable technologies. Tracking energy efficiency, non-renewables, and thermal resources can be done in existing regional REC tracking systems, though it adds complexity. Including non-electric thermal resources requires additional specifications for the conversion of the energy produced to an electrical equivalent.

3.1 Cost Impacts

In this section we explore available data on the relative cost of efficiency and renewable generation in meeting an RPS. Data on the relative costs incurred in implementation are important for policymakers seeking to design, implement, and evaluate combined policies.

Studies have generally found that energy efficiency is relatively low cost and that costs would be less than for procuring renewable energy. However, none of the studies that we identified evaluated actual implementation costs of combined efficiency and renewable standards.

For example, McKinsey's (2010) greenhouse gas abatement cost curve lists many energy efficiency measures, such as residential lighting and appliances and new building efficiency, as having a negative abatement cost. Cappers and Goldman (2010) modeled the financial impact of various energy efficiency business models on ratepayers. In all scenarios, moderate and aggressive energy efficiency implementation reduced total ratepayer bills (Cappers and Goldman 2010).

In another study, the Edison Foundation (2012) found that electric efficiency through utility instituted programs was achieved at $43/MWh equivalent in 2010. When load control programs were not included, savings were achieved at an average cost of $35/MWh equivalent (Edison Foundation 2012).

Further, ACEEE (2009) examined the average program costs of energy efficiency in 14 states, finding that utility costs ranged from $16/MWh to $33/MWh, with an average of $25/MWh (Figure 5). These costs include program incentives, planning, delivery, marketing, evaluation, and administrative costs, but do not include the cost a customer might pay when taking advantage of an incentive program. Though the savings presented in Figure 5 are not specifically used to meet RPS requirements, the data demonstrate that energy efficiency costs vary by state.

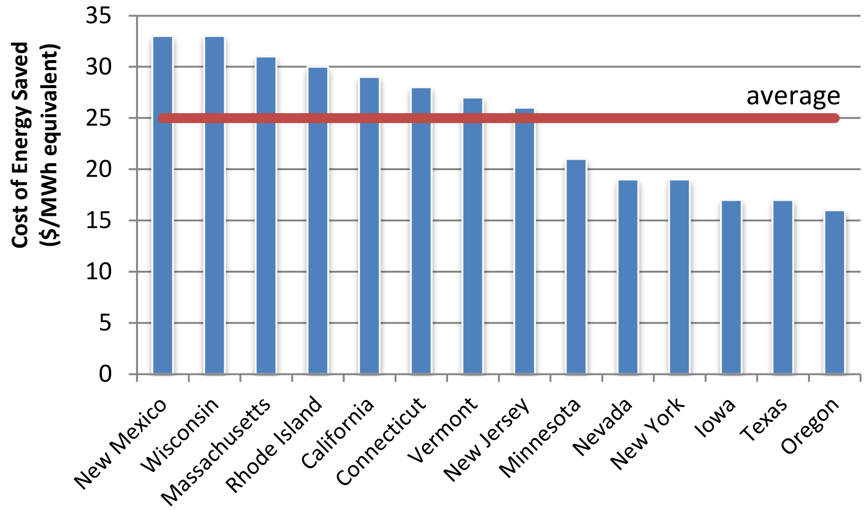


Figure 5. Average program costs of saved energy

Source: ACEEE 2009

We reviewed state RPS compliance reports and other available data to assess actual costs of procuring efficiency and renewables in meeting RPS targets.[10] Table 9 presents the limited publically available cost information for alternative resources used to meet state RPS obligations. Estimates of the costs of efficiency for RPS compliance are available for only two states – Connecticut and Michigan. The costs reported for Pennsylvania are for a wide range of non-renewable generation sources and efficiency that are eligible Tier II resources for compliance with the state RPS.

Table 9. Prices for Alternative Technologies

State	Mechanism	Price	Metric
Connecticut	Energy efficiency	$10-$25/MWh	Price of energy efficiency credits (EECs) within CT's energy efficiency tier, 3/2009-6/2012
Michigan	Energy efficiency	$15.82/MWh	Weighted average energy optimization cost
Pennsylvania	Non-renewables	Weighted average price ($0.32/MWh), range ($0.01-$1.75/MWh)	Tier II credit pricing

Note: Credit pricing does not reflect the life-cycle cost of renewable energy.

Sources: Spectron Group 2012, MPSC 2012, PA PUC 2012

[10] The cost to procure energy efficiency credits is based in part on supply/demand dynamics. It may not reflect the program cost of energy efficiency.

In Connecticut, Tier III credits (energy efficiency credits, or EECs) have historically seen credit prices at least slightly lower than Tier I renewable energy certificates (RECs) (Figure 6). Prices tracked closely in 2009 and 2010 but in 2011 this trend began to end. By mid-2012, Tier I RECs increased up to nearly $50/MWh, while EECs remained in the $10/MWh range. Presumably the increase in Tier I pricing is due to a shortage of eligible renewable supply.

