The renewable portfolio standard: design considerations and an implementation survey

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Abstract

Renewables have social and environmental benefits compared to conventional electricity sources, but are rarely competitive on a strict financial cost basis. This is because conventional sources are sometimes subsidized, their full pollution costs are ignored, and renewables involve newer, higher-cost technologies whose relative costs will fall with commercialization. Governments use several mechanisms to support renewables, including direct financial support (grants, loans), indirect support (R&D, demonstrations), reform of financial costs of conventional sources (subsidy removal, pollution taxes), and the Renewable Portfolio Standard (RPS). The RPS requires a minimum share of electricity from renewable energy sources. Its use is spreading because it maintains an incentive for renewable producers to reduce costs, links the regulated market outcome to an environmental target, and reduces government involvement. Although it is too early to evaluate fully its effectiveness, the survey for this study explored implementation issues in three European countries, nine US states, and Australia, and found the following. The RPS target is usually set to have environmental benefits without causing significant price increases (cost caps are sometimes used). Most jurisdictions limit eligibility to grid-connected, domestic renewables. The RPS is usually applied to producers rather than consumers, and to energy output not capacity. Flexibility mechanisms are desired but a challenge to implement. Administration in the US and Australia is by government with delegation to independent utility regulators, while in Europe it is more the responsibility of government. Everywhere, the RPS is applied alongside other mechanisms of renewables support.

Keywords: Renewable portfolio standard

1. Introduction

The Renewable Portfolio Standard (RPS) is a policy instrument to increase the production of electricity from higher-cost energy sources with desirable social and environmental benefits. The RPS requires the market to deliver a minimum amount of electricity (typically as a percentage of total sales) from specific fuels and/or technologies. It is similar to many other types of minimum standards established by governments to address real or perceived market failures, examples being minimum standards for insulation in new buildings, fuel efficiency in new vehicles, or recycled content in consumer packaging (Rader and Norgaard, 1996; Prevost, 1998).

The RPS is rapidly emerging as a popular mechanism among policy makers to increase the penetration of renewables in the electricity market. In this paper, we look at why the RPS is popular, what are the key design considerations, and present the results of a survey of its implementation. We conclude with suggestions on its continued application and evolution.

2. Definition and rationale

Definitions of renewable electricity vary but typically include any electricity produced from a renewable fuel source such as sunlight, wind, geothermal heat, wave or tidal energy, running water and organic matter. In some

1 To be included in this definition, the organic matter must be derived from a renewable source of biomass such as sustained yield forestry or agricultural crops. Gas (primarily methane) derived from organic matter in existing landfills is sometimes included in this definition since the gas would otherwise be flared or released directly to the atmosphere.
cases, these fuels are associated with a unique technology, such as photovoltaic cells or wind turbines. However, other technologies, such as fuel cells, gas turbines, and reciprocating engines, can be powered by either renewable (e.g., biogas) or non-renewable fuels (e.g., natural gas or diesel). Hence, the fuel rather than the technology tends to be the main distinguishing characteristic of renewable electricity sources.

Renewables usually have significantly lower social and environmental impacts and risks when compared with electricity derived from conventional sources, such as non-renewable fossil fuels. These environmental benefits may be both local (e.g., fewer smog-contributing emissions) and global (e.g., reduced emissions of greenhouse gases). Renewable electricity supplies may also enhance energy security by increasing supply diversity and increasing the use of indigenous fuels or technologies, making energy systems less vulnerable to volatile fuel prices or disruptions in individual fuel supplies. Renewables can also support economic development through higher labour intensity, reduced payments on imported fuels (increasing local multiplier effects), and new opportunities for local technologies or expertise.

In spite of all these societal benefits, renewables are usually found to be more expensive than conventional electricity sources when compared on a financial cost basis. Because of this, both monopoly and competitive electricity producers have concentrated their investment on conventional electricity technologies, with renewables usually accounting for only a small percentage of the generating stock.²

There are three main reasons for the discrepancy between the social and economic benefits of renewables and their high financial cost relative to conventional, polluting generation sources:

- Some jurisdictions provide subsidies to conventional generation sources.
- The full costs of pollution (externalities) are not included in the financial cost of conventional electricity sources.
- Renewables are often associated with newer, higher-cost technologies, whose relative costs will fall in time with widespread commercialization because of economies of learning and economies of scale in equipment manufacture.³

Fig. 1 shows these three effects. On the left, it shows that, from a strict financial cost perspective, most renewables are more expensive than conventional electricity sources. On the right, it shows the potential impact of taking these three factors into account in a long-run social cost perspective. If subsidies were removed and externality costs included, the costs of conventional electricity sources could rise substantially. At the same time, renewables’ costs could decrease as a result of advancing commercialization.⁴ The relative cost changes will vary for different technologies and jurisdictions.

Thus, from a social cost perspective, renewables are increasingly recognized as desirable resources, but also as resources that will have difficulty developing rapidly on their own, given the tendency of market investment to focus on the financial dimension. In response, governments have developed an array of policies to improve the financial situation of renewables in order to achieve a more socially optimal level of investment. There are four broad categories of measures to support renewables:³

- Increase the cost of polluting sources of supply. This may include the reduction or elimination of subsidies to conventional sources, higher energy or pollution taxes, stronger technology regulations, or emission cap regulations.
- Provide direct financial support to renewables. This may include capital grants, preferential purchase prices, tax advantages, or low interest loans. Energy price subsidies can be in the form of preferential fixed purchase tariffs (Germany), a fixed premium on the prevailing electricity price (Spain), or a premium determined by competitive bidding (England). Support may come from government or from all electricity consumers via a public benefits charge.
- Assist the commercialization of renewables with indirect support. This may include funding of demonstrations projects, audits and evaluations, resource assessments, R&D support, and training.

