Policy Analysis

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A Federal Renewable Electricity Requirement

What's Not to Like?

by Robert J. Michaels

Executive Summary

Rising energy prices and climate change have changed both the economics and politics of electricity. In response, over half the states have enacted "renewable portfolio standards" (RPS) that require utilities to obtain some power from "renewable" generation resources rather than carbon-emitting fossil fuels. Reports of state-level success have brought proposals for a national standard. Like several predecessor Congresses, however, the most recent one failed to pass RPS legislation.

Before trying one more time, legislators should ask why they favor a policy so politically correct and so economically suspect. Support for a national program largely stems from misleading claims about state-level successes, misunderstandings about how renewables interact with other environmental regulation, and misinformation about the actual benefits renewables create.

State RPS programs are largely in disarray, and even the apparently successful ones have had little impact. California's supposedly aggressive program has left it with the same percentage of renewable power as in 1998, and Texas's seemingly impressive wind turbine investments produce only two percent of its electricity. The public may envision solar collectors but wind accounts for almost all of the growth in renewable power, and it largely survives on favorable tax treatment. Wind's intermittency reduces its efficacy in carbon control because it requires extra conventional generation reserves. Computer-generated predictions about a national RPS are generally unreliable, but they show that with or without one the great majority of generation investments for the next several decades will be fossil-fueled.

Even without the technological and environmental shortcomings of renewables, the case for a national RPS is economically flawed. Emissions policies are moving toward efficient market-based trading systems and more rational setting of standards. A national RPS clashes with principles of efficient environmental policy because it is a technological requirement that applies to a single industry. Arguments that a national RPS will create jobs, mitigate energy price risks, improve national security and make the United Sates more competitive internationally are in the main restatements of elementary economic fallacies. It is hard to imagine a program that delivers as little in theory as a national RPS, and the experiences of the states indicate that it delivers equally little in practice.

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Introduction

High expectations for "renewable energy" unite activists who decry America's reliance on foreign oil, the high cost of fossil fuels, and the environmental damage they cause. By contrast, the public's knowledge of renewables is spotty and has not noticeably improved with increased media coverage.[1] Nevertheless, opinion polls increasingly show majorities in favor of deploying more renewables to cope with environmental pollution and climate change.

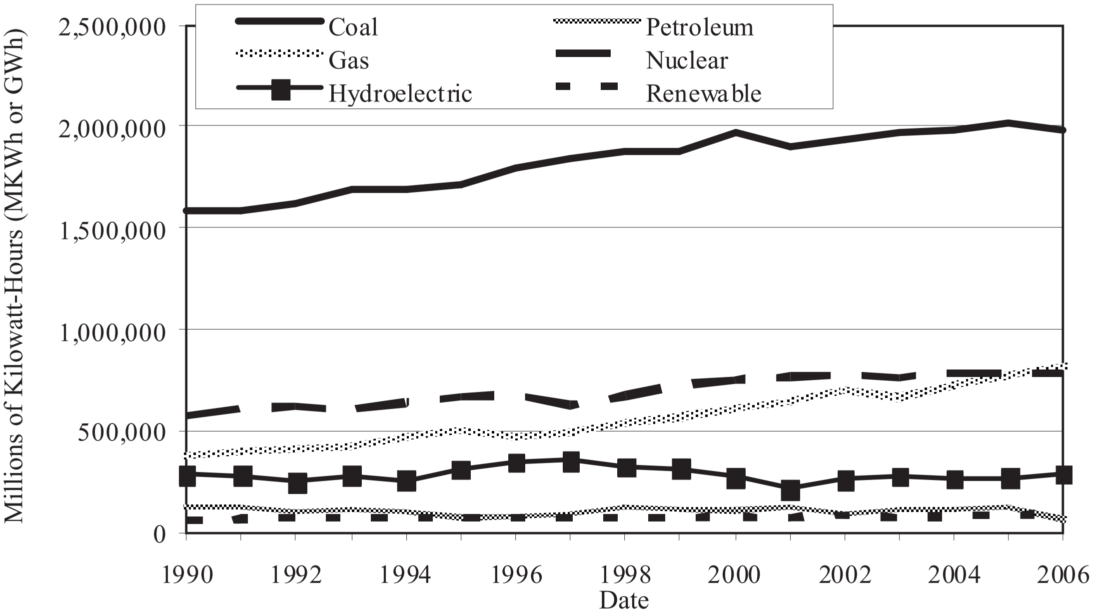
Current renewables policies emphasize four types of generation, which do not include all sources (such as hydroelectric power) that in reality renew themselves:

- *Biomass and Waste Conversion* burn materials to heat water and turn a turbine. Biomass can be the residue of a commercial crop such as cornstalks or pressed sugar cane, or it can be remnants of tree cutting and lumber manufacture. Waste includes discarded organic materials and solids, as well as landfill gas.
- *Geothermal Energy* uses underground heat sources, primarily volcanic magma, to heat water and produce steam. It generally involves the sinking of pipes containing the water to be heated.
- *Wind Energy* uses a rotor and gearing mechanism to turn a turbine when wind is blowing at it.
- *Solar Energy* is of two types. *Photovoltaic* energy is created when sunlight strikes a surface coating and energizes it to react with a substrate to produce direct current. *Thermal* energy can either be "passive," like water heating when exposed to sunlight, or "active," as when several mirrors direct sunlight at a water container that will boil and create steam.

The Economics of Renewable Energy

Figure 1 shows U.S annual power production in millions of kilowatt-hours (MKWh, also known as gigawatt-hours GWh) by type of generator from 1990 to 2006. Over the period it grew by an average of 1.84 percent

Figure 1
Electricity Generation by Source, 1990–2006



Source: U.S. Energy Information Administration, *Electric Power Monthly*, various issues.

per year.[2] Because generators of all types have physical life-spans of 20 or more years and can often be repowered and retrofitted with pollution controls at reasonable cost, the relative magnitudes in the figure will persist for some time.

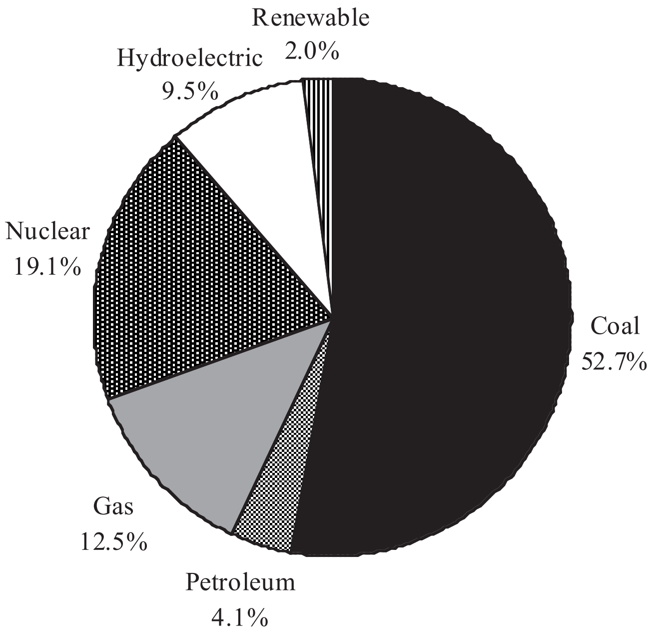
Figures 2 and 3 show both constancy and change in power production by source. Renewables have been the beneficiaries of both private and public investments in research and production, and advocates claim that some of them are competitive with conventional generators, at least in certain applications. Despite the trends and claims, however, most utilities obtain negligible percentages of their power supplies from renewables. Moreover, the share of production by renewables has changed little, moving from 2.03 percent in 1990 to 2.15 percent in 2005 and 2.39 percent in 2006.[3] That's all the more surprising given that environmental regulation has increased the cost of conventional power generation.

Figures 4 and 5 show substantial changes in the relative contribution of various renewables. Biomass (waste and wood) conversion fell from 72.5 percent to 57.5 percent of renewable production between 1991 and 2006.[4] Geothermal fell from 22.8 to 15.3 percent while solar remained a tiny (and declining) percentage. The biggest gainer was wind power, up from 4.2 percent to 26.7 percent.

The continuing insignificance of renewable energy is striking, particularly when compared with the range of government policies adopted to promote it over the past several decades. Both federal and state governments have granted direct payments to producers or indirect transfers like the federal Production Tax Credit for power generated by wind, sunlight and biomass burning, currently inflation-adjusted to 1.9 cents per kilowatt-hour.[5] Other indirect support has included tax-funded research and preferential operating rules (such as California's) that prioritize renewable energy dispatch even when more cost-effective power sources are available.[6] Finally, policies designed to raise the cost of conventionally produced electricity can make renewables

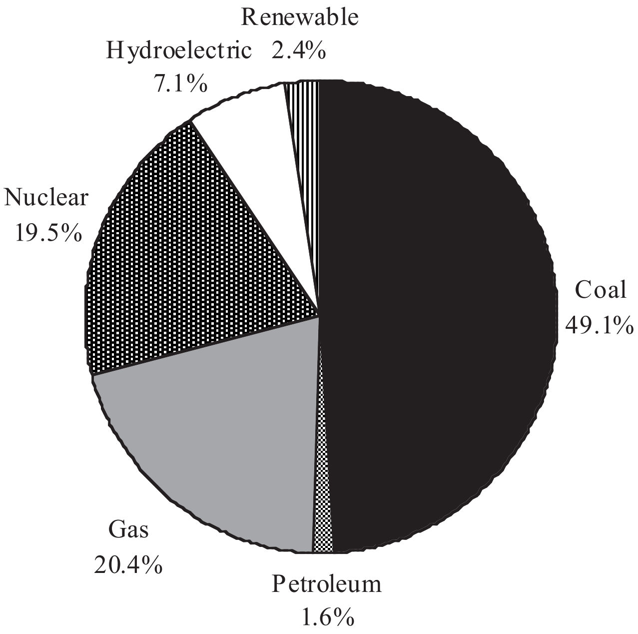
The continuing insignificance of renewable energy is striking, particularly when compared with the range of government policies adopted to promote it.