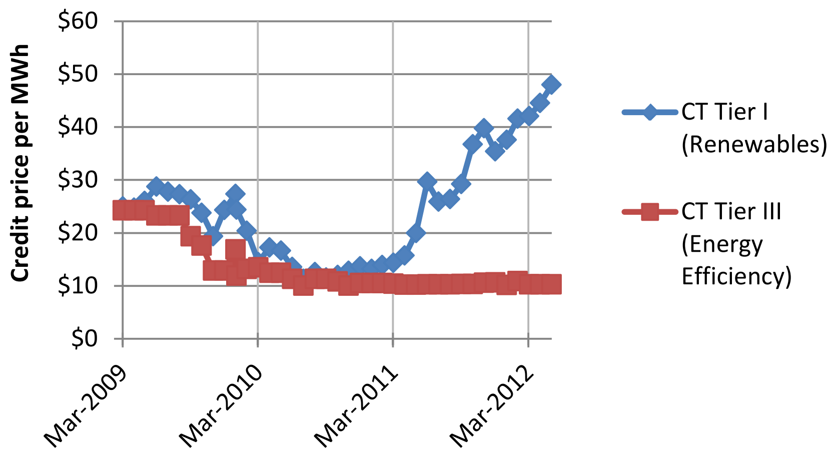


Figure 6. Efficiency and renewable credit trading prices in Connecticut

Source: Spectron 2012; indicative pricing only

The Michigan Public Utilities Commission (PUC) has estimated the relative costs of efficiency and renewables needed for RPS compliance. The PUC is required to examine the cost effectiveness of the state's RPS by comparing lifecycle costs of new conventional coal plants to renewables and energy efficiency. As part of this report, the PUC determines the "energy optimization cost," which is the "life cycle levelized cost of conserved energy of the largest electric providers, weighted by the life cycle savings in MWh over the most recent planning period (MPSC 2012)." In its 2012 report, the Michigan PUC found that the weighted average energy optimization cost of conserved energy was $15.82/MWh, compared to a life cycle cost of $91.19/MWh for renewable energy.[11] In contrast to REC pricing, the Michigan cost estimates reflect the full cost of generating the renewable energy; not the premium above conventional generation costs. The life cycle cost of renewable energy is calculated based on contracts submitted to the PUC for approval, weighted by the estimated production over the life cycle of the agreement.

When examining costs in Pennsylvania specifically, by looking at published data from the PUC, renewable energy (Tier I) was more expensive than the state's Tier II resources

[11] For comparison of levelized costs, the Energy Information Administration's Annual Energy Outlook 2011 uses a 2016 levelized cost of new on-shore wind of $97/MWh ($2009). See http://205.254.135.24/oiaf/aeo/pdf/2016levelized_costs_aeo2011.pdf.

(waste coal, distributed generation systems, demand-side management, large-scale hydro, municipal solid waste, wood pulping and manufacturing byproducts, and integrated gasification combined cycle coal technology). Tier I average weighted price of certificates in the 2009-2010 compliance period was \$4.77/MWh, compared to \$0.32/MWh for Tier II resources (PA PUC 2012).

In a number of states, estimates of the above-market costs of renewable energy used for RPS compliance are available from prices in REC markets. RECs, which represent only the non-energy attributes of renewable energy or typically the above-market cost of the renewables compared to other generation sources, by comparison to the weighted average optimization cost of renewable energy, have been selling for less than \$50/MWh in most markets. Figure 7 presents REC pricing for 2008 through 2012. These data are from a REC broker and used for indicative purposes only.