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² Exceptions to this are found in jurisdictions blessed with low cost, large-scale hydropower resources. Brazil, for example, generates almost all of its electricity from hydropower. However, some analysts argue that large-scale hydro should not be included with other renewables because of the large environmental and social impacts it can cause. Also, hydro reservoirs, large and small, with rapid rates of in-fill from siltation, are questionable as renewables.

³ Of course, since pre-industrial times renewables have also been associated with very old technologies. However, this comment refers to the recent rebirth of interest in renewables with the resulting flourish of newly emerging technologies like photovoltaics, modern windmills and biomass gasification for use in advanced combustion turbines.

⁴ There is not complete agreement on the representation in this figure. Some analysts argue that even when externalities are accounted for, subsidies are removed and key renewables achieve significant market penetration, the costs of fossil-fuel generated electricity may in many cases still be lower.

⁵ Mechanisms that focus specifically on the collection of funds to support renewables are excluded from this list. For example, many jurisdictions have implemented volumetric fees on electricity sales. These so-called public benefits surcharges (e.g., such as Britain’s Non-Fossil Fuel Level and California’s Competition Transition Charge) are simply a non-bypassable and competitively neutral means of raising funds for support programs. They do not directly encourage uptake of renewables, except possibly where these surcharges are applied differentially, providing some cost advantage to certain types of energy sources and raising funds to promote other support programs. A differential surcharge would be the same as a pollution tax, which is covered in another category of policy support.
Foster voluntary or mandatory market shares for renewables. This may include voluntary agreements with producers, green tariffs allowing consumers to pay extra for renewables, and the renewable portfolio standard.

Since the energy crisis days of the 1970s, governments have especially relied on the first three mechanisms to support renewables. Still today, governments are pushing to increase the cost of polluting sources of supply, especially in Europe with the imposition of various kinds of pollution taxes. Western countries, and increasingly developing countries like China, have reduced the subsidies provided to fossil fuels. Indirect support has been relied on in a fairly continuous fashion by almost all countries. However, the most significant commitment has been through direct financial support. For example, electric utilities have fostered renewable investments by independent power producers in many jurisdictions by providing fixed-tariff financial support (Loiter and Norberg-Bohm, 1999). With the passage in 1978 of the Public Utility Regulatory Policy Act (PURPA) in the US, many utilities guaranteed favourable, long-term fixed purchase prices for renewable electricity. This has been the same in Germany and some other countries in Europe.

Today, the fixed financial support approach is being overtaken by the RPS. There are three major reasons for the growing popularity of the RPS.

- A RPS maintains continuous incentives for renewable producers to seek cost reductions (economic efficiency) and can be designed to ensure that these cost reductions are passed on to consumers (equity). This is achieved by mechanisms that establish continuous cost competition among renewable producers for their share of the RPS.
- Because a RPS ensures the attainment of a specific market share, it can be directly linked to government policy targets. Thus, governments can set a RPS target and show how that will contribute to meeting an environmental target, like CO₂ reduction.
- A RPS minimizes government involvement relative to other measures. The government’s budget need not be involved, as customers pay producers the extra financial cost of renewables, and selection of winning bids is made by market forces rather than government evaluation.

With this background, explaining the current attractiveness of the RPS, the next section reviews the key considerations in designing one.

3. Key considerations in designing a Renewable Portfolio Standard

The key considerations when developing a RPS are interrelated and should not be considered in complete isolation from one another. Most of these issues will also benefit from a clear set of policy objectives to help guide design and implementation.

3.1. Selection of target

The main challenge of the RPS is determination of the binding target or quota for renewable energy production. There are several aspects to this determination.
3.1.1. Target size

The selection of the size of the target requires consideration of impacts on different objectives, including anticipated costs. These impacts will depend in part upon the local cost and availability of different renewables and the price of traditional energy supplies. Ideally, the target would be large enough to move the industry towards the environmental objective, but not so large that it results in significant increases in electricity prices. The size of the target can also affect the level of competition among fuels or technologies. For example, if targets exceed available resources or could be achieved with a relatively small number of highly competitive large projects, there may be less competition and little pressure to innovate. Some knowledge of the supply curve for renewables is, therefore, particularly important in establishing targets.\(^7\)

3.1.2. Target timing

Another consideration in selecting the target is timing. Some lead time may be required to permit cost-effective responses to the targets. This lead time will depend upon the magnitude of the targets and the types of eligible resources. For example, if existing facilities are not eligible for meeting targets, sufficient lead time will be required for investments in new facilities. Some phase-in period may be required to permit time for adaptation and to allow the government to conduct interim evaluations of targets in order to assess actual impacts and make adjustments where necessary. The phase-in can also be designed to accommodate expected adjustments to the supply curve, thereby maintaining fairly stable compliance costs and avoiding significant windfalls for lower-cost producers. The duration and stability of targets is also important in that if the RPS is predictable over a long time horizon, buyers and sellers are more likely to enter into long-term supply contracts. Long-term commitments that guarantee a revenue stream are very important for securing low-cost project financing, especially for high capital-cost technologies such as renewables.