Figure 2
Percentage of U.S. Electricity by Type of Generator, 1990



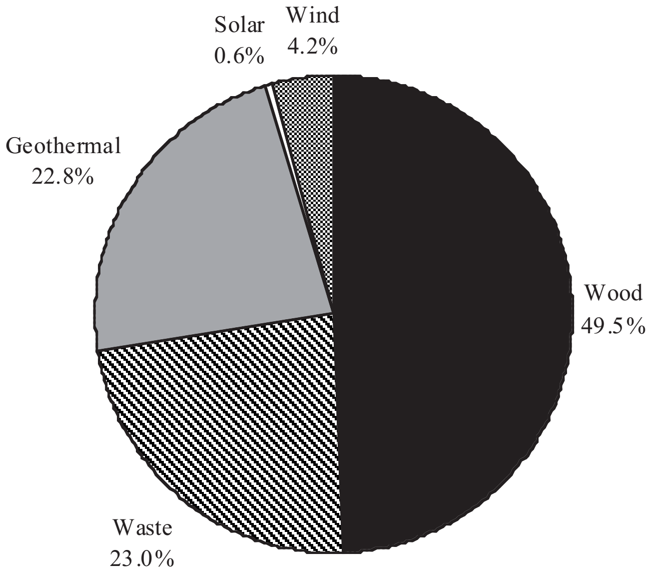
Source: U.S. Energy Information Administration, *Electric Power Monthly*, various issues.

Figure 3
Percentage of U.S. Electricity by Type of Generator, 2006



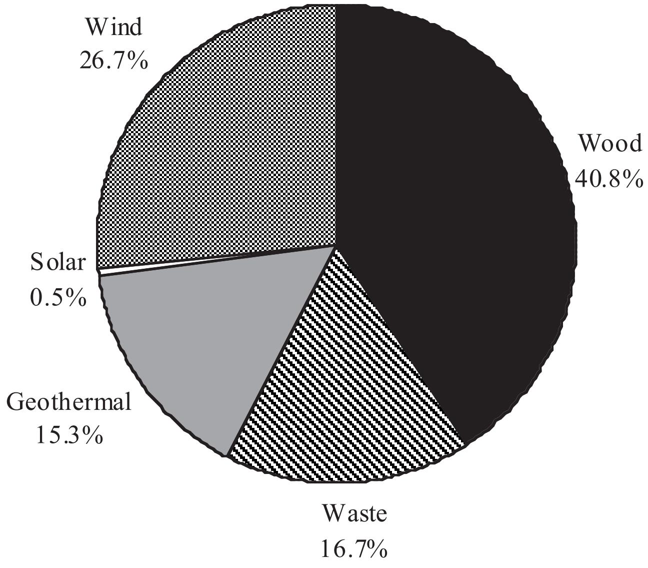
Source: U.S. Energy Information Administration, *Electric Power Monthly*, various issues.

Figure 4
Percent of Renewable Generation by Source, 1991



Source: U.S. Energy Information Administration, *Electric Power Monthly*, various issues.

Figure 5
Percent of Renewable Generation by Source, 2006



Source: U.S. Energy Information Administration, *Electric Power Monthly*, various issues.

more attractive. Such policies include design standards or retrofit requirements for pollution controls, fuel regulations such as limitations on the sulfur content of coal, locational restrictions, and onerous siting procedures.

The continuing high cost of renewable energy has rendered it a minor presence. Table 1 provides 2004 levelized costs (defined as capital costs plus operation and maintenance costs over the lifetime of a facility divided by the total power produced over that lifetime) per kilowatt hour (kWh) for conventional and renewable plants.[7] It shows production costs per kWh calculated under current law, current law without the federal energy production tax credit, current law without the federal investment tax credit, current law with economic rather than accelerated depreciation, a tax regime providing no investment preferences ("level playing field"), and costs assuming zero taxes.

Even if their production costs are competitive, locational constraints on renewables add other important costs that do not apply to conventional plants. Because pipelines and railroads can deliver fuel to the latter, conventional plants can be sited with due consideration for reliability and the cost of moving their power to consumers. A grid's reliability varies with the placement of its generators, and transmission line losses increase with distance. Wind turbines, however, are best located on open, remote plains where the wind blows regularly. "Active" solar collectors require large fields with high exposure to sunlight, and the heat that fuels geothermal plants cannot be transferred like the heat embodied in conventional fuels. Biomass conversion requires abundant farm or logging waste, and a cost-effective biomass generator must be within 50 miles of its fuel source.[8]

The upshot is that renewable generators typically require more installed transmission capacity than conventional ones, and transmission costs are no minor matter. The wind energy industry, for instance, contends that a lack of transmission capacity is the biggest economic obstacle it faces.[9] Accordingly, Senate Majority Leader Harry Reid (D-NV) is currently sponsoring a bill to provide $10 billion in bonding authority to the five regional federal power administrations for transmission lines intended to reach renewable facilities .[10]

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Table 1
Real Levelized Costs of Electricity

Technology	Current Law	No PTC	No ITC	Economic Depreciation	"Level Playing Field"	No Tax
Nuclear	4.31	5.55	4.31	4.70	5.94	4.57
Conventional Coal	3.53	3.53	3.53	3.79	3.79	3.10
Clean Coal (IGCC)	3.55	3.55	4.06	3.80	4.37	3.53
Natural Gas	5.47	5.47	5.47	5.61	5.61	5.29
Biomass	5.34	5.56	5.34	5.74	5.95	4.96
Wind	5.70	5.91	5.7	6.42	6.64	4.95
Solar Thermal	12.25	12.25	16.68	13.74	18.82	13.84
Solar Photovoltaic	22.99	22.99	32.6	26.34	37.39	26.64

Source: Gilbert Metcalf, "Federal Tax Policy Toward Energy," National Bureau of Economic Research Working Paper 12568 (Oct. 2006) at 36.
Note: All figures are cents per kWh at 2004 prices. Details of assumptions and calculations are given in source.

Sporadic operation of many renewable energy facilities compounds the problems of locational specificity.

Sporadic operation of many renewable energy facilities compounds the problems of locational specificity. Wind turbines only produce when the wind blows and cannot be dispatched like conventional powerplants when they are needed for system reliability. Storage technologies for large amounts of electricity are still on the distant horizon and will in any case be expensive. Accordingly, most wind power and solar power plants require additional provisions for reserves, a topic discussed in more detail below. Moreover, transmission that links sporadically available power sources to distant consumers will only occasionally be used to capacity.

The locational needs associated with many renewable energy sources have other consequences. First, generating equipment can be mass-produced, but sites cannot. The U.S. Department of Energy has expressed concern that the best available wind sites are already in use, and even if generation technology continues to improve, newer installations will be less productive than earlier ones.[11] Second, a national RPS would have to account for interstate disparities in available renewable sites. It is generally agreed that some market for "credits" must emerge, in which utilities with few nearby renewables can purchase claims on output from distant producers to fulfill their RPS requirements. A credit system may be necessary for efficiency, but legislators will soon notice (if they have not already) that some of them represent areas that will consistently profit from the sale of credits and others represent areas whose residents must continually pay for them. Third, generators bidding in competitive power markets must generally commit themselves a day in advance of operation due to startup and shutdown costs. Adding more as-available renewables (above some minimum threshold) and giving them priority will increase operating costs.

The Birth of RPS

The generally poor results of earlier initiatives to increase generation from renewables have led their proponents to favor production quotas. Renewable portfolio standards (RPS) require that a set percentage of power delivered to a utility's customers be derived from renewables of the types described above. As of October 2007, 25 states and the District of Columbia had instituted some form of RPS.[12] Six other states have non-binding percentage renewable goals. Table 2 provides a summary of the states' basic provisions, which sometimes also include set-asides for particular types of renewables.

There is a great deal of support for a federal RPS in both political parties.[13] By one count, 17 pieces of legislation that included a nation-

Table 2
State Renewable Portfolio Requirements*

State	Target	Other Characteristics
AZ	15% by 2025	30% of renewables to be on-site after 2011, solar setaside
CA	20% by 2010	1% annual increase required
CO	20% by 2020	4% of requirement from solar, 10% overall required for municipals and coops
CT	23% by 2020	Three-tier system
DC	11% by 2022	Complex 2-tier system, requires 0.386% solar by 2022
DE	20% by 2019	2% solar by 2019
HI	20% by 2020	
IL	25% by 2025	At least 75% of renewables must be wind, annual increases required
IA	105 MW, no date	
MA	4% by 2009	1% annual increase also required after 2009 until regulators end requirement
MD	9.5% by 2022	2% of total power must be solar
ME	30% by 2000	10% new resources by 2017
MN	25% by 2025	Xcel Energy quota of 30% by 2020
MT	15% by 2015	
NH	23.8% by 2025	
NC	12.5% by 2021	10% for municipals and coops
NJ	22.5% by 2021	2% of renewable generation to be solar
NM	20% by 2020	
NV	20% by 2015	5% of total to be solar, energy efficiency credits up to 25% of total
NY	24% by 2013	1% of generation to be customer-sited renewables
OR	25% by 2025	5–10% for smaller utilities
PA	18% by 2020, 8% Tier 1 (renewables), 10% Tier 2 (includes non-renewables)	0.5% solar by 2020
RI	16% by 2020	1% annual increases required
TX	5,880 MW by 2015	
WA	15% by 2020	
WI	10% by 2015	Utilities have different percentage requirements

Sources: Database of State Incentives for Renewables & Efficiency (DSIRE), “Renewable Portfolio Standards,” map at http://www.dsireusa.org/documents/SummaryMaps/RPS_Map.ppt and Pew Center on Global Climate Change, “States with Renewable Portfolio Standards,” http://www.pewclimate.org/what_s_being_done/in_the_states/rps.cfm.

*Some states have non-binding goals. They include Missouri (11% by 2020), North Dakota (10% by 2015), South Dakota (10% by 2015), Utah (20% by 2025), Vermont (renewables to meet load growth by 2012), and Virginia (12% by 2022) North Dakota (10% by 2015), Vermont (renewables to meet load growth by 2012), and Virginia (12% by 2022).

al RPS were introduced between 1997 and 2006.[14] In June 2007, the U.S. Senate narrowly rejected a 15 percent quota, but in August the House of Representatives passed one.[15] The House again adopted an RPS in the energy bill passed on December 6, 2007, but RPS proponents in the Senate could not overcome a filibuster against the same provision and were forced to eliminate it from the energy bill passed later that month.[16]

Environmental organizations and firms that would profit from an RPS lead the parade of RPS supporters, but policy elites embrace RPS as well.[17] The privately funded National Commission on Energy Policy recommends a federal RPS that will require 15 percent renew-

The generally poor results of earlier initiatives to increase generation from renewables have led their proponents to favor production quotas.