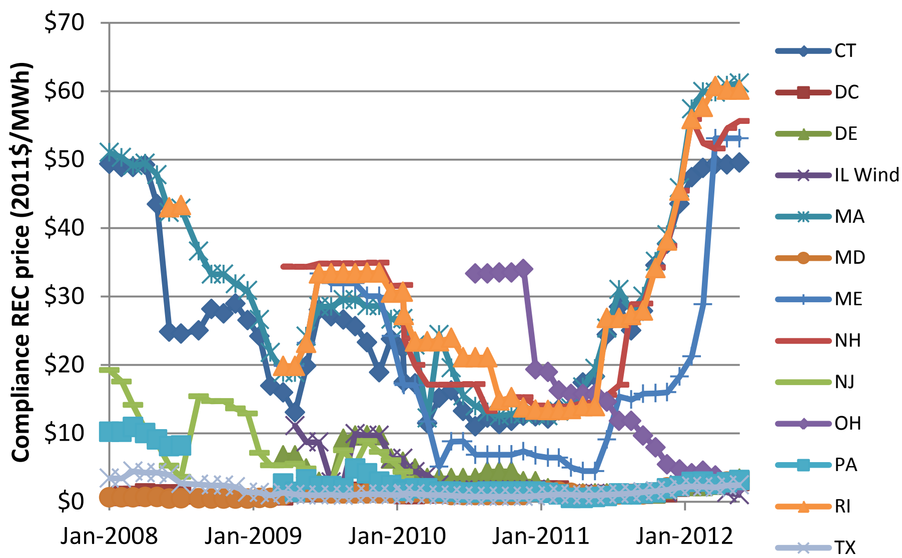


Figure 7. Compliance market (primary tier) REC prices, January 2008 to June 2012

Source: Spectron Group 2012; indicative pricing only

The cost of thermal resources per MWh is more challenging to determine, because the calculation will depend on how long the thermal system produces and whether it is displacing natural gas or electric heating. According to one solar hot water installer, installed costs run about \$110-\$140/square foot, with average commercial systems of 40 square feet having a total cost of \$4,500 to \$6,000. The cost per MWh depends on the cost of capital, lease terms or asset life, and insurance and maintenance costs.

While we were able to obtain only a limited amount of data on actual costs of using efficiency to meet RPS targets, the data show some variation. For example, in Connecticut, credit trading prices for efficiency and renewables have tracked closely over some periods. Whereas, in Michigan, estimates show efficiency costs to be substantially lower than renewable energy costs. The question of relative compliance costs is an important one for policymakers considering combined policies and further examination of data available in the future may be warranted.

3.2 Evaluation, Measurement and Verification of Energy Efficiency

While renewable energy is fairly easy to measure and verify, typically through the use of a meter, the evaluation, measurement and verification (EM&V) process for energy efficiency programs is less straight forward. EM&V determine how much of an energy efficiency program's savings is due to the program alone, rather than effects of external sources, like the weather (ACEEE 2012). Programs often use a combination of deemed savings values, engineering calculations, and direct measurement (WRI 2008). According to the State Energy Efficiency Action Network (2011), EM&V methods are "sometimes seen as expensive, not credible, not timely, not transparent, a burden, not a benefit." Proper implementation of EM&V measures is critical for effective implementation of an RPS includes energy efficiency. If protocols are not rigorous, then the inclusion of efficiency may displace renewable generation without an equivalent reduction in electricity use. This, in turn, will reduce the overall effectiveness of the policy in achieving environmental or energy goals. The U.S. Department of Energy has gathered feedback from program administrators, PUCs, utilities, evaluators, and others in order to develop a uniform protocol for determining energy savings (DOE 2012).

Each state currently determines a unique EM&V approach, commonly through the development of a state-specific technical reference manual. Approaches vary by state to meet the needs of state regulatory bodies; states with more aggressive energy efficiency targets and incentives may require more rigorous and more expensive EM&V (Shiller et al. 2011). Messenger et al. (2010) documented the approach of a select number of states. While Messenger et al. (2010) examined the protocols used to evaluate ratepayer-funded energy efficiency programs, not energy efficiency used in state RPSs, the study's lessons on EM&V are broadly applicable. Of the states examined, three states (California, New York, and Wisconsin) developed their own EM&V protocol, requiring use of specific methods to evaluate impacts; two states (Florida and Iowa) rely on the International Performance Measurement and Verification Protocol; and eight states (California, Connecticut, Massachusetts, Maine, Minnesota, New York, Texas, and Wisconsin) developed a technical reference manual (also referred to as a standard energy efficiency measure database).

Looking at states that include energy efficiency in an RPS policy, we found that Connecticut and Pennsylvania have developed their own technical reference manuals, and Michigan's efforts to develop a manual are underway. In Connecticut, energy efficiency programs are run through the Connecticut Energy Efficiency Fund (CEEF). The CEEF develops a program savings documentation (PSD), which serves as a technical reference manual that the Department of Public Utility Control (now the Public Utilities Regulatory Authority) determined must be used by utilities when documenting Class III (energy efficiency) credits. The PSD shows "energy efficiency impacts of installations as well as realization rates, which include persistence and free ridership (CT DPUC 2007)." In addition, the CEEF has third-party evaluators perform impact evaluations on a regular basis (CEEF 2011). Pennsylvania adopted a revised technical reference manual in May 2009 that addresses how demand-side management will be addressed under its RPS. The manual is updated on an annual basis. In Michigan, efforts to develop a technical reference manual are underway; the state's first compliance year is 2012.

The effectiveness of efficiency targets is highly dependent on the level of rigor in EM&V protocols. Without rigorous procedures, utilities could over-estimate the level of energy efficiency deployed. If combined renewable and efficiency targets are used, over-estimating the contribution of efficiency would reduce the level of renewable energy required to meet the overall target.

3.3 Alternative Energy Credit Tracking

Including a variety of resources in an RPS can create some additional challenges with respect to tracking compliance. Most states use electronic tracking systems to track utility compliance with the RPS. In these electronic databases, each MWh of renewable energy generation is given a unique serial number, and can be transferred among account holders and retired to demonstrate compliance with state policy (ETNNA n.d.). Tracking systems typically serve a specific region (generally aligned with wholesale power markets), though some states (e.g. Michigan, North Carolina, Nevada) have developed their own tracking systems. Figure 8 shows regional tracking markets in the United States. A national system, the North American Renewables Registry, serves areas not already covered by a regional tracking system.