3.1.3. One or multiple renewables targets

An issue in target setting is whether or not there should be one target for which all renewables will compete or a separate target for different types or classes of renewables. Under the first approach, the least-cost options would be developed to meet the overall target. This approach may minimize costs and enhance environmental objectives, but it may not contribute to other objectives such as greater supply diversity or increased support for newly emerging, but still expensive, renewables. It could be that one renewable will capture almost the entire RPS market, even though other renewables would eventually become competitive if given the opportunity for broad commercialization. For example, the State of Connecticut has established separate targets for Class 1 renewables (solar, wind, landfill gas, and sustainable biomass) and Class 2 renewables (hydropower and municipal solid waste). The intent is to restrict the share of hydropower and municipal solid waste in meeting the state’s overall RPS objective so that other technologies will be supported.

3.1.4. Cost cap and target adjustment

Because RPS is focused on achieving a target, it faces the risk of pushing up the electricity price if the target is set too high. To counter this risk, a cost cap for renewables can be implemented in various ways. For example, if renewable electricity providers or consumers are using tradable certificates to coordinate the market for renewables, the program administrator could provide an unlimited number of certificates at a price equal to the cost cap. Producers could purchase certificates when the market price of renewables exceeds the cost cap. The program administrator could use these funds to promote renewables in other ways. Alternatively, a penalty may be established which provides an effective cap on program costs since participants would simply pay the penalty if the cost of meeting targets exceeded the penalty price. The value of price caps and penalties, however, must be weighed against any increase in administration costs or complexity for the program. The Netherlands has a cost cap, but the mechanism appears to be somewhat complex. Even if certificates or penalties are not involved, the administrator could adjust targets downwards if costs begin to exceed a certain threshold. However, reasonable lead time is required to change targets and changes should not jeopardize the credibility and predictability of the program, which could have serious consequences for its long term success.

3.2. Eligible resources

In addition to specific targets, the RPS must contain a list of resources eligible for meeting the requirements. This will depend in part upon the objectives of the RPS and the local viability of different types of resources. Different types of resources will have different costs and benefits.

3.2.1. Renewables vs. other desired technologies

A key decision is whether the RPS should be limited to renewable sources of electricity, in the strictest sense, or whether other energy/technology combinations should be included. This depends on the objectives. Thus, in some jurisdictions, fossil fuel based co-generation or fuel cells are included because of their energy efficiency effects, with a resulting contribution to the environmental

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\(^7\) A supply curve depicts the cost of different levels of generation. The curve slopes upward since higher cost supplies will typically need to be called upon to meet higher levels of demand.
objective. Similarly, resources such as solar water heaters may be included where the installation leads to a reduction of fossil fuel consumption. The Italians, on the other hand, prefer to focus the RPS strictly on renewable electricity sources, with other policies directed to efficiency and end-use fuel switching objectives.

3.2.2. Existing renewables vs. new investments

Another eligibility consideration is whether the RPS should apply to all renewable resources or only new investments in renewable resources. Applying it to new investment helps ensure that this is the focus of the policy and prevents windfall profits to plants that already exist. However, this can make the policy more difficult to administer because a determination must be made about what is truly new. If the goal is simply to expand particular renewables at the lowest cost, the policy should be indifferent between reconditioning improvements to an existing renewable facility and a totally new renewable facility. If existing facilities are included in the RPS, irrespective of whether additional investments are made, then the target for the RPS could be adjusted upward to ensure that an objective of additional investment in renewable energy is met.

3.2.3. Grid-connected renewables vs. all renewables

A determination must also be made as to whether the RPS applies to only grid-connected facilities or also off-grid facilities. While the simplest approach is to focus the policy on changing the grid-transmitted market share of renewables, some would argue that environmental objectives are equally served by the development of renewables anywhere, including off-grid. However, administrative realities must also be considered. For example, even if the myriad of small, off-grid systems were bundled for administration under a RPS, it could be difficult to verify their annual production and administrative costs could be high. With grid-connected renewables, an additional issue is whether generation on site, downstream of a firm or household’s meter, should be included. This can be allowed as long as a dedicated meter can verify on site renewables production.

3.2.4. Facility size

The size of resources may also be part of the RPS determination. The Maine RPS, for example, has an upper limit of 100 MW. Size limits can affect the number of potential projects required to meet the overall target. They can also indirectly affect objectives such as diversity and the location of projects.

3.2.5. Imports vs. domestic renewables

Finally, it must be decided whether or not the RPS allows competition from external renewable resources. The Danish RPS, for example, allows imports of renewables to satisfy the RPS as long as these meet all other eligibility requirements. In many jurisdictions, such determinations will require some consideration of existing trade agreements and commercial law, which may limit policy makers’ ability to discriminate between domestic supplies and imports.

3.3. Applicability

The applicability of targets is also an important consideration in RPS design. Key issues include the geographic coverage of the standard, the applicability of the standard to specific market participants, and whether it should be applied to capacity or energy.

3.3.1. Geographic coverage

In terms of geographic coverage, the RPS may be most effective if the breadth of its application is matched to the breadth of environmental and other objectives. This explains why the European Union, which sees renewables as an explicit component of its greenhouse gas emission reduction objective, is seeking to achieve an EU-wide RPS. However, the physical limitations to trade must be considered. In some countries, the lack of grid interconnection makes implementation of a national RPS problematic, unless some form of credit trading is permitted. In these cases, it may be easier initially to set a RPS for each major grid area.

3.3.2. Market participants regulated by the RPS

The RPS must also identify the market participants who are responsible for meeting the requirements (i.e. to whom the RPS applies). Possible participants include generators, wholesale customers or brokers, retail suppliers and/or consumers. Some jurisdictions want the RPS to be associated with final consumption, hoping that its intent will thus become clearer to consumers; an example is Denmark. Others, such as Italy, believe that the administrative ease of regulating producers is more important.