A national RPS is being sold to policymakers as something akin to a free lunch.

able power by 2020.[18] Consulting firms frequently issue encouraging public reports.[19] Public policy intellectuals are almost uniformly supportive of RPS.[20]

Private support for RPS is reinforced by governmental agency support. The U.S. Environmental Protection Agency cannot officially lobby for a national standard, but agency documents suggest support for state programs.[21]

Finally, a number of utilities that would be subject to RPS have also embraced it. Southeastern utilities played a major role in derailing RPS in the Senate's 2007 energy bill, but supporters include Pacific Gas & Electric's Peter Darbee and National Commission on Energy Policy Co-Chair John Rowe of Exelon Corporation, the parent of Chicago's Commonwealth Edison and Philadelphia's PECO.[22]

A national RPS is being sold to policymakers as something akin to a free lunch, with an amazingly large roster of social and economic benefits. Proponents claim that it will:

- improve environmental quality and reduce greenhouse gas emissions;
- reduce demand for natural gas to such an extent that the slightly higher electricity prices that an RPS might deliver would be more than offset by declining natural gas prices;
- so stimulate the renewable energy sector that production costs will decline, both hastening and making an inevitable transition away from fossil fuels less painful;
- allow America to dominate the renewable energy business, and the increased exports that follow will create jobs to replace those lost from reduced conventional power production;
- reduce price volatility in electricity markets because renewables will grow primarily at the expense of natural gas-fired production, whose costs are determined in the highly volatile natural gas market;
- reduce future generation requirements because a properly designed RPS can be better coordinated with policies for demand management and with energy efficiency standards for appliances and lighting;
- enhance economic efficiency by allowing firms to trade renewable energy credits in the same manner that business trade SO_2 emission allowances under the 1990 Clean Air Act; and
- move foreign policy in a positive direction by freeing us from dependence on distant and unstable energy sources, while simultaneously allowing us to set a positive example for the world as it moves into a climate-constrained future.

This study examines the above claims and finds them without merit. First, I examine the regulatory architecture of state RPS laws and discover that they are poorly designed and ineffective, with loopholes, exceptions, and ambiguous language that can be used to suggest compliance with unreachable targets. Second, I examine the content of the California RPS and utility responses to it in greater depth as possible indicators of how a national RPS might play out in practice. Third, I critically examine the methods and results of cost-benefit studies that have analyzed a national RPS, and conclude that its environmental effects will be more modest than expected and its consumer benefits may well be negative. Fourth, I consider the environmental case for an RPS and conclude that renewable energy mandates are poor tools for addressing environmental "market failures." Fifth and finally, I find reason to reject the macroeconomic case for an RPS as a "job creation" program.

The Regulatory Architecture of RPS Programs

RPS standards differ significantly from state to state, and those differences are important determinants of their costs and benefits. Accordingly, the regulatory architecture of state programs warrants further examination. Broadly, economic considerations often appear secondary to political considerations in RPS design. Exceptions and provisions that allow non-compliance probably reflect the

Table 3
Eligible Technologies under State RPS Requirements or Goals, Jan. 2008

	AZ	CA	CO	CT	DE	DC	HI	IA	IL	MA	MD	ME	MN	MO	MT
Biomass	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CHP, Waste Heat	X			X			X					X			
Energy Efficiency							X		X					X	
Fuel Cells				X								X	X		
Geothermal	X	X	X		X	X	X				X	X			X
Hydro		X	X	X	X	X	X	X	X		X	X	X		X
Landfill Gas	X	X	X	X	X	X	X		X	X	X	X		X	X
Municipal Waste		X		X		X	X	X			X	X	X		X
Ocean Thermal		X		X	X	X	X			X	X				
Solar Photovoltaic	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Solar Thermal	X	X		X	X	X	X		X	X	X	X	X	X	X
Tidal		X		X	X	X				X	X	X			
Wave		X		X	X	X	X			X	X				
Wind	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

	NC	ND	NH	NJ	NM	NV	NY	OR	PA	RI	TX	VA	VT	WA	WI
Biomass	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CHP, Waste Heat	X	X				X			X					X	
Energy Efficiency	X					X			X					X	
Fuel Cells				X	X				X						
Geothermal	X	X		X	X	X		X	X	X	X	X		X	X
Hydro	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Landfill Gas	X		X	X	X	X	X	X	X	X	X		X	X	X
Municipal Waste			X	X		X			X				X		
Ocean Thermal			X				X	X		X	X			X	
Solar Photovoltaic	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Solar Thermal	X	X	X		X	X			X		X	X	X	X	X
Tidal			X	X			X	X		X	X	X		X	X
Wave	X		X	X			X	X		X	X	X		X	X

Source: EPA, Renewable Portfolio Standards Fact Sheet, Jan. 2008. http://www.epa.gov/chp/state-policy/renewable_fs.html

The actual experience with RPS at the state level is a powerful argument against extending it to the nation.

high costs of full compliance in many states. Rather than science or economics, politics often determines whether a resource is or is not renewable. Whatever attraction RPS programs might have in theory, they are far less attractive in fact. The actual experience with RPS at the state level is a powerful argument against extending it to the nation.

Targets and Timetables

All state RPS laws specify dates by which utilities are to meet their requirements.[23] There are few indications, however, that regulators or elected officials have set their targets on the basis of an economic (benefit-cost) analysis.[24] Instead the standards have been largely determined by rhetoric rather than forecasts of their actual effects.[25] A higher target (if it is actually met) puts more renewables in place but probably at higher costs per unit of capacity if construction must be rushed or inferior sites must be used.

Almost every RPS state has also set intermediate targets. California's 2002 renewables law (as amended in 2005), for instance, requires 1 percent annual increases, which, if achieved, will meet a 20 percent 2010 target. Like final targets, intermediate ones are more grounded in politics than economics. Some advocates expect that the enactment of unattainable targets will intensify the search for breakthrough technologies, but regulatory reality may say otherwise. A utility facing an RPS may prefer familiar resources over unproven ones, knowing that regulators have previously allowed pass-through of the formers' costs. More speculative technologies that fail can put the utility out of compliance and at risk of regulatory disallowances for imprudence.[26] Managerial risk aversion may partially explain the dominance of wind resources in most RPS states and the generally low use of novel technologies.

Almost all RPS states have cost caps, some in the form of maximum prices for purchased renewables and others as maximum allowable increases on consumers' bills. If no qualifying power is available for less than the cap, the utility is exempted from its RPS requirement.[27] Once again, little or no evidence is available to suggest that economic analysis played a role in setting these caps. Finally, some states allow out-of-state resources to satisfy their RPS, while others have in-state restrictions. The latter, however, may soon result in constitutional litigation.

Defining "Renewable"

Any RPS must define "renewable." The task is not as easy as it appears because both politics and technology matter. Table 3 shows the energy sources that qualified in 2006 under various state RPS.

As a group, these states agree on only three technologies; biomass conversion, solar photovoltaic and wind.[28]

- Reserves of fossil fuels grow through discovery, but most state RPS programs treat them as literally nonrenewable. Among the exceptions, Pennsylvania treats coal waste as renewable and Maine does likewise for efficient gas-fired generators.
- Some states call gas-burning fuel cells renewable, others require them to use renewable energy sources, and still others disqualify all fuel cells.
- Uranium is technically "non-renewable," but supplies are so abundant that depletion is no real concern. Even if nuclear energy is *de facto* renewable, no state includes it.
- Waste-to-energy facilities burn trash, a resource hardly at risk of "depletion." Only nine states, however, define it as renewable.
- Rivers and reservoirs regularly renew themselves but most RPS states only call *small* hydroelectric facilities (5 to 60 megawatts (MW)) renewable.[29]
- Most RPS states lump all renewables together into equivalent megawatts regardless of their technologies and operational characteristics. Others, like Connecticut and Pennsylvania, have "tiers" for more exotic (solar) and less exotic (waste burning) sources. Still others have set-asides like Nevada's 5 percent solar requirement.

Demand management ("conservation") can substitute for energy production from any source, but RPS programs seldom consider it. Complex "Integrated Resource Planning" (IRP) regimes such as California's claim to treat conservation symmetrically with generation as a source of "electricity services."[30] If they are symmetric, however, an RPS devoted exclusively to renewables or uncoordinated with demand management will surely be inefficient.[31]

Demand management often takes the form of rate schedules with provisions such as real-time pricing or interruptibility intended to make users realize the full cost of the power they are consuming that moment. Regulators have given little attention to the relationships between time-sensitive rates and renewables, which may be important because most renewables operate only sporadically and changes in their availability can impose important costs on utilities and their customers.

Regulatory Institutions

RPS exemplifies a *quota obligation* in which government sets a goal, timetable, and penalties for noncompliance. Three basic mechanisms are in use to implement and monitor renewables policy:

- A utility chooses how to meet the goal, but further regulatory intervention in the planning process may be possible.
- A *feed-in tariff* fixes the amount that the utility or government will pay for a unit of renewable energy or capacity. Users may pay the tariff in full, or it may be subsidized.
- In a *tender* system the utility or government specifies an amount of renewable capacity or energy and accepts the lowest qualifying offer(s) to supply it.[32]

Any of these could in principle minimize the cost of procuring a given quantity of renewable energy. For instance, assume a quota of 1,000 MW of renewable energy capacity. One producer can make up to 600 MW for $1 million per MW, and several others can produce any desired quantity for $2 million. If the buyer knew everyone's cost (and was a good bargainer) it could offer just over $1 million to the first supplier and just over $2 million to one or more of the others.

Such knowledge is unlikely, so instead, assume a feed-in tariff of just over $2 million. The first producer will happily take the offer and the rest will come from those with higher costs (Some other rules must ration the last 400 MW among those offering to supply it).