If states allow non-renewable resources to meet their RPS, they must determine how to track compliance. Generally, regional tracking systems can be modified to track those resources or the state can develop its own tracking system – either electronic or otherwise.

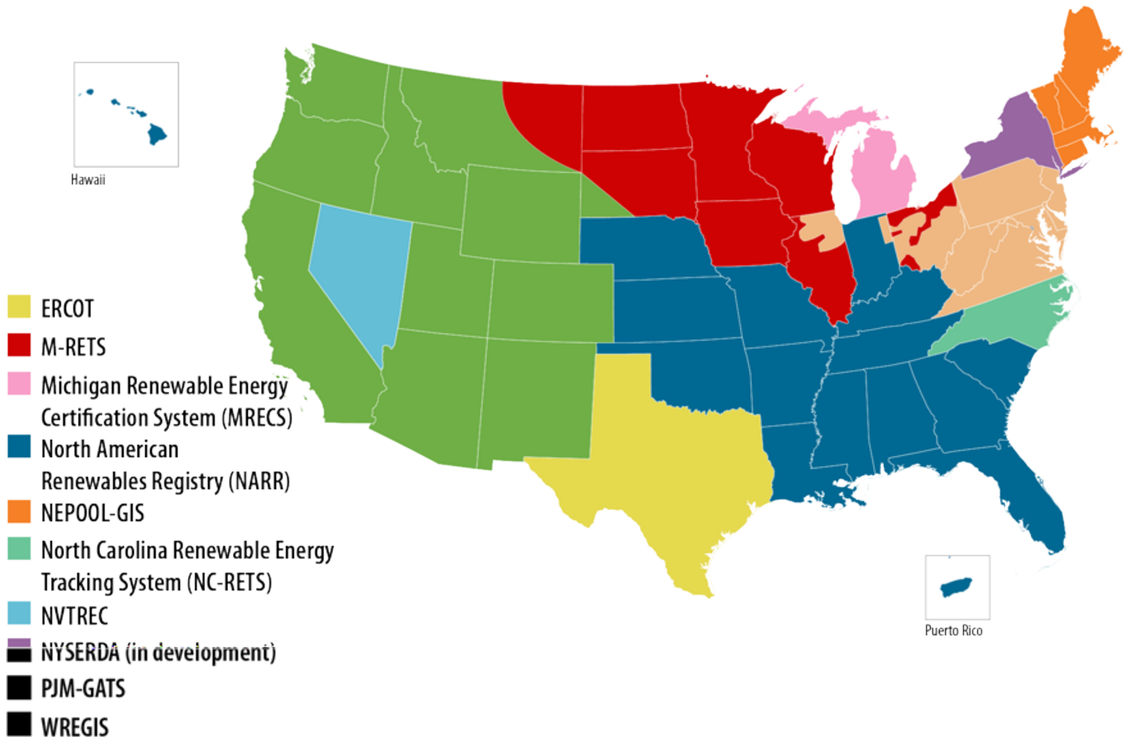


Figure 8: Regional tracking systems in the United States

Note: NAR covers states and provinces not covered by an NYSE Blue tracking system; Nevada uses both NVTREC and WREGIS.

Many states have developed or are developing credit tracking systems to track alternative resources and RPS compliance. The same tracking systems used to track renewables can be used to track EECs, non-renewable, and thermal resources. Connecticut, Michigan, North Carolina, Ohio, and Pennsylvania use tracking systems to account for energy efficiency, while in Hawaii and Nevada, utilities report energy efficiency savings directly to the PUC. Similarly, Michigan, Ohio, and Pennsylvania use tracking systems to account for non-renewable resources. West Virginia's legislation directs the PUC to establish a system of tradable credits to establish, verify, and monitor compliance, though a system has not yet been established as of August 2012. Table 10 describes how states are tracking energy efficiency and non-renewable energy.

Table 10. Tracking Mechanisms Used by States

State	Energy Efficiency Credit Tracking	Non-Renewable Credit Tracking
CT	NEPOOL GIS	N/A
HI	Reporting to PUC	N/A
MI	MIRECS	MIRECS
NV	Reporting to PUC	N/A
NC	NC-RETS	N/A
OH	PJM-GATS and M-RETS	PJM-GATS and M-RETS
PA	PJM-GATS	PJM-GATS
WV	To be determined	To be determined

N/A = not applicable
Notes: In Nevada, renewable energy is tracked through the Nevada Tracks Renewable Energy Credits (NVTRECs) system, but energy efficiency is not included in NVTRECs. Energy efficiency measures are tracked by utilities and reported directly to the Nevada Public Utilities Commission as part of the utility's compliance report.
Connecticut does not need to track non-renewable credits, but the NEPOOL-GIS tracking system does track all energy resource types (e.g. coal, natural gas, nuclear).