3.3.3. Energy production vs. installed capacity

The RPS may apply to energy production or installed capacity. While the capacity may be easier to verify in advance of production, energy production is more correlated with the desired environmental benefits and provides an incentive to maximize the production from individual projects.

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8 Australia’s proposed RPS includes credits for solar water heaters which either displace fossil fuels directly (e.g., gas-fired boilers) or indirectly (e.g., reduced electricity consumption and hence production).

9 In fact, the Italians exclude small producers, so that the RPS responsibility is associated with only about 100 producers nation-wide.
3.3.4. Company-wide vs. product-specific

In jurisdictions with retail access or voluntary green power rates, there have been concerns expressed about the interaction between the RPS and so-called green marketing, which seeks to encourage individual customers to voluntarily support higher-cost renewable energy sources. For example, if the standard is applied on a company-wide basis, marketers could simply shift the requirement into a single green product and sell that product at a premium to those customers willing to pay more for green power. This could reduce the incremental benefits of the RPS and generally raises concerns about equity. In particular, some customers would be paying a premium to a company that is simply meeting a minimum statutory requirement. To avoid this problem, the standard could be applied at a product level and any products marketed as “green” would be required to exceed this standard. Alternatively, the government might undertake a consumer education campaign to ensure customers are aware of the minimum requirements when choosing products and paying premium prices.

3.4. Flexibility mechanisms

A RPS can be less costly to implement, yet still achieve the same target, if there is flexibility in how it is applied both to individual producers and across the entire market.

3.4.1. Account balancing mechanisms for each producer

One way to increase flexibility is to allow those to whom the policy is applied to have some flexibility in the choice of calendar year and in the period for achieving their annual RPS. This is known as an account-balancing mechanism. For example, the inherent uncertainty of some types of renewables (e.g. wind) may make it difficult to achieve precisely the RPS target each year. However, the electricity provider can be given extra months to meet the previous year’s commitment as long as the full RPS requirement is achieved on average over a period of years.

3.4.2. Trading mechanisms between producers

Another way to increase flexibility is to allow trade among electricity providers so that the RPS target is met in aggregate, even if some providers may exceed the RPS while others fail to achieve it. This approach can significantly decrease the total cost of the RPS because it allows the maximum of renewables electricity production from those with the lowest renewable cost. In some jurisdictions, this trading is facilitated by the creation of tradable renewable electricity certificates and possibly even a centralized exchange (Voogt et al., 2000; Mitchell and Anderson, 2000). The Netherlands and Denmark have such certificates. However, the creation of certificates is not essential for trading to occur. The RPS administrator could allow electricity providers to use a variety of instruments to show that the RPS target is being achieved even while they trade among themselves. For example, contracts between providers could be filed with the administrator and these verified against the actual inputs of electricity to the grid.

3.5. Administrative responsibilities

There are several administrative responsibilities in implementing a RPS. These could all be handled by one RPS administrator or delegated to specialized agencies.

3.5.1. Setting RPS target

The RPS target would likely be set at a senior level of government since it involves critical trade-offs between environmental targets, economic development goals, and concerns about electricity prices.

3.5.2. Certification of renewables

Certification of renewables could be delegated to the operator of the grid, subject to periodic review by the government agency responsible for administering the RPS. Environmental regulators could help with the definition of what is a renewable resource.

3.5.3. Compliance monitoring

Compliance monitoring could be delegated to the operator of the grid, since this entity will already have information on production of connected facilities. If non-grid production is also eligible for the RPS, compliance could be much more complicated to verify and may require involvement of some other entity.

3.5.4. Setting and collecting penalties for non-compliance

Penalties for non-compliance will be set at senior levels of government, but could then be administered by the grid operator or an environmental agency.

3.6. Complementary mechanisms

The RPS need not exclude other initiatives to support renewables and may work best in conjunction with other policies. Indeed, all jurisdictions that have instituted a RPS have continued to some degree with other renewables support policies. As noted earlier, these include direct financial support, indirect financial support of commercialization, reduced subsidies to conventional energy and, in some cases, increased taxation for conventional, polluting forms of electricity production. Both Denmark and Netherlands, for example, mesh their RPS programs with some form of environmental taxes. Ideally, these policies would be designed and implemented in the context of an overall renewables or environmental policy in order to minimize conflicts, maximize synergies, and promote an efficient level of investment.
4. Experience with the Renewable Portfolio Standard

The RPS is gaining popularity as a mechanism for fostering renewable electricity production. Thus far, this has occurred primarily in developed countries, but a number of developing countries are now also looking seriously at the mechanism. In this section, we summarize the results of a survey of recent experiences in implementing the RPS. While it is too early to fully assess the effectiveness of RPS, the growing number of experiences provides a broad sense of the range of approaches and the initial implementation preferences of policy makers.

This section is divided into three focus areas: the US, the European Union (EU), and Australia. Table 1 provides a summary of the key considerations for RPS design and implementation as described in the previous section. This provides the structure for the following tables that summarize developments in each of the three focus areas. Information was not obtained for all jurisdictions for all the considerations listed in the table. Also, the world of RPS is changing so rapidly that the table will be quickly out of date as existing programs are modified and new programs implemented. The point of the survey, therefore, is not to provide accurate details of each jurisdiction, but instead to give a sense of the general trends in RPS at the time of the survey, which is late 1999/early 2000.

4.1. United States

In the US, the RPS has recently been implemented in nine states as part of a broader restructuring of their electricity markets. The RPS is under consideration in other states and has been included in a number of proposed restructuring bills at the federal level (US Department of Energy, 1999).