Alternatively, assume a tender system in which the buyer accepts offers up to a total of 1,000 MW. The first producer will offer between $1 and $2 million, and some of the others will supply the rest. Both the quota and the feed-in tariff are economically efficient. There is no way to get this quantity of renewables for a smaller value of alternatives.

The cost of generating renewable energy varies by facility and is often not public information. If sellers privately submit bids and each winner is paid the highest bid accepted—as is the case in a tender system—each seller's best strategy is to bid its true costs.[33] Winning bidders subsequently have an incentive to produce efficiently because they retain the difference between their bids and their costs.

A feed-in system requires the *buyer* to set a price, but without accurate information about sellers' costs it will probably set the wrong price. The buyer will either offer too little and fall short of its desired amount or offer more than is necessary for it.

Some renewable energy advocates prefer a feed-in system because it gives suppliers price certainty.[34] A tender system's market-clearing price, however, also provides certainty. State price-setting experiences under the Public Utility Regulatory Policies Act of 1978 suggest that prices under a feed-in system will often be set incorrectly and be politically difficult to adjust.[35]

Different mechanisms provide different incentives for innovation. In principle, a feed-in tariff will outperform a tender system (at least for the final units to be supplied) because an innovator will keep all of the difference between the offered price and its own costs.

Prices under a feed-in system will often be set incorrectly and be politically difficult to adjust.

Even efficient feed-ins and tender systems for renewable energy may make energy markets more inefficient.

Under a tender system, if higher cost producers lower their costs by innovating, market price will fall and, with it, the return to non-innovating producers. Tradable credits concentrate inventive efforts on those technologies that are closest to maturity, rather than those whose costs will drop by more if efforts are made over longer periods.[36]

Even efficient feed-ins and tender systems for renewable energy may make energy markets more inefficient. The remarkable rise in the efficiency of gas-fired generation in the 1980s and 1990s, for instance, suggests that considerable improvements in conventional plants are still possible. Both feed-in and tender systems, however, only provide incentives for improving the efficiency of renewables, potentially "crowding out" more efficient technologies in conventional generation.[37]

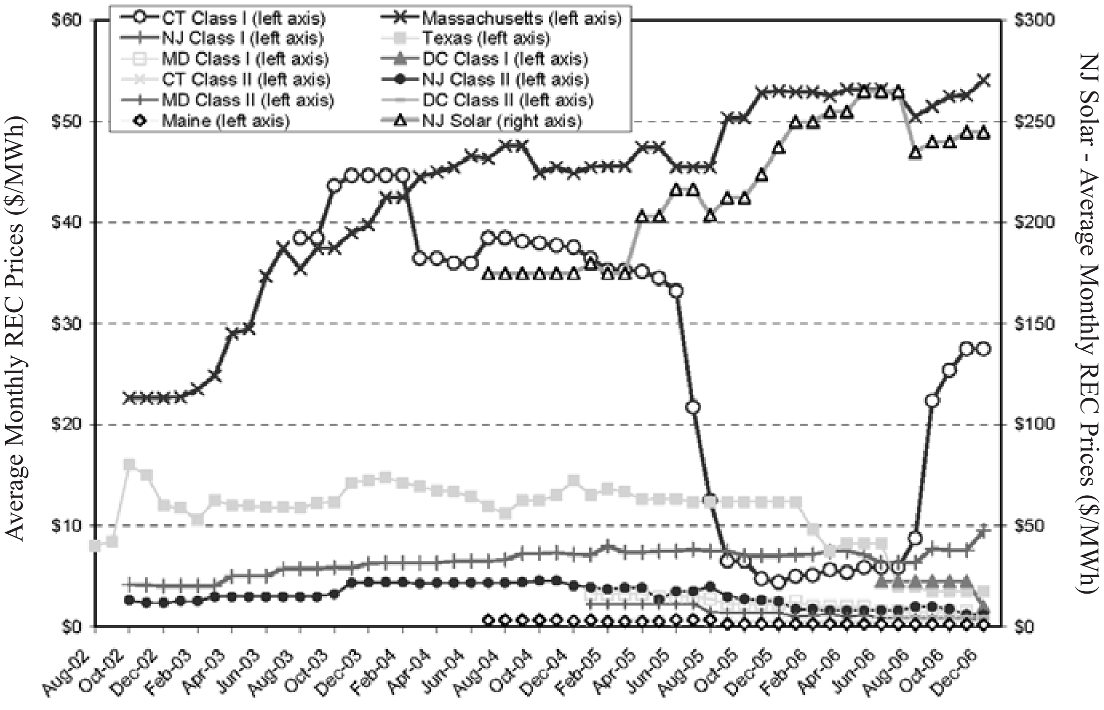
Compliance and Trading

All state RPS programs require regular reports from utilities on compliance with their timetables. Compliance, however, has been specified in ways that range from full integration of renewables to the signing of contracts for facilities yet to receive construction permits. As the general failure of states to comply becomes evident (see below), some like California have chosen to redefine compliance downward, even in the face of legal provisions that require actual operation of a plant.

In most RPS states, compliance can be achieved by direct utility investments, operating arrangements with non-utility renewables owners, or the purchase of Renewable Energy Credits (RECs). A utility short of its RPS requirement must pay a market price for credits that give it a claim on a qualifying renewable source. In principle, REC markets can facilitate new investments while allowing resource-poor utilities to achieve compliance.

Currently REC markets are regional in scope. They exchange credits at market prices, typically bundled with power from the

Figure 6
Compliance REC Prices in Various States, 2002–2006



Ryan Wiser et al., "Renewables Portfolio Standards: A Factual Introduction to Experience from the United States," LBNL-62569, Lawrence Berkeley National Laboratory, April 2007, p. 11.

credited source.[38] If eligible capacity is tight, they will sell at roughly the premium for a renewable over a conventional source.

Almost all state REC markets, however, have ceiling prices. If no capacity is available at the ceiling, some require payments from utilities to fund renewable research or subsidies. In some regulatory systems utilities can pass such charges on to their ratepayers.

RECs may be traded as their holders desire, but in practice an REC market operates on a razor's edge. When capacity is insufficient, the ceiling price prevails. But when it grows to exceed the RPS, a credit becomes almost worthless.

This uncertainty leaves renewables developers unable to collateralize REC revenues for financing, and price ceilings prohibit them from realizing the scarcity values of their plants when capacity is short. If eligible renewables are scarce, RECs will trade in thin markets whose prices will have less information content.

Figure 6 shows the evolution of REC prices in some states that have relatively liquid markets.[39]

It is difficult to make generalizations about the data; each state's experience has been different. Maine's existing biomass (wood chip) conversion capacity, for instance, exceeds its RPS requirement, and its RECs accordingly sell for negligible prices. Massachusetts' prices have increased as its utilities have experienced increasing shortfalls from their annual RPS requirements (see below). Prices for Connecticut's "Class I" credits (solar, wind, new sustainable biomass, and others) began high and then fell radically after a regulatory redefinition of eligible biomass capacity made it temporarily redundant. Credits against New Jersey's solar set-aside requirement (measured on the right-hand axis) currently carry extremely high prices. Unlike most other states, New Jersey has no price ceilings.

Still, renewable contracts and credits currently have only minor impacts on retail rates in most states because they are still in the early stages of their phase-ins. Rates thus far have increased only from 0.1 percent (Maine) to 1.1 percent (Massachusetts).[40]

Utilities can meet state requirements by purchasing RECs, but credits are not the same as power itself. A source of RECs that is not interconnected with the RPS state—or is not dispatchable for other reasons—will be worth less to the grid operator and require additional arrangements to ensure reliability.[41] In some states a utility may purchase RECs from a generator who cannot economically deliver the power to the utility's territory.

States vary in their interconnection requirements for RECs. At one extreme are the few that require in-state sources, possibly in violation of the Constitution's Commerce Clause. California and some others require deliverability into the state, which may both satisfy the Commerce Clause and allow Californians to enjoy some of the renewables' benefits.[42] A few others allow deliveries anywhere and do not require interconnections.

However well or poorly they function, REC markets matter for compliance. Even under favorable assumptions about state funding of supplemental payments for renewables (see below), California will require an REC market if it is to come into compliance with its own standards.[43] RECs may also be important obstacles to a national RPS. At least for the medium term, some utilities will see steady deficits and others will get long-lived streams of REC payments from them.[44]

The crediting mechanism is inequitable in a second way. If air quality is localized, a renewable may benefit those who reside near it and not those served by a distant utility that buys its RECs. The latter pay higher bills to improve the environments of others, who can take the benefits with them because air quality is monetized in real estate markets. Homes in clean environments sell at premiums relative to similar ones elsewhere.[45] Any further analysis depends on the degree of localization. Supporters of a national RPS argue that without it non-RPS states will "free ride" and get better air without paying for it.[46] If air quality is local, however, RECs allow people in renewable-rich areas to free ride on credits purchased by people whose air remains unimproved.

Market uncertainty leaves renewables developers unable to collateralize REC revenues for financing.

The Politics of RPS

Why have some states adopted RPS while others have not? A regression analysis helps us to determine the characteristics of adopters and non-adopters:

- States with high per capita income are more likely to adopt RPS standards than states with low per capita income.[47]
- RPS states have significantly lower Republican voter registrations, but the effect of Republicans vanishes when income is added to a multiple regression.
- A higher residential price per kWh (perhaps reflecting more stringent preexisting regulation) raises the likelihood of an RPS, but income also washes out its effect.
- States with appointed rather than elected commissioners are more likely to have RPS, but this effect also vanishes when income is added to the regression.
- The probability of an RPS is unrelated to the amount of renewable energy generating capacity in the state, and it is also unrelated to gas price risk exposure as measured by the percentage of gas-fired generation. Having more coal-fired generation, however, lowers the likelihood of an RPS, even in regressions with income included.
- An RPS looks like a luxury good whose purchase depends on the strength of existing conventional energy interests.

Enthusiasts for a national RPS appear to be unaware of state-level compliance problems or have chosen to disregard them in the expectation that a federal standard will force compliance.