While tracking alternative generation sources adds complexity to the tracking needed for compliance, states have generally been able to modify existing tracking systems to do so. Most states have opted to track non-renewables and efficiency within the electronic tracking systems used for renewable tracking, although two states have opted to have efficiency reported directly to the PUC for compliance and verification.

3.4 Thermal Energy Conversion

Thermal energy resources require additional specification in order to be used in RPS policies. Key considerations include: how to measure the actual energy used or displaced, whether the thermal resource is displacing electric heating or a fuel such as natural gas, and how to convert the used or displaced energy into an electrical equivalent.

First, it is possible that the capacity of a thermal generation system will be greater than the amount of actual output utilized. For example, with solar water heating, if the sun is shining but the water heater is already at the correct temperature, no additional thermal output is utilized. States can take this into account by only crediting the actual output utilized toward RPS targets. Metering can be required. In North Carolina, useful thermal energy must be either metered or calculated using an industry-accepted means, which is subject to audit. In Washington, D.C., the output of thermal systems is used. Residential systems may use the Solar Rating and Certification Corporation's estimated annual performance of OG-300 certified systems, but commercial systems must be metered. In Hawaii, a public benefits fee administrator provides a rebate for solar water heating systems. Utilities are able to take credit for the number of rebates issued, multiplied by the estimated savings per system, which is based on a periodic evaluation of the rebate program (HECO 2011). The U.S. EPA's Heat Meter Standard Initiative has submitted a heat meter standard proposal for accreditation. A national heat meter standard would ensure that the benefits of thermal energy are accurately calculated, and could promote a "quality market for heat meter products" (Critchfield 2012).

Second, thermal output must be converted to electric equivalent (MWh). Converting non-electric thermal output into a measure equivalent to MWh is done using a conversion factor of 3,412,000 British thermal units (Btus) to 1 MWh. North Carolina, Washington, and Washington, D.C. specify this conversion rate in statute. Other states use the same formula, but do not specify it in statute.

4 Conclusions

State RPS policies adopted in recent years have included or expanded eligibility for non-renewables. Four states allow for non-renewable resources: Michigan, Ohio, Pennsylvania, and West Virginia, and each of those states plus Connecticut, Hawaii, Nevada, and North Carolina allow energy efficiency measures to contribute to the state RPS.

In order to ensure that certain sectors do not overwhelm renewables goals, nearly all states allowing RPS contributions from energy efficiency or non-renewable sources provide a separate tier or cap on the amount that these alternative sources can contribute. Energy efficiency levels are often capped at 25% or less of total RPS compliance, with some caps at higher levels. Non-renewable energy levels are typically capped at lower percentages, such as 10%. Capping these sectors creates certainty for industries involved with meeting RPSs.

State experience demonstrates that where allowed, non-renewables and energy efficiency are being heavily utilized. States are typically maximizing allowable energy efficiency. Some states have even exceeded the cap and are banking excess energy efficiency savings for use in future years. Because many states have been maximizing the use of efficiency or non-renewables in reaching targets, the level of the cap is an important policy design element that warrants thoughtful consideration.

Another important design feature for policies that combine efficiency and renewable generation is verification. Because of the challenges in estimating the actual reduction in energy usage resulting from efficiency measures, displacing renewable generation with efficiency offers some risk of undermining the effectiveness of the policy, unless proper verification is implemented. If rigorous protocols are not used, then obligated entities may over-estimate the level of energy efficiency used to meet compliance. If this were to occur, renewable energy generation would not be able to contribute as much to meeting a combined standard. Thus, rigorous protocols for measuring and verifying efficiency savings are essential for achieving environmental and energy goals of combined standards.

Literature shows that the cost of efficiency should be less than for renewable generation in many locations, but actual data on the costs of using efficiency and renewables to meet RPS targets were available in only a very small number of states. At least one state (Connecticut) showed fairly comparable efficiency and renewable costs for a substantial period of time based on tradable credit prices. However, a credit price comparison does not fully capture the avoided generation costs of efficiency. Another state (Michigan) estimated a substantially lower cost for efficiency. The actual cost differential for implementing efficiency and renewables is an important consideration for policymakers seeking to design similar policies, and further investigation of these costs is warranted as more data become available. The cost of appropriately evaluating, measuring and verifying efficiency may also warrant additional investigation.

Experience implementing RPSs with non-renewables to date is limited, but Pennsylvania and West Virginia demonstrate that non-renewable energy targets are on track to meet requirements. In Pennsylvania, the non-renewable resource tier has consistently traded at low prices and ample supplies have been available. In a number of states, non-electric thermal resources are allowed (all RPSs allow electric thermal resources), but uptake has generally been limited. A key issue for the inclusion of thermal resources is the determination of metering requirements; states may choose to require the metering of actual utilized thermal output rather than total thermal output.