4.1.1. Federal government proposal

To date, no national RPS has been passed in the US. However, a number of bills have been introduced at the federal level that contain a mandatory RPS, including the Comprehensive Electricity Competition Act proposed by the Clinton Administration. The objectives of each RPS or RPS proposal vary. However, the RPS has received general support from many in the renewable energy industry and from public advocates (Haddad and Jefféris, 1999). The National Association of Regulatory Utility Commissioners, for example, has issued a resolution supporting renewable energy provisions, including a RPS, in restructuring legislation.

The federal government’s proposal would establish a national RPS requiring that 7.5% of electricity supplies be generated from renewable sources (other than hydro) by 2010. The requirement would continue through 2015 with sunset provisions for all existing renewables at that time. To promote flexibility and efficiency in meeting the standards, the proposal would establish renewable generation credits which may be traded or banked for future use. The value of the credits would be capped at 1.5 cents per kWh.

4.1.2. Individual state programs

California was one of the first states in the US to undergo major electricity market restructuring, including the introduction of retail competition for all customers. Although recommended by the California Public Utilities Commission, the RPS was not adopted in California. In its final restructuring bill, the state legislature opted instead for a collection of other mechanisms to support renewables funded through a universal charge on electricity sales in the state (Wiser et al., 1998).

As of May 2000, the RPS has since been introduced in some form in at least nine states that have undergone market restructuring. These are summarized in Table 2. Virtually all of these programs are in the early stages of implementation, with numerous implementation details still being developed. The various program designs reflect

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Table 1
Summary of key considerations in RPS design

<table>
<thead>
<tr>
<th>Selection of target</th>
<th>Size of the target</th>
<th>Timing of the target</th>
<th>One target for all renewables vs. separate target for individual renewables</th>
<th>Cost cap vs. no cost cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eligible resources</td>
<td>Strictly renewables vs. inclusion of other technologies/energy forms</td>
<td>All resources vs. only new renewables investment</td>
<td>Only grid-connected facilities vs. all renewable facilities</td>
<td>Any size renewable vs. facility size limitation</td>
</tr>
<tr>
<td>Allow renewable imports vs. only domestic facilities</td>
<td>Applicability</td>
<td>Geographic area covered</td>
<td>Market participants to whom the RPS applies</td>
<td>Energy vs. installed capacity</td>
</tr>
<tr>
<td>Flexibility mechanisms</td>
<td>Account balancing mechanism</td>
<td>Trade among electricity providers</td>
<td>Administrative responsibilities</td>
<td>Setting the RPS target</td>
</tr>
<tr>
<td></td>
<td>Certification of renewables</td>
<td>Compliance monitoring</td>
<td>Penalties</td>
<td></td>
</tr>
</tbody>
</table>

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10 The category “complementary mechanisms” has been omitted because there are usually many of these in each jurisdiction; this could be a research survey in itself.

11 Iowa and Minnesota have also established absolute targets for renewable energy. However, these were developed in the absence of retail competition and as offsets to specific projects.
<table>
<thead>
<tr>
<th>State</th>
<th>Selection of target</th>
<th>Eligible resources</th>
<th>Applicability</th>
<th>Flexibility mechanisms</th>
<th>Administrative responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arizona</td>
<td>0.2% in 2001; 1% by 2005; 1.1% by 2007 through 2012</td>
<td>At least 50% or renewable power must come from solar generating facilities. This increases to 60% by 2004</td>
<td>Applies to annual kWh retail sales of relevant utilities</td>
<td>Companies may request a waiver or modification in extreme circumstances</td>
<td>Penalties to be imposed after 2004 by Commission</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remainder may come from sources such as landfill gas, wind, and biomass, including solar hot water or research and development on solar electric resources.</td>
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<td></td>
<td></td>
<td>The order requires Commission to establish a working group by 2003 to assess costs and benefits of the RPS and make recommendations as to whether targets should be increased</td>
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<tr>
<td></td>
<td></td>
<td>The Commission can increase the portfolio percentage after 2004 if the cost of portfolio electricity has declined to a Commission-approved cost/benefit ratio</td>
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<td></td>
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<td>Research and development must be limited to 10 percent or less (5% or less by 2002)</td>
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<td></td>
<td></td>
<td>Only new solar and environmentally-friendly renewable electricity technologies installed on or after January 1, 1997 are eligible</td>
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</tr>
<tr>
<td>Connecticut</td>
<td>Class I Technologies; 0.5% in 2000; 6% in 2009 and thereafter</td>
<td>Class I: solar, wind, new sustainable biomass, landfill gas, fuel cells</td>
<td>Standard based on “output”, which has been defined to mean “capacity” in state licensing regulations</td>
<td>Credit trading mechanism is provided for but has not yet been developed</td>
<td>License application projection requirements</td>
</tr>
<tr>
<td></td>
<td>Class I or II Technologies: an additional 5.5% in 2000; 7% in 2009 and thereafter</td>
<td>Class II: hydro, MSW, other biomass</td>
<td>Service provider-based standards</td>
<td></td>
<td>Supplier must submit documentation to Department of Public Utility Control (DPUC) demonstrating that the supplier complied with the RPS in the previous 12 months</td>
</tr>
<tr>
<td></td>
<td>No explicit cost cap</td>
<td>Out-of-state renewables eligible</td>
<td></td>
<td></td>
<td>License suspension, revocation, civil penalties, new customer restrictions, depending on degree of non-compliance</td>
</tr>
<tr>
<td>Maine</td>
<td>30% of retail sales starting March 1, 2000 and each year thereafter</td>
<td>Eligible renewables: fuel cells, tidal, solar, wind, geothermal, hydro, biomass, MSW under 100 MW, and qualified small power facilities</td>
<td>Applies to retail energy sales</td>
<td>If service begins less than 6 months prior to December 31, compliance period extends to the next December 31</td>
<td>Must be met over 12-month period</td>
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<tr>
<td></td>
<td></td>
<td>No multipliers for unique resources</td>
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</tbody>
</table>
No explicit cost cap

Other eligible sources: energy efficiency or cogeneration sources (the legislated definition of energy efficiency is at least 60% thermal efficiency, no matter the source).