The first states to adopt an RPS were Iowa (1991), Massachusetts (1997), Minnesota (1997), and Nevada (1997). All were in compliance with their initial requirements, but Massachusetts and Nevada have since fallen into deficit. Iowa's requirement is so small (105 MW) that compliance is not an issue. Minnesota (whose definition of renewables includes hydropower) began with an easy standard but in 2005 reset it to a goal of 20 percent by 2015. Minnesota, like Massachusetts and Nevada, is also out of compliance with its timetable.

The remarkably low level of compliance with even modest RPS requirements warrants further examination, particularly because nearly all RPS states impose seemingly stringent penalties for noncompliance.[48] A possible explanation lies in the fact that most RPS states have cost caps on renewables that can excuse utilities from their requirements if prices are too high.[49] A national RPS might well contain similar escape provisions.[50]

Enthusiasts for a national RPS appear to be unaware of state-level compliance problems or have chosen to disregard them in the expectation that a federal standard will force compliance.[51] The May 2007 *Electricity Journal*, for instance, contains six articles that as a group attempt to make a comprehensive case for a national RPS. They contain much useful data, but figures on state-level compliance are conspicuously absent, as is also the case in other endorsements of a national RPS. Instead, advocates like Sovacool and Cooper are quick to tell us that California, New York, and Nevada have "made impressive progress."[52] The Pew Center on Global Climate Change likewise notes that "In a number of instances, RPSs have clearly played a central role in fostering rapid and significant expansion of the amount of renewable energy provided in a state."[53] Its report concentrates on five states, "chosen to maximize diversity among key criteria" and "intended to provide a representative sample."[54]

A closer examination of those states is instructive.

Texas

Texas's 1999 retail choice legislation included a requirement that 2,000 new MW of renewable capacity be built by 2009 in the territories of the five utilities that make up the Electric Reliability Council of Texas (ERCOT).[55] A boom in wind turbine construction (to the exclusion of other renewables) led to attainment of that goal in early 2007. In 2000 the legislature raised the amount to 5,000 MW by 2015 and 10,000 by 2025, with at least 500 MW of the 2025 total from renewables other than wind. Each retail server (utilities and competitive suppliers) must own capacity or obtain credits proportional to its share of load.[56] Since almost all wind generation is at some distance from consuming areas, many retailers meet their requirements by purchasing credits from its owners. There is currently an active market in these credits.[57] Texas is alone among the states in staying ahead of a meaningful renewable requirement. Even so, the Pew report fails to discuss the actual contribution that renewables make to the electricity system. As discussed in more detail below, during summer peak-load periods the state's wind units produce only 2.9 percent of their nominal capacities.[58] Thus the state's 2,800 MW of wind equate to a considerably smaller amount of dependable capacity.

During summer peak-load periods Texas's wind units produce only 2.9 percent of their nominal capacities.

Massachusetts

Industry restructuring brought Massachusetts an RPS in 1997. Pre-existing capacity sufficed to meet a one percent requirement that was in effect through 2002. In each subsequent year the state's utilities were to obtain 0.5 percent more renewable output from new or upgraded facilities to reach a 4 percent goal in 2009.[59] Resistance from rural residents, environmentalists, and the state's two U.S. Senators has dimmed expectations that wind power would suffice to satisfy the RPS.[60] Utilities achieved compliance in 2003 by using credits banked in 2002. They then fell 32.6 percent short of 2004's 1.5 percent requirement, and by 2005 (the latest available data) the gap had increased to 37.4 percent.[61] Utilities had to pay the state $55.13 for each deficit MWh in addition to the actual cost of obtaining or producing the power.[62] Even Pew's optimistic author sees "considerable uncertainty regarding Massachusetts' ability to achieve its ascending RPS targets."[63]

Nevada

The Pew report sees Nevada as possibly the next Texas. Its 2005 RPS regulations mandate annual increases that will give renewables 20 percent of the electricity market in 2015, 5 percent of which must be solar power. One might expect easy attainment of Nevada's targets, given its windy deserts and proven geothermal resources. In reality, the state produced no wind power at all in 2006. Nevada Power's (Las Vegas) and Sierra Pacific Power (Reno) have together signed contracts for power sufficient to comply with the state's 9 percent 2007 requirement, but their actual supplies were 3 and 6 percent respectively. Nevada Power met its requirement by purchasing 1.02 million kwh from Sierra Pacific, which was unable to deliver them over their weak interconnection.[64] Both utilities are also behind on their solar quotas. (Nevada currently has no penalties for noncompliance.) The Pew report notes the two utilities' financial difficulties, but claims that new project proposals and applications have left officials "increasingly sanguine" about future RPS compliance.[65]

Pennsylvania

Pennsylvania's "Alternative Energy Portfolio Standard" sets up a two-tier requirement. The first includes commonly recognized non-hydro renewables and has a solar set-aside. The second includes incinerated trash and waste coal, although environmentalists view the latter with some alarm. The tiers are to produce 8 and 10 percent of Pennsylvania's power in 2021. A utility only falls under the standard after recovering transition costs that it incurred in the state's restructuring program. Three utilities became subject to RPS on Feb. 28, 2007, and the others will join them at various dates up to Jan. 1, 2011.[66] As of this writing there are no publicly available data on compliance.[67]

Colorado

The Pew report discusses Colorado for only one discernible reason: a November 2004 referendum there authorized a 10 percent RPS by 2015. A 2007 law raised this to 20 percent by 2020, with a 4 percent solar set-aside. Municipal utilities and rural co-operatives are subject to lower requirements. Compliance data are currently unavailable, and some rules are still being made. Pew's author apparently mentions Colorado because it shows that referenda are potential alternatives to regulation.[68]

RPS in California: A Cautionary Tale

The 2006 Pew report finds only one of its five representative states in compliance with its own RPS, and the value of renewables to that state's system is far less than their nominal capacity might suggest. Two of the five states examined by Pew were out of compliance as soon as their requirement became binding. A fourth uses a controversial definition of renewables and has no available compliance data. The last does not have all of its rules in place to implement its program.

Pew, however, chose not to examine California. That's unfortunate, because California may provide the best forecast of what will happen under a federal RPS.

California may provide the best forecast of what will happen under a federal RPS.

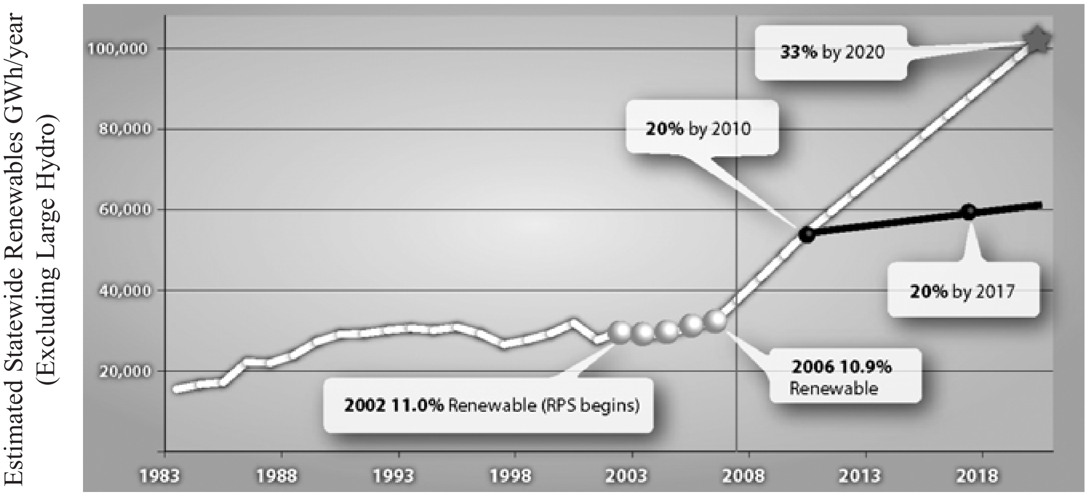
The History of RPS in California

The double-digit RPS first took root in California in 2002, an almost natural extension of the integrated resource planning that was reinstated after California's failed attempt at designing power markets. It originally required each of the state's three large corporate utilities to increase renewable purchases by at least 1 percent a year to reach 20 percent by 2017. A 2005 law advanced the 20 percent deadline to 2010 and set an additional goal of 33 percent by 2020.

The return of integrated resource planning has made RPS compliance an integral and politicized part of utility procurement reviews. The law defines compliance as actual operation of the renewable facility, but all sides are stepping back from any literal use of that definition for reasons made clear in Figure 7.[69]

Even with mandates and subsidization, renewables have failed to take off in California—or even to keep up with load growth.[70] In 1998 10.7 percent of the utilities' power came from renewables, a figure that had only grown to 11 percent when the RPS became effective in 2002. In May 2003, the California Public Utilities Commission (CPUC) estimated that reaching 20 percent by 2010 would require 4,200 MW of new renewables by then. Between 2003 and January 2007, however, only 242 MW of new renewables went on-line.[71] By 2007 renewable power had fallen to 10.7 percent of utilities' supplies, the same fraction as in 1998.

Figure 7
Actual California Renewable Power Production vs. RPS



Source: California Energy Commission, "2007 Integrated Energy Policy Report," Final Commission Report no. 100-2007-008-CMF, p. 126.

2007 saw the addition of only 114 MW renewable capacity, 85 MW of it located in Oregon. The CPUC estimates that only 140 MW will actually begin operation in 2008.[72] The many reasons for this poor performance included siting difficulties, delays in the planning process, contracting problems, and uncertainty about future regulation, including the state's greenhouse gas reduction program. All of these would also be present under a federal RPS, which will need provisions to determine which reasons for failure or delay are the utility's responsibility and which are not.

Compliance in Theory and Practice

It is difficult to envision a federal rule that would not produce disputes over compliance like those taking place in California. Its utilities claim to be in compliance because, as of August 2007, they had signed contracts with developers for 4,805 MW.[73] Projects that account for over half of that total, however, have yet to even begin the environmental review process necessary to begin construction. Another important percentage of the renewable energy generating capacity to-come is scheduled to be built in areas that cannot currently be reached by transmission lines.