States have generally been able to modify state or regional electronic tracking systems to track efficiency and non-renewables. Typically this has not affected regional trading where implemented. However, a few states, such as Hawaii and Nevada, have opted to have utilities report energy efficiency directly to the state's public utility commission.

Overall, states have had limited experience with implementing clean energy standards or renewable energy standards that incorporate efficiency and non-renewables. Nevertheless, experience to date suggests that when these technologies are eligible to meet policy targets, they are often heavily utilized. Therefore, careful consideration of caps and resources eligibility is warranted. Because most states have only several years or less of experience with these policies, future investigation of the implementation of these policies may yield additional insights on relative costs and other factors.

Appendix. State Statutes Specifying Alternative Resources

State RPS statutes are listed below. Additional resources on state RPS policies can be found DSIRE (www.dsireusa.org).

Arizona: AAC R14-2-1801 et seq.
http://www.azsos.gov/PUBLIC_SERVICES/Title_14/14-02.htm#ARTICLE_18

Connecticut: Conn. Gen. Stat. § 16-245a et seq.
http://www.cga.ct.gov/current/pub/chap283.htm#Sec16-245a.htm

Hawaii: HRS § 269-91 et seq. http://www.capitol.hawaii.gov/hrscurrent/Vol05_Ch0261-0319/HRS0269/HRS_0269-0091.HTM

Indiana: IC 8-1-37. http://www.in.gov/legislative/ic/code/title8/ar1/ch37.html

Maine: 35-A M.R.S. § 3210. http://janus.state.me.us/legis/statutes/35-A/title35-Asec3210.html

Maryland: Md. Public Utility Companies Code § 7-701 et seq.
http://mlis.state.md.us/asp/web_statutes.asp?gpu&7-701

Michigan: MCL § 460.1001 et seq.
http://www.legislature.mi.gov/%28S%28d4sw3j45qm5wazabiezg4t3i%29%29/mileg.aspx?page=getObject&objectName=mcl-Act-295-of-2008

Nevada: NRS 704.7801 et seq. http://www.leg.state.nv.us/nrs/NRS-704.html#NRS704Sec7801

New Hampshire: New Hampshire Statutes, Chapter 362-F.
http://www.gencourt.state.nh.us/rsa/html/NHTOC/NHTOC-XXXIV-362-F.htm

New York: NY PSC Order, Case 03-E-0188.
http://www3.dps.ny.gov/pscweb/WebFileRoom.nsf/Web/85D8CCC6A42DB86F85256F1900533518/$File/301.03e0188.RPS.pdf?OpenElement

North Carolina: N.C. Gen. Stat. § 62-133.8.
http://www.ncga.state.nc.us/EnactedLegislation/Statutes/HTML/BySection/Chapter_62/GS_62-133.8.html

Ohio: ORC 4928.64 et seq. http://codes.ohio.gov/orc/4928.64

Pennsylvania: 73 P.S. § 1648.1 et seq.
http://www.dsireusa.org/documents/Incentives/PA06Ra.htm

Texas: Texas Utilities Code § 39.904.
http://www.statutes.legis.state.tx.us/Docs/UT/htm/UT.39.htm#39.904

Washington: RCW 19.285 - Energy Independence Act.
http://apps.leg.wa.gov/RCW/default.aspx?cite=19.285

West Virginia: W. Va. Code and §24-2F-1 et seq.
http://www.legis.state.wv.us/WVCODE/ChapterEntire.cfm?chap=24&art=2F

Wisconsin: Wis. Stat. § 196.378.
http://nxt.legis.state.wi.us/nxt/gateway.dll?f=templates&fn=default.htm&vid=WI:Default&d=stats&jd=ch.%20196

References

American Council for an Energy-Efficient Economy (ACEEE). (2012). Evaluation, Measurement and Verification (EM&V). www.aceee.org/topics/emv. Accessed October 5, 2012.

ACEEE. (2011). State Energy Efficiency Resource (EERS) Activity. http://aceee.org/files/pdf/policy-brief/State%20EERS%20Summary%20October%202011.pdf. Accessed October 2, 2012.

ACEEE. (2009). Saving Energy Cost-Effectively: A National Review of the Cost of Energy Saved through Utility-Sector Energy Efficiency Programs.

Aldy, J.E., Kotchen, M.J., and A.A. Leiserowitz. (2012). Willingness to pay and political support for a US national clean energy standard. Nature Climate Change. Advanced Online Publication. May 13. doi:10.1038/nclimate1527

Barnes, J. (2011). E-mail communication. North Carolina Solar Center. Raleigh, NC. December 16, 2011.

Brown, M.A., York, D., and M. Kushler. (2007). Reduced Emissions and Lower Costs: Combining Renewable Energy and Energy Efficiency into a Sustainable Energy Portfolio Standard. The Electricity Journal. Volume 20, Issue 4. May. p. 62-72. doi:10.1016/j.tej.2007.03.005

Cappers, P. and C. Goldman. (2010). Financial impact of energy efficiency under a federal combined efficiency and renewable electricity standards: Case study of a Kansas “super utility”. Energy Policy. 38. p. 3998-4010. doi:10.1016/j.enpol.2010.03.024

Clean Energy States Alliance (CESA). (2012). Designing the Right RPS: A Guide to Selecting Goals and Program Options for a Renewable Portfolio Standard. http://www.cleanenergystates.org/ assets/2012-Files/RPS/CESA-RPS-Goals-and-Program-Design-Report-March-2012.pdf. Accessed October 5, 2012.