Out-of-state renewables eligible

Qualified renewable and cogeneration output are eligible from multi-fuel hybrid generators.

No multipliers for unique resources.

Solar, wind, ocean thermal, wave, or tidal, fuel cells using renewable fuels, landfill gas, and low-emission, advanced biomass.

Contemplates 12-month compliance period.

1% /year increase thereafter until date determined by Division of Energy Resources (DOER) as to whether product-based standards will apply.

No multipliers for unique resources.

1% by December 2003, or 1 year after the date that the average cost of any renewable technology is within 10% of average market price, whichever is sooner.

0.5% year increase to 4% in 2009.

Applies to total Nevada energy consumption.

Applies to total Nevada energy consumption.

No explicit cost cap in legislation.

0.2% as of January 1, 2001.

50% from new solar electric or solar thermal "new" resources defined as installed and commissioned operations after July 1, 1997.

Legislation implies service-provider based standards (undetermined).

Credit trading under review by DOER—assessing whether to award credits to renewable generators or retail suppliers.

Commission may conduct periodic audits to verify compliance.

Commission will review RPS, with 3 years and has authority to waive requirement for RPS.

Supplier must annual report by May 1st demonstrating compliance for previous year and ensuring no double-counting has occurred.

Commissioner certifies that RPS has been met and that renewables have not been double-counted.

<table>
<thead>
<tr>
<th>State</th>
<th>Selection of target</th>
<th>Eligible resources</th>
<th>Applicability</th>
<th>Flexibility mechanisms</th>
<th>Administrative responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Increases by 0.1% annually until 1% annually</td>
<td>Remaining 50% from renewable energy resources: (‘renewable’ defined as: wind, solar, geothermal and biomass energy resources in Nevada that are naturally regenerated)</td>
<td>Service-provider based standards</td>
<td>License suspension, revocation, depending on degree of non-compliance</td>
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<tr>
<td>Sierra Pacific</td>
<td>given special treatment</td>
<td>No out-of-state resources eligible</td>
<td></td>
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<tr>
<td></td>
<td>Rural electric coops, general improvement districts, and others are exempted</td>
<td>No multipliers for unique resources</td>
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<tr>
<td>New Jersey</td>
<td>Class I Technologies: 0.5% in 2001; 1% by 2006; 4% by 2012</td>
<td>Class I: solar, PV, wind, fuel cells, geothermal, wave or tidal, and methane gas from landfills or a biomass facility, provided that the biomass is cultivated and harvested in a sustainable manner</td>
<td>Applies to total energy load supplied to retail customers</td>
<td>Credit trading system still to be formalized but is specified as provision of an RPS</td>
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<td></td>
<td>Class I or II Technologies an additional 2.5% in 2000 increasing to 6.5% in 2012 (all subsequent additions after 2012 must be met by Class I renewables only)</td>
<td>Class II: hydro &lt; 30MW and waste-to-energy facilities that meet the “highest environmental standards”</td>
<td>Service provider-based standards</td>
<td>File report by April I providing all pertinent documentation to demonstrate compliance in past year</td>
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<td>Out-of-state renewables eligible</td>
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<td></td>
<td></td>
<td>Class II technologies must come from states open to retail competition</td>
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<td></td>
<td></td>
<td>No multipliers for unique resources</td>
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<tr>
<td>Pennsylvania</td>
<td>Does not have an RPS but rather competitive default provider provisions The provisions specify a % of customers to be served by a minimum % requirement of renewables Example: GP Utility: 0.2% renewables for 20% of residential customers increasing to 80% of customers in 2004</td>
<td>No out-of-state renewables eligible</td>
<td></td>
<td>Suppliers must make-up a deficit (additive to next year’s requirement)</td>
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<td></td>
<td></td>
<td>Class II technologies must come from states open to retail competition</td>
<td></td>
<td>If deficit persists, revocation or suspension of license, or financial penalties, will be considered</td>
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<td></td>
<td></td>
<td>No multipliers for unique resources</td>
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</tr>
<tr>
<td>State</td>
<td>Target</td>
<td>Type of Renewable Energy</td>
<td>Commission's Action</td>
<td>Retailers' Penalty</td>
<td></td>
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<tr>
<td>Texas</td>
<td>1280 MW by 2003</td>
<td>Solar, wind, geothermal, hydroelectric, wave or tidal, and biomass or biomass-based waste products (including land-fill gas)</td>
<td>Commission has established a renewables credit trading system starting 2002. Renewable capacity additions have a minimum of 10 years of credits to recover over-market costs</td>
<td>Retailers with insufficient credits are subject to a penalty of $50/MWh or 200% of the average cost of credits traded during the year</td>
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<tr>
<td></td>
<td>1730 MW by 2005</td>
<td>No multipliers for unique resources</td>
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<tr>
<td></td>
<td>2280 MW by 2007</td>
<td>New renewables from anywhere can receive RECs if delivered to Texas in compliance with strict metering and verification requirements</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>2880 MW by 2009</td>
<td>New renewables from anywhere can receive RECs if delivered to Texas in compliance with strict metering and verification requirements</td>
<td></td>
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</tr>
<tr>
<td>Wisconsin</td>
<td>0.5% by 2001 increasing 0.35% every 2 years until 2.2% by 2011</td>
<td>Fuel cells, tidal or wave, solar thermal or photovoltaic, wind, geothermal, biomass, hydro &lt; 60 MW</td>
<td>Applies to retail energy sales; Provision allows for credit trading between providers and/or banking of credits for subsequent years (no rules established yet)</td>
<td>Annual report (no later than April 15) describing compliance (can include certifications from wholesale suppliers but required documentation open to discretion of Commission)</td>
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<td></td>
<td>Violating requirements or filing misleading certifications may result in fine between $5,000 and $500,000</td>
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</tbody>
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*Not termed an RPS but falls under a “Renewable Energy Goal”.