Using contracts to measure compliance puts all megawatts on an equal footing despite the fact that some use established technologies and others are highly speculative. The latter include Southern California Edison's 500 MW "Stirling engine" solar array whose footprint will cover 7 square miles, with an option to expand to 850 MW. San Diego Gas & Electric has contracted with the same developer for 300 MW, expansible to 950.[74] If all are built, they will cover 25 square miles. The developer's largest installations to date produce 150 *kilowatts*, but San Diego chose not to require even a 1 MW pilot project.[75] These projects alone render over a third of claimed compliance capacity speculative at best.[76]

Wind and solar power account for nearly all of the remaining contracts, but transmission to some sites does not yet exist. The California Energy Commission (CEC) estimates a cost of $1.2 billion for transmission necessary to carry all of the claimed 2010 compliance capacity.[77] Even if contracts are valid measures of compliance, a 2006 CEC study estimates that 20 to 30 percent of them will fail.[78]

Wind units make up a substantial portion of the claimed compliance total, but nearly half of them will be unable to contribute power to the system (even when the wind is blowing) unless additional transmission is built, which requires time-consuming determinations of necessity and environmental compliance. Adding together renewable capacity installed between 2002 and 2007, approved but non-operational capacity, and proposed capacity, as of January 2008 only 1664 of 6,359 MW (26.1 percent) would be dispatchable biomass, geothermal and small hydro facilities. The state's future reliance on intermittent renewables will be even greater. Of approved new capacity, 1,956 of 2,298 MW (85.1 percent) are nondispatchable wind or solar.[79]

Regulating Procurement

The California utilities' remarkable lack of compliance in part reflects planning and procurement requirements also enacted after the state's failed restructuring. The complex process of evaluating a renewable generation opportunity begins with a "market price referent" that compares the 10-year levelized cost of the renewable with that of a new gas-fired plant. The MPR is a ceiling on what the utility must pay for the power. Assuming the renewable's cost is low enough to allow its procurement but above the MPR, the state gives the utility or developer a "Supplemental Energy Payment" equal to the difference. The funds come from banked "Public Goods Surcharges" previously paid by consumers as 3 percent premia on their bills. The CPUC is concerned that the increasing costs of renewables, particularly wind, will soon exhaust funds available for SEPs.[80]

The byzantine rules require that the utility use a "least-cost best-fit" (LCBF) procedure to determine compatibility of the renewable with its existing resource mix. Next, it submits a "transmission ranking cost report" (TRCR) to evaluate the plant's impact on the grid. Each utility has its own LCBF proce-

Even if contracts are valid measures of compliance, a 2006 CEC study estimates that 20 to 30 percent of them will fail.

California's utilities may be using RPS as a strategic tool to vertically reintegrate themselves.

dure, which the CEC says "suffers considerable murkiness and requires a high degree of interpretation and judgment."[81]

Since utilities are entitled to collect both the MPR (which they themselves determine) and any Supplemental Energy Payments, they have few incentives to monitor costs. Recognizing this, the CPUC has appointed a Procurement Review Group (PRG) for each utility, whose members have no commercial interest in renewables.[82] Thus far, PRGs have had few differences with utilities.

The Energy Commission has noted that the details of applying MPR, LCBF, and TRCR are "known only to utilities and individuals participating in [PRGs]" under non-disclosure agreements. The limits on information flow make it "impossible for policy makers to determine whether [the utilities] are selecting projects that are truly least-cost and best aligned with the state's policy to provide long-term benefits to the system."[83] Utilities claim that their competitive situations warrant a high degree of secrecy, since otherwise potential generation suppliers could exercise market power. In 2006 a court denied the utilities' request that the individual Energy Commissioners be personally required to sign confidentiality agreements.[84]

Cost Caps, Penalties, and Strategies

California penalizes RPS shortfalls at a seemingly punitive 5 cents per kWh, but only up to $25 million per year. These threats are hardly credible, since Southern California Edison and Pacific Gas & Electric have annual sales over $9 billion. Even these low penalties are not certainties.[85] If a utility's approved renewables cost more than the MPR and supplementary payment funds are exhausted, it is exempt and pays nothing. An RPS that carries meaningless penalties can only encourage utilities to act strategically, an incentive compounded by the underlying politics.

RPS follows a common pattern in environmental legislation. A legislature reacts to a perceived problem with an ambitious law and a short implementation timetable, leaving the details of rulemaking and enforcement to regulatory agencies. Noncompliance only becomes evident with the passage of time, and carries few adverse political consequences. The original legislators and regulators have moved on, leaving their successors to enact reforms and apportion blame.

California's RPS has followed this rather cynical narrative. Legislators lost interest soon after its enactment, and stringent term limits ensure their quick departures. Almost from the outset, regulators have understood that utilities will not meet the RPS, but the law's pricing and penalty provisions make meaningful enforcement impossible. Accordingly, it is understandable why the CPUC supports the utilities' contract-based claims of compliance in its reports to the legislature. Its January 2007 report opens by stating that utilities are "closing in on the 20 percent target with four years of procurement ahead."[86] It mentions in passing the law's definition of compliance as actual operation, but all graphics and data refer to signed contracts. The report further assumes that all new contracts will succeed and all expiring ones renewed or reformulated.[87] Its latest (April 2008) report provides no detailed numerical data on either compliance amounts or contracts.[88]

California's utilities have little to lose from noncompliance. Instead, they may be using RPS as a strategic tool to vertically reintegrate themselves. In the state's 1996 restructuring Pacific Gas & Electric and Southern California Edison divested their in-state fossil-fueled generators to non-utility producers.[89] Today, scarcity prevails. Most of the promised renewables exist only on paper, and fossil plant construction has lagged because of uncertainty about future market rules and regulatory policies. As of September 2007, 2,278 fossil-fueled MW were being built, 1,200 of which will not be operating before mid-2009.[90] These amounts are insufficient to cover average annual load growth. Even if more renewables were in process, much necessary transmission would remain unbuilt and, in some cases, still unsited. Even demand management is falling short of its goals.[91] California is short on both production and conservation, its abilities to adjust constrained by its own regulations.

For utilities the lack of resources may be an opportunity. In mid-2006 the CPUC ordered Southern California Edison to install 250 MW of quick-start gas turbines and implement 300 MW of demand response in order to minimize the likelihood of blackouts in summer 2007.[92] Noting time constraints, the order exempted SCE from procurement and planning regulations requiring the examination of alternatives and competitive bidding. In July 2007, the Arizona Corporation Commission voted not to approve a line that would be an important conduit for future supplies to California. Shortly afterward, SCE told the CPUC that its absence would require the company to obtain 1,380 MW of new generation.[93] San Diego Gas & Electric has long sought CPUC approval of its Sunrise Powerlink transmission project, claiming it is necessary to reach renewables it requires for RPS compliance. Critics claim that the transmission lines will primarily move energy into the southwest from plants in Mexico owned by SDG&E's parent company.[94]

National RPS Costs and Benefits

Renewable energy is more costly to produce than conventional energy. Nevertheless, most of the 18 studies of a national RPS that appeared between 1997 and 2007 found that it would have little effect on electricity prices.[95] Using a complex computer model, several have concluded that a national RPS passes a cost/benefit test.

As in all such analyses, the results are largely implicit in the assumptions. Engineering models in common use can produce accurate estimate of how (e.g.) a fuel price increase will affect power prices and system operations. These models, however, start from present-day facts to derive present-day conclusions. Assumptions about the future are harder to devise and work with. There are many plausible choices, and their predicted effects will depend on details of the model that are themselves largely assumptions.

For example, expectations about future fuel prices will determine investments in both conventional and renewable generation as well as power prices. Changes in the demand for power will depend on relatively predictable demographics and unpredictable changes in generation technologies and conservation options that themselves affect prices. New metering technologies and rate designs can better inform users about the cost of the power they are consuming and induce shifts in their time patterns of consumption. Unpredictable changes in law, regulations and market institutions will affect all aspects of production and consumption, and a national RPS is but one of many possibilities.

NEMS

One computer model dominates RPS research. The U.S. Energy Information Administration's National Energy Modeling System is the source of forecasts in EIA's *Annual Energy Outlook*, and is freely available to other researchers. NEMS is a complex computer package that consists of 13 "modules" that together estimate and forecast hundreds of variables.[96] They include prices and outputs of energy commodities (including imported oil), consumption by various users (residential, industrial, etc.), and macroeconomic variables such as GDP. NEMS's forecasts depend on literally thousands of assumptions, some chosen by users and others hidden in the model's mathematical structure.[97] NEMS's detail and complexity effectively exclude non-specialists from using it and evaluating the quality of its results.

NEMS dominates this forecasting "market" despite its remarkably poor performance, which has improved little if at all since its 1994 introduction.[98] The farther in the future, the poorer the correspondence between forecasted and actual outcomes. NEMS appears to predict some important variables well, but the seeming precision conceals poor forecasts of their components.[99] One can always hope that a superior model will come along, but NEMS differs little from many other long-range forecasting models that have consistently failed.[100] Futures contracts predict gas prices more accurately than NEMS's gas market module.[101]

Even if all RPS states are in compliance with their programs, renewables will produce only 29 percent more power.

If most investments to meet an RPS are wind, they will not be viable if they must bear the actual operating costs they impose on the grid.

Forecasts based on NEMS depend heavily on assumptions about technological change. A 2007 EIA study for the U.S. Senate of a 15 percent RPS for 2030 illustrates the importance of those assumptions. Simple extension of existing trends (see Figures 2 and 3) would predict a continuing increase in wind power and little change in biomass generation. NEMS, however, projected a 400 percent rise in wind generation and a 700 percent increase in biomass, leaving wind energy to produce 16 and 68 percent of renewable power in 2030.[102] The reversal appears to stem from assumptions about future technology for which EIA provides little rationale.[103] Other potentially helpful information cannot be input into NEMS. For example, EIA compilations of proposed generation currently show thousands of megawatts of wind capacity and very small amounts of biomass.[104]

Business-as-Usual Scenarios

A reasonable starting point is to ask what will happen if current policies and expected trends continue. This "business-as-usual" scenario yields some unexpected outcomes.[105] Under BAU, gas-fired and nuclear generation will change little over the next 20 years and coal-fired power will meet most demand growth.[106] Non-hydroelectric renewables will produce only 3.6 percent of the 2030 total, up from slightly over 2 percent in 2006. The share of fossil fuels will remain approximately unchanged.[107] Only extreme changes in assumptions lead to a prediction of over 4 percent renewable power in 2030. Even if all RPS states are in compliance with their programs, renewables will produce only 29 percent more power than under BAU and will still be under 5 percent of the total.[108]

One finding common to most NEMS studies is that a national RPS will increase power prices by relatively little, generally under 5 percent. That figure is the net effect of higher cost renewables and lower gas prices as they replace gas-fired plants.[109] Yet those calculations have problems. Nearly all of these studies have underestimated both the cost of renewables and the increase in gas prices. Some studies neglect costs of integrating renewables into the grid, and nearly all assume that the federal production tax credit on wind energy will be permanent.