CESA. (2011). Fuel Cells: Briefing Papers for State Policymakers. http://www.cleanenergystates.org/assets/2011-Files/Hydrogen-and-Fuel-Cells/CESA-Fuel-Cells-Brifing-Papers-for-State-Policymakers-Aug2.pdf. Accessed September 12, 2012.

Consortium for Energy Efficiency (CEE). (2011) State of the Efficiency Program Industry. http://www.cee1.org/files/2011%20CEE%20Annual%20Industry%20Report.pdf. Accessed October 5, 2012.

Connecticut Department of Public Utility Control (CT DPUC) (2011). Annual review of Connecticut electric suppliers’ and electric distribution companies’ compliance with Connecticut’s renewable energy portfolio standards in the year 2008. http://www.dpuc.state.ct.us/electric.nsf/$FormRenewableEnergyView?OpenForm. Accessed March 27, 2012.

CT DPUC (2007). DPUC Review of CL&P and UI Conservation and Load Management Plan for year 2007 and 2008. Docket No. 06-10-02. May 23. http://www.dpuc.state.ct.us/electric.nsf/60a3df2c610b4cd6852575b3005ce06c/7ffc4cb5809da9ed8525730d0050bd2c?OpenDocument. Accessed March 27, 2012.

Connecticut Energy Efficiency Fund (CEEF) (2011). Connecticut's Investment in Energy Efficiency: 2010 Report of the Energy Efficiency Board. http://www.ctenergyinfo.com/2010%20Annual%20Legislative%20Report%20Final(1).pdf. Accessed March 27, 2011.

Critchfield, J. (2012). The Development of a U.S. Heat Meter Standard. Webinar for the Clean Energy States Alliance Members and State-Federal RPS Collaborative. U.S. EPA. March 30. http://www.cleanenergystates.org/assets/event-presentations/March-30-Solar-Thermal-Combined-Presentations.pdf. Accessed September 12, 2012.

Database for State Incentives for Renewables & Efficiency (DSIRE). (2012). Rules, Regulations & Policies. http://www.dsireusa.org/incentives/index.cfm?EE=1&RE=1&SPV=0&ST=0&searchtype=RPS&sh=1. Accessed March 27, 2012.

Department of Energy (DOE). (2012). Uniform Methods Project: Protocols Development. Improving EM&V for Energy Efficiency Programs. http://www.nrel.gov/docs/fy12osti/54945.pdf. Accessed October 5, 2012.

Edison Foundation (2012). Summary of Ratepayer-Funded Electricity Efficiency Impacts, Budgets, and Expenditures. http://www.edisonfoundation.net/iee/Documents/IEE_CEE2011_FINAL_update.pdf. Accessed October 5, 2012.

Energy Information Agency (EIA). (2012). Analysis of the Clean Energy Standard Act of 2012. May. http://www.eia.gov/analysis/requests/bces12/pdf/cesbing.pdf. Accessed May 14, 2012.

Environmental Tracking Network of North America (ETNNA) (n.d.). REC Questions & Answers. http://etnna.org/images/PDFs/ETNNA-REC-QandA.pdf. Accessed March 27, 2012.

Friedman, B., Bird, L., Barbose, G. (2009). Energy Savings Certificate Markets: Opportunities and Implementation Barriers. NREL Report No. CP-6A2-45970. http://www.nrel.gov/docs/fy09osti/45970.pdf. Accessed March 27, 2012.

Haugen, D. (2012). "Ohio could pit cogeneration against wind farms." Midwest Energy News. April 13. Accessed May 16, 2012.

Hawaiian Electric Company (HECO) (2011). 2010 Renewable Portfolio Standard Status Report. May 26. Docket No. 2007-0008. http://www.heco.com/vcmcontent/StaticFiles/pdf/2010_rps.pdf. Accessed March 27, 2012.

Hawaii Public Utilities Commission. (2011). Renewable Portfolio Standards Law Examination. Docket No. 2007-0008.

McKinsey (2010). Impact of the financial crisis on carbon economics: Version 2.1 of the Global Greenhouse Gas Abatement Cost Curve. http://www.mckinsey.com/en/Client_Service/Sustainability/Latest_thinking/~/media/McKinsey/dotcom/client_service/Sustainability/cost%20curve%20PDFs/ImpactFinancialCrisisCarbonEconomicsGHGcostcurveV21.ashx. Accessed March 27, 2012.