This requirement is essentially a negotiated single utility provision.
the unique objectives and circumstances of each state, making generalizations difficult. The targets range from 2 to 30%. At 30%, Maine’s RPS target appears very large, but all existing resources (less than 100 MW) are included and it currently gets 50% of its electricity from hydro and biomass resources that are eligible for inclusion in the RPS. None of the state programs have explicit cost caps, although in some cases, penalties and credit programs provide de facto caps. Urban waste and landfill gas are often included as eligible resources, and sometimes technologies, like fuel cells and cogeneration. Most RPS targets are to be applied to electricity retailers. Almost all the programs envision sometimes technologies, like fuel cells and cogeneration.

### European Union

Several European countries have implemented mechanisms similar to the RPS (Table 3), and the European Union (EU) is considering adopting a formal renewable RPS with a community-wide credit trading system (Goldstein et al., 1999).

#### 4.2.1. European commission proposal

As part of its effort to establish a liberalized internal electricity market, the EU is developing harmonized rules on the treatment of renewables in order to avoid distortion of trade and competition in electricity from renewable sources.

In November 1997, the EU issued a White Paper laying down a strategy and action plan for establishing common rules for the treatment of renewable electricity sources. The paper laid out an objective to attain a minimum penetration of renewable energy sources in the EU by 2010. In June 1998, the Council of Ministers passed a resolution supporting this objective and requested a proposal for joint rules covering green electricity. In April 2000, the EU issued a proposed directive for a community-wide policy (Commission of the European Communities, 2000).

To date, the directive has not been adopted.

#### 4.2.2. Individual country programs

As part of a major electricity market restructuring in 1990, the United Kingdom developed a universal charge on electricity sales with a tendering procedure for acquiring new renewable resources (Mitchell, 1995). This procedure is somewhat similar to the RPS but the program attempts to maximize market share within an overall cost cap. Thus, a particular market share target has not been pursued. However, with the increasing desire to meet specific environmental objectives, the government is now looking at reform options, and has recently initiated discussions on a new policy that would see a RPS with a 10% renewables requirement by 2010 (UK Department of Trade and Industry, 1999).

The government of the Netherlands has negotiated a voluntary quota for green energy with the country’s major utilities. Producers of green electricity (utilities and independent power producers) receive a subsidy for each kWh provided to the grid. This is financed by an environmental tax throughout the country on conventional energy consumption. Utilities have an option of paying the environmental tax instead of achieving their quota. Producers and utilities can also trade green energy certificates among themselves to meet the quota (Kwant and van Leenders, 1999). The Parliament will decide whether to introduce a mandatory RPS in 2001 and intends to continue and broaden the application of green energy certificates as it further liberalizes the electricity sector (Energy Research Foundation — ECN, 2000).

In Italy, operators who produce and import more than 100 GWh are obliged, from 2001, to provide at least 2% of the electricity produced and imported (net of cogeneration, exports, and self-consumption) from renewable sources built or re-powered after the entry into force of the government’s decree concerning the electricity market in March 1999 (Fanelli, 1999). The quotas will triple electricity production from renewable sources by 2010.

In Denmark, binding annual quotas have been developed for renewable electricity production with a goal to produce 20% of the country’s electricity from renewable sources by 2003 (Odgaard, 1999). Power production that qualifies for green certificates can be traded to meet this requirement. The Danish government will also sponsor periodic bids for power from off-shore windfarms that will be eligible for special subsidies and can then also qualify for green certificates. In this way, the economic efficiency of the quota system has been combined with special support for higher-cost technologies.

Belgium is among several other countries that are close to implementing a RPS.

### 4.3. Australia

Australia recently announced an ambitious nationwide RPS (Table 4) that will be implemented beginning in 2001 via a renewable certificate trading scheme (Government of Australia, 1999). As currently contemplated, the program establishes a nation-wide target for a 2% increase in renewable electricity market share by 2010, growing from 10.5 to 12.5% of total electricity production. To provide greater certainty, the target has been translated into a fixed electricity requirement of about 25,500 GWh in 2010. Legislation to support the measure was introduced in June 2000.