For those who trust it, NEMS can analyze numerous proposed policies. Generalizing again, it usually predicts that any policy that does not compel investment in renewables will have little impact on the percentage of power they supply. For example, EIA used NEMS to analyze recommendations by the National Commission on Energy Policy for a $6/ton greenhouse emissions charge that rises to $8.50 in 2025, accompanied by a $4 billion production tax credit for new non-emitting generation from 2006 to 2009.[110] Even these seemingly large incentives raise renewables' share of 2025 generation by under 1 percent.[111] Evaluating another policy proposal, researchers at Resources for the Future used their own model (considerably simpler than NEMS) to determine that a national RPS was superior to an equivalent value production tax credit both for cutting emissions and inducing investment in renewables.[112]

Emissions and Gas Prices

NEMS and other models agree that an RPS will reduce carbon emissions by less than the RPS percentage. A 10 percent increase in generation by renewables cuts them by approximately 6 percent.[113] This occurs for two reasons. First, intermittent renewables run in lieu of quickly adjustable gas-fired units rather than coal-fired plants whose output cannot be adjusted quickly. The former emit smaller volumes of greenhouse gases than the latter per kWh produced. Second, when nondispatchable renewables rise to 20 percent of capacity, they begin to replace nuclear rather than fossil-fueled generators.[114]

NEMS-based RPS studies almost uniformly predict lower gas prices as renewables displace gas-fired generation.[115] Some predict a large enough decline that the RPS brings a "free lunch" of environmental benefits at no net cost, but their claim is economically illogical because it fails to account for the wealth lost by those who produce gas (workers, capitalists, equipment makers, etc.). A buyer who saves a dollar on gas can buy the same quantity as before and still have it to spend elsewhere. That unspent dollar, however, is lost to those who produce gas. The net effect is a transfer rather than an increase in the nation's wealth.[116]

Moreover, any fall in gas prices will be short-lived since in any competitive market, the highest-cost producer just breaks even. If an RPS causes price to fall, some formerly viable producers will take losses. As they leave the market, less is produced, price rises, and benefits to gas consumers fall.

The Dominance of Wind Energy

As shown in Figure 3, wind is the only renewable whose output has increased significantly since 1990. An indexed production tax credit (PTC), currently 1.9 cents per kwh, first became law in 1992, and investment began its upward trend in 1998. The PTC has expired and been temporarily extended four times, and investment has dropped drastically with each expiration.[117] The Energy Policy Act of 2005 extended the PTC to certain other renewables, but investment in them has yet to respond.

Wind energy has some advantages over other forms of renewable energy. Wind, for instance, is the least site-specific renewable, and many large consuming areas are within easy transmission range of windy ones.[118] Wind units often encounter less local resistance than fossil plants and other renewables, and they can be grouped into large "farms."

Two obstacles, however, stand in the way of future wind investments. First, localized hostility is growing as units grow in size, visibility (some over 400 feet high) and audibility. Second, wind's costs have greatly increased in recent years. Costs per installed kilowatt steadily declined from the 1980s through the early 2000s. They then rose by 60 percent per installed kilowatt between 2003 and 2006, and 18 percent between 2005 and 2006 alone. The most important part of the increase was an increase in turbine costs, which is expected to continue over the near future.[119]

Many national RPS scenarios predict that the preponderance of compliance investments will be wind. Operating experience has confirmed that the costs of adding small amounts of intermittent renewables to an existing grid are low. Random fluctuations in wind require the same type of response as fluctuations in load or minor generator outages.

It is also generally agreed that if wind or other intermittent sources come to exceed 15 to 20 percent of capacity, they begin to impose higher operating costs.[120] Wind unit outages (non-production of power) will probably be more highly correlated than outages of conventional plants, i.e. if it is calm at one location in a control area it is also relatively likely to also be calm at others.[121] The magnitude of those costs in a particular system depends on its generation mix, interconnections, transmission grid, and weather.

The most complete U.S. study to date examined the cost to a utility (4,600 MW peak load) of maintaining industry operating standards with alternative amounts of wind capacity.[122] Assume that a wind unit will be paid the marginal cost per kwh of conventional generation it replaces, net of payments to the system operator for balancing and load-following services. If there is only a small amount of wind capacity the system incurs no extraordinary cost and it receives an average of $30 per MWh over the year. Raising wind capacity to 1,000 MW (about 20 percent of system capacity) lowers its net payment per MWh to $15, and raising it to 2,000 MW drops it to $8. If most investments to meet an RPS are wind, they will not be viable if they must bear the actual operating costs they impose on the grid.

Wind's usefulness to a grid operator is lowered by the general inverse association between peak loads and wind velocities. In most regions, on-peak velocities are also lower in summer than winter. At the five highest load hours of 2006, wind units in California produced an average of 12.2 percent of nominal capacities.[123] Average California wind generation during on-peak hours (7 AM to 10 PM) in July 2006 was 495 MW (21 percent of capacity) and 464 MW in August.[124] Similarly, the average output of Texas 2,800 MW of wind generators is 16.8 percent of capacity, most of

Wind's usefulness to a grid operator is lowered by the general inverse association between peak loads and wind velocities.

Under most plausible assumptions about fuel prices and technological development, only a very small amount of investment in renewables will pass a market test.

which occurs off-peak. For system planning purposes, its grid operator set a wind turbine's "effective capacity" at 10 percent of its nominal amount, a figure later downgraded to 8.7 percent.[125]

Advocates of a national RPS also have yet to estimate the cost of new transmission required to reach isolated wind generators. Some local data, however, are emerging. Depending on their exact locations, the 10,000 MW of renewables (nearly all wind) for Texas's 2025 RPS will require between $1.7 and $3.0 billion in new transmission.[126] To meet its 33 percent 2020 standard, California must construct $5.7 billion of new 500 and 230 kv lines alone (the two highest generally used voltages). It will also require lower voltage lines, $655 million of new transformers, and 1,800 MVAR of reactive power.[127] For comparison, in 2005 transmission spending by U.S. corporate utilities was $5.8 billion, including upgrades and replacements of depreciated facilities.[128]

The intermittent availability of wind power means that transmission of that power will generally cost more than lines that carry conventional power. A radial line to an isolated wind unit will only be loaded to capacity during the relatively few hours when winds are strongest. Unlike lines embedded in a dense network, transmission to a distant power plant can increase risks to reliability. Losing a line in a dense network is often a minor problem because power can take many alternative paths. Losing a line to an isolated generator means that its power cannot be delivered and more reserves may be required to maintain reliability.

Renewables and Markets

Over the past 20 years, markets for "wholesale" power have grown in scope and competitiveness. Instead of relying only on generation that they own, to varying degrees utilities everywhere can now obtain power by contracts with other generation owners (including non-utilities and industrial cogenerators). Utilities can also often use regional energy markets in which day-ahead and hourly prices equate supply and demand.

The case for competitive contracting and markets in electricity is the same as elsewhere—competition motivates the efficient use of resources, the efficient planning of investments for the future, and rewards innovation. Electricity markets, however, are constrained by operating considerations. The production of power in an interconnected grid must equal its load at all times. Since a mismatch (in either direction) lasting only a single second can bring regional blackouts, the operator must have reserves available that can be brought on line quickly, and have units operating that can follow second-by-second changes in load.

Further, transmission constraints in electricity differ in important ways from those in other networks. Unlike water or gas, power flows along individual AC lines follow physical laws and cannot be directly controlled by the system operator. Instead the operator (often a computer algorithm) must sometimes operate high cost generators in particular locations in order to maintain regional balance and neither overload nor destabilize (underload) individual lines.

These technological requirements mean that the scope of power markets and the behavior of their participants must be constrained to maintain reliability. If there are no transmission constraints and generators may be started and stopped on a moment's notice, the least-cost production mix will ensure that those units with the lowest marginal costs will operate before those with higher costs, a phenomenon known in the field as "dispatch by merit order." A single utility that owned and operated all of the generation in a control area would dispatch by merit order, and a competitive market where generators bid in their power at marginal cost would behave similarly. Security constraints, however, mean that strict merit order dispatch is impossible in both cases. Dispatch is also complicated by different "ramp rates" at which the outputs of different types of generators can be changed. Nuclear and coal units have low operating costs, but their output can not be altered quickly enough to match unexpected changes in load. Gas-fired units have higher operating costs, but the need to "follow" unexpected load changes will mean that some must operate even if lower marginal cost coal units are available. Hydroelectric power burns no fuel and renews itself with the seasons, but it does have a marginal opportunity cost—using part of a limited reservoir at one date means that less will be available on others when it might be more valuable. In practice, hydro in the west is valuable for "shaping" power over the day to minimize the costs of bringing gas-fired units up to meet peaks and turning them down as demand falls in the evening.

Whether the system is centrally dispatched or market-based, a renewable—like hydro—can improve reliability and reduce operating costs. Renewables like biomass and geothermal may be base-loaded and integrated into either a market or a centralized system like conventional plants. Intermittent renewables, as we have seen, can bring operating problems to centralized systems if they are a large enough component of resources. They also, however, can constrain the use of markets.

The simple fact that wind units have a seeming marginal cost of zero (and that their output is not storable) does not unambiguously imply that they are beneficial.[129] As noted above, for efficient operation, the net income to the producer of a wind-generated energy must equal the difference between the cost of the power it replaces and the increased costs of maintaining reliability that its intermittency imposes. As also noted above, this figure can become negative when wind looms large enough, meaning that the system's avoidable costs would be minimized if the units were disconnected. In the absence of some method for assessing the wind's actual contribution in real time, wind units will always bid into the market (at a zero price) while operating costs are higher than otherwise. The ancillary services will be priced at their scarcity value, but if wind is not, market prices will induce overinvestment in wind and require that more, rather than less, fuel be burned. Adding a production tax credit increases the distortion.