Messenger, M., R. Bharvirkar, B. Golemboski, C.A. Goldman, S. Schiller. (2010). Review of Evaluation, Measurement and Verification Approaches Used to Estimate the Load Impacts and Effectiveness of Energy Efficiency Programs. Ernest Orlando Lawrence Berkeley National Laboratory. LBNL-3277E. http://eetd.lbl.gov/ea/emp/reports/lbnl-3277e.pdf. Accessed March 27, 2012.

Michigan Public Service Commission (MPSC). (2012). Report on the Implementation of the P.A. 295 Renewable Energy Standard and the Cost-Effectiveness of the Energy Standards. http://www.michigan.gov/documents/mpsc/implementation_PA295_renewable_energy2-15-2012_376924_7.pdf. Accessed March 27, 2012.

Nadal, S. (2006). Energy Efficiency Resource Standards: Experience and Recommendations. ACEEE Report E063. http://www.aceee.org/research-report/e063. Accessed May 15, 2012.

NEPOOL-GIS. (2012). Public Reports: Number of Certificates by RPS Eligibility. https://www.nepoolgis.com/myModule/rpt/myrpt.asp?r=118&TabName=RPS. Accessed October 2, 2012.

Nevada Public Utilities Commission (NV PUC). (2011). Docket No. 11-04001, Order issued April 27.

NC-RETS. (2012). Public Reports: RECs Issued 2011. https://portal2.ncrets.org/myModule/rpt/myrpt.asp?r=108&TabName=Certificate. Accessed May 7, 2012.

Pennsylvania Public Utility Commission (PA PUC). (2012). Pricing for AEC Sales. http://www.puc.state.pa.us/electric/electric_alt_energy.aspx. Accessed March 27, 2012.

PA PUC. (2011). 2010 Annual Report: Alternative Energy Portfolio Standards Act of 2004. http://www.puc.state.pa.us/electric/pdf/AEPS/AEPS_Ann_Rpt_2010.pdf. Accessed March 27, 2012.

Public Service Commission of West Virginia (PSC WV) (2011a). Approval of compliance plan submitted under the Alternative and Renewable Energy Portfolio Standard Act. Case No. 10-1914-E-CP, Order Issued September 26, 2011. http://www.psc.state.wv.us/scripts/orders/ViewDocument.cfm?CaseActivityID=329852&Source=Docket. Accessed May 3, 2012.

Public Service Commission of West Virginia (PSC WV) (2011b). Approval of compliance plan submitted under the Alternative and Renewable Energy Portfolio Standard Act. Case No. 10-1912-E-CP, Order Issued September 26, 2011. http://www.psc.state.wv.us/scripts/WebDocket/ViewDocument.cfm?CaseActivityID=329853. Accessed May 3, 2012.

Regulatory Assistance Project (RAP) and Center for Climate and Energy Solutions (C2ES). (2011). Clean Energy Standards: State and Federal Policy Options and Implications. http://www.c2es.org/docUploads/Clean-Energy-Standards-State-and-Federal-Policy-Options-and-Implications.pdf. Accessed May 3, 2012.

Restuccia, A. (2012). "Bingaman launches uphill battle with 'clean' power proposal." The Hill. March 1. http://thehill.com/blogs/e2-wire/e2-wire/213585-bingaman-floats-long-awaited-clean-energy-standard. Accessed May 14, 2012.

Sandalow, D. (2012). U.S. Senate Committee on Energy and Natural Resources. Full Committee Hearing: The Clean Energy Standard Act of 2012. Archived Webcast. At 43 minutes. http://www.energy.senate.gov/public/index.cfm/hearings-and-business-meetings?ID=0e90e4ea-a5be-44ae-b7f0-a9cd9b98dbdb. Accessed June 20, 2012.

Shiller, S., Goldman, C., and Galawish, E. (2011). National Energy Efficiency Evaluation, Measurement and Verification (EM&V) Standard: Scoping Study of Issues and Implementation Requirements. Lawrence Berkeley National Laboratory. LBNL-4265E.

Siegfried, S. (25 March 2011). Personal communication. Public Utilities Commission of Ohio, Columbus, Ohio.

Solar Energy Industries Association (SEIA) and GTM Research. (2011) U.S. Solar Market Insight: 2010 Year-In-Review Full Report.

Spectron Group. (2012). Data accessed through Vantage database. London, UK. http://www.spectrongroup.com. Accessed June 30, 2012.

U.S. Department of Energy (DOE). (2012). Uniform Methods Project: Protocols Development. www.nrel.gov/docs/fy12osti/54945.pdf. Accessed September 12, 2012.

Washington Utilities and Transportation Commission. (2012). Company Program Plans and Targets. http://www.utc.wa.gov/regulatedIndustries/utilities/energy/Pages/CompanyProgramPlansandTargets.aspx. Accessed October 5, 2012.

World Resources Institute (WRI). (2008). The Bottom Line On Energy Savings Certificates. http://pdf.wri.org/bottom_line_energy_savings_certificates.pdf. Accessed March 27, 2012.