The measure will apply nationally, with all electricity providers on individual grids with over 100 MW of installed capacity in all States and Territories contributing...
<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Netherlands</td>
<td>3.2% of sales by 2001</td>
<td>Eligibility extends to heat pumps, heat storage waste (50% of waste stream considered to be biomass and thus credited as renewable)</td>
<td>Applies to producers</td>
<td>Renewables have green labels which can be traded</td>
<td>Administered by the utilities on a voluntary basis, although government has now established a verification bureau</td>
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<td>Indirect cost cap in that renewable energy gets a rebate of the environmental tax; thus, producers can opt to pay the tax instead of achieving the target</td>
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<tr>
<td></td>
<td></td>
<td>Allows imports (such as hydro from Norway)</td>
<td>Covers the entire country</td>
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<tr>
<td></td>
<td></td>
<td>Only applies to grid-connected sales/resources</td>
<td>Applies to energy not capacity</td>
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</tr>
<tr>
<td>Denmark</td>
<td>20% of sales by 2003</td>
<td>Does not include waste or large hydro generation</td>
<td>Applies to final consumers</td>
<td>Renewables have green certificates which can be traded</td>
<td>Administered by the energy ministry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Allows imports</td>
<td>Covers the entire country</td>
<td>Consumers have 3 months into the next year to correct imbalances from the previous year</td>
<td>Penalty is the tax payment for kWh that fail to meet the RPS requirement</td>
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<tr>
<td></td>
<td></td>
<td>Only applies to grid-connected sales/resources</td>
<td>Applies to energy not capacity</td>
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<tr>
<td>Italy</td>
<td>2% of electricity (excluding CHP) to come from new renewables starting 2003</td>
<td>Only new renewables are eligible</td>
<td>Applies to electricity producers/importers exceeding 100 GWh/year (about 100 electricity providers)</td>
<td>Green certificates allow for year-to-year balancing by individual energy providers and trading between providers</td>
<td>Grid operator confirms compliance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Combination of old and new renewables should mean evolution from 7% in 1999 to 14% by 2010</td>
<td>Strict definition of renewables (not CHP or fuel cells, etc.)</td>
<td>Green certificates can be obtained 1 or 2 years in advance</td>
<td>Penalty is exclusion from the grid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Renewable must produce at least 100 MWh/year</td>
<td>Applies to energy not capacity</td>
<td></td>
<td>Grid operator creates marketplace for green certificates</td>
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<tr>
<td></td>
<td></td>
<td>Applies for only 8 years operation of a resource, meaning that the % of renewables must keep increasing to sustain the 2% total</td>
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<tr>
<td></td>
<td></td>
<td>Allows imports</td>
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<td></td>
<td>Only applies to grid-connected sales/resources</td>
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</table>
Table 4

<table>
<thead>
<tr>
<th>Country</th>
<th>Selection of target</th>
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<th>Flexibility mechanisms</th>
<th>Administrative responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Renewables output in GWh set by RPS to achieve a 9,500 GWh increase in renewable energy supplies by 2010</td>
<td>Normal renewables plus biomass wastes, solar hot water, pumped hydro storage (excludes any fossil-fuel based CHP)</td>
<td>Applies to whole country</td>
<td>3 year balancing mechanisms for electricity providers</td>
<td>Utility regulator or separate administrator to be established to certify renewable producers, issue credits, assign individual party’s liability for target, and monitor compliance</td>
</tr>
<tr>
<td>RPS focuses on new renewables, built after January 1997</td>
<td>Only grid-connected sales are liable for target but off-grid projects are eligible for credits</td>
<td>Applies to retailers or wholesale buyers that purchase electricity directly from power pool or its equivalent</td>
<td>Tradable renewable certificates</td>
<td>Penalty of $40 (Aus.)/MWh for kWh in non-compliance</td>
<td></td>
</tr>
<tr>
<td>Target phased in over 10 year period beginning in 2001</td>
<td>Only retailers or wholesale purchasers on grids with more than 100 MW of installed capacity are required to meet standard</td>
<td>Requirement based on proportionate share of total energy sales, not capacity</td>
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</table>

5. Conclusion

The RPS is a policy tool whose rapid rise in popularity is explained by its continuous incentive for renewable producers to reduce costs, its direct link to the attainment of environmental targets, and its reduced requirements for government financial and management involvement. It has been implemented recently by several US states, several European countries and Australia. Many other countries, developed and developing, are also in the process of designing a RPS.

It is too early to provide an evaluation of the success of RPS as a mechanism. However, the survey reported in this paper provides information on the critical considerations in designing a RPS and a general sense of the choices being made by different jurisdictions. A few generalizations can be offered at this point.

The selection of the target involves a three-way trade-off between environmental improvement, long-term technology strategy, and cost. Jurisdictions that are especially focused on getting the greatest environmental improvement at the least cost will have only one standard for all renewables and may even include technologies that are not renewables. Jurisdictions that are interested in long-term development of new technologies will tend to have classes of standards, ensuring a more diverse mix of renewables and even other technologies. Most jurisdictions are concerned with the uncertainty of cost, so cost caps or some equivalent mechanism are common.

In terms of eligibility, most jurisdictions are starting out conservatively, limiting the scope to local renewables, excluding off-grid renewables, and trying to make sure that truly new renewable resources are developed because of the policy.

Geographic application of policies is also limited at this point. However, with Australia as an example, there are efforts in the US and Europe at the federal level for multi-jurisdictional application. The general tendency is to apply the standard to providers rather than consumers of electricity. The standard is almost universally applied to energy production rather than capacity, which is in keeping with the underlying environmental objective. Flexibility mechanisms are widely accepted as desirable. Their implementation is only slowed by the administrative complexity that they entail.

Administration of the RPS in the US and Australia is conducted through a combination of government and then delegation to electricity regulators. In Europe it is more in the domain of government at this point, but various institutional reforms are being undertaken.
All jurisdictions continue to employ a suite of measures to support renewables, even after implementing a RPS.

Acknowledgements

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References