Cost and Benefit Calculations

Thus far our discussion has been almost all about the potential costs of a national RPS. If we accept the outcomes of models like NEMS, we can expect that a national RPS will have a relatively minor effect on power costs. The effect on gas prices is a pure transfer from producers to consumers. If intermittent renewables impose operating costs that are not borne by their owners, those costs will be "socialized" into higher bills and there will be incentives to invest in them beyond economically efficient levels. In effect, part of the return to renewables investors comes from an ability to shift those costs onto others, including those of the production tax credit. If there are transmission requirements for renewables beyond those associated with conventional resources that produce equivalent amounts of reliable power, the difference is also a cost. In summary, under most plausible assumptions about fuel prices and technological development, only a very small amount of investment in renewables will pass a market test and prove competitive with conventional generation.

If all of the costs and benefits of renewable fuels were priced in energy markets, that would be the end of the story: An RPS would be a straightforward special-interest policy and on net economically inefficient. But comparisons like these are not the entire story. A generation mix heavier with renewables might also produce social benefits that more than outweigh these costs.

There are many possible types of such benefits that have been brought forth by advocates as possible reasons for encouraging investment in renewables that do not pass market tests by themselves. An examination of those arguments follows.[130]

The Environmental Case for Renewable Energy

The environmental case for a national RPS is founded upon a theory known to some economists as "market failure." Roughly speaking, market failures occur when the costs (or bene-

A design standard such as an RPS may be inefficient because it forecloses any possibility that other policies can do the same job at a smaller cost.

No advocate of a national RPS has ever attempted to estimate the costs and benefits of different percentage requirements, or to compare an RPS with alternatives.

fits) of some activity to society are greater (or less) than those experienced by the person who decides on that activity. If everyone paid their share of the benefits derived from the use of environmentally benign power (or for appliances designed to save electricity), the value of the cleaner environment (along with the power itself) could eclipse that of higher electricity bills. If negotiations among people to voluntarily pay for this environmental benefit are too costly (as they probably are), the theory of market failure often recommends such interventions as corrective taxes or subsidies.[131] All this, of course, presupposes that government would faithfully carry out economists' recommendations without bringing politics into the picture.

Our earlier discussion of intermittent resources illustrates these points. Disregarding possible environmental benefits for the moment, an investor considering a wind generator compares its expected discounted future revenue (at market or contract prices) with the cost of building it. If owners of wind units do not bear the cost of standby capacity, they will overinvest in it. They will build plants that they would not build if required to bear all of the costs associated with their decisions. Here the "market failure" is not a fault of any market, but rather the effect of a regulatory choice not to charge investors in wind units the full cost of their actions.

Next let's assume that no special provisions are needed regarding the wind generator's intermittency, but that operating it eliminates emissions from fossil generation that harm health. Now too few renewables will be built because investors receive only the price of power as payment and do not capture any of the benefits of cleaner air.

Estimating the true net benefits of wind generation thus requires two adjustments. We must add the value of cleaner air to that of the power it produces, and add the cost of standby capacity to the cost directly incurred by the builder. In subsequent sections we will encounter other rationales for a national RPS. In terms of their policy relevance, however, by far the most important are those that treat an RPS as environmental policy.

Market failures have long been used to illustrate and rationalize pollution control policies such as taxes and subsidies, but the first to propose RPS on those grounds were economist Richard Norgaard of the University of California, Berkeley and Nancy Rader, an attorney for wind producers.[132] Norgaard and Rader also favored an RPS as a response to market failures that had led to dependence on foreign energy (discussed below) and an unsustainable environment.

More strongly than other RPS advocates, Norgaard and Rader view renewables as necessary for the attainment of long-term environmental sustainability. They find pollution taxes and tradable emission permits desirable but insufficient because they do not directly spur the development of renewables. Absent an RPS, pollution will fall but power production will continue to exploit what Norgaard and Rader view as an unsustainable fossil resource base. Norgaard and Rader do not examine the implications of elites choosing eligible resources and implementation plans.[133]

It is helpful to think of an RPS as a physical design standard for power systems. Where transactions costs are high—for instance, when dealing with automobile tailpipe emissions—a design standard such as the catalytic converter may be efficient. In industries like electricity, however, a design standard may be inefficient because it forecloses any possibility that other policies can do the same job at a smaller cost. Even if better abatement methods are available, an inefficient standard may persist for political reasons or because of sheer inertia.

An RPS is one of many possible policies to address environment-related market failures. An alternative appears in the Clean Air Act and subsequent amendments. It requires the U.S. Environmental Protection agency to set quantitative standards for concentrations of "criteria pollutants" that currently include sulfur oxides, nitrogen oxides, particulate matter, carbon monoxide, ground-level ozone, lead, and most recently mercury.[134] EPA sets permissible levels using health-based "primary standards" and "secondary standards" intended to limit environmental and property damages, but leaves it to states to decide how best to meet them.[135]

Critics of every political stripe have found fault with EPA's standards for criteria pollutants, the methods it uses to set them, and its enforcement policies. Nevertheless, EPA's methods bear some resemblance to principles of efficient pollution control derived from economic theory. By comparison, a national RPS violates virtually all of these principles.[136]

Environmental Economics

The first principle of efficient environmental policy is to select a standard that will maximize net benefits. The fact that a national RPS will replace some polluting generators with non-polluting ones says nothing about its desirability, which depends on the benefits of lower emissions and the costs of abating them.

However imperfectly, EPA sets its standards by estimating the values of the lives saved by reducing a pollutant and the costs of achieving the reduction. By contrast, no advocate of a national RPS has ever attempted to estimate the costs and benefits of different percentage requirements, or to compare an RPS with alternatives such as the retrofitting of existing generators or policies to manage power demand. The EPA analogue of an RPS would be an order to replace 20 percent of all cars with bicycles but with no attempt to estimate the resulting drop in pollution, no determination of whether the reduction is optimal, and no examination of alternatives that would achieve the same benefits.[137]

After setting the acceptable level of a pollutant on efficiency grounds, the second principle of efficient environmental policy is to attack all emission sources. Minimizing the total cost of a given reduction requires equating the marginal costs of abatement at every source, whether a generator or a facility in some other industry. A national RPS looks only at power plants and does not examine other sources of the pollutant. Even if there is a particular reason to concentrate on power plant emissions (perhaps the costs of monitoring such large sources are very low), replacing an existing or planned conventional generator with a renewable energy generator is just one of many ways to achieve the reduction.

The third principle of efficient environmental policy is to attack the pollutant directly rather than regulating inputs, outputs, or the design of the process that produces it. Renewability is an aspect of design and building renewable energy plants will only by accident be the optimal way to achieve a given reduction in emissions. The alternative is to set some standard (possibly with tradable credits) and allow potential polluters to choose their own ways of meeting those standards. In effect, an RPS rewards investments in certain types of generation rather than investments (including research) in pollution control that may be more cost-effective.

The fourth and final principle of efficient environmental policy is to match the geographic area being regulated to the area impacted by the pollutant. Even if an RPS is the lowest cost means of pollution control, a national standard is only appropriate if its boundaries include all sources of the pollutant and contain all of the damages. If production and/or harm from a pollutant is localized, regulation should likewise be localized. If the affected area extends beyond national boundaries (for instance, in the case of carbon dioxide emissions), international arrangements are called for.

A national RPS may reduce emissions of some pollutant, but only by accident will a renewable energy facility built in response to it achieve that reduction.

The Superiority of Market-Based Environmental Regulation

Most economists will be quick to agree that market-based environmental policies will be more efficient than direct interventions such as an RPS, and policymakers are coming to agree with them.[138] The most common market-based institution is known as a "cap and trade" system. Under it, polluters as a group receive a set total of pollution allowances that they can use to achieve current compliance, bank for future use, or exchange among themselves in markets.

Economists have found EPA's SO_2 and NOx cap-and trade programs to be efficient methods for achieving compliance with its standards.[139] Additional markets are being planned to for operation under the recently issued Clean Air Interstate and Clean Air Mercury rules (CAIR and CAIM).[140]

Allowance markets efficiently reduce emissions for the same reasons that markets for more ordinary goods and services generally outperform "command-and-control" regimes. Markets economize on the information required to achieve efficient allocations because they facilitate decentralized trading. Rather than a centralized information processing authority, markets take knowledge that is dispersed among buyers and sellers and allow them to trade as they see fit. When they do, prices emerge as indicators of scarcity, signaling people to redirect their activities and adjust their behavior.[141] Even if individuals trusted government with personal information, only by a rare accident would its agents manage to collect and process all of the data required to determine an efficient outcome.

In a competitive market, price equals the marginal (incremental production) cost of the highest-cost seller and the marginal valuation (willingness to pay) of the last buyer whose offer is accepted. In a competitive market for allowances, generators have incentives to create transactions that minimize the cost of achieving a given reduction in emissions. Generators who can cheaply reduce their own pollution will do it so that they can sell allowances to those who can only reduce theirs at higher cost. Some generators with extremely high costs of controlling their emissions will find it worthwhile to reduce output or close down and sell their allowances.

Only at a carbon price of $56 or more per ton would the wind generator (without a tax credit) be competitive with an older coal-fired plant.

A national RPS may reduce emissions of some pollutant, but only by accident will a renewable energy facility built in response to it be the efficient instrument to achieve that reduction. An RPS gives renewables priority simply because they are renewables rather than because they are efficient ways to mitigate pollution. If pollution allowances are tradable, the power plants to be built will be those with the lowest totals of annualized operating, capital and allowance costs. These need not be renewables.

Looking forward, an RPS could even be an obstacle to the adoption of superior generation and abatement technologies. Because an RPS prespecifies admissible types of resources, it may adapt poorly to innovations. The choice of qualifying renewables appears to be as much political as it is scientific. Defining a new technology as renewable can reduce the returns to owners of already existing ones. Some renewables benefit from policies like the federal Production Tax Credit, and their owners will resist its extension to potentially superior plants.[142] By contrast, a cap-and-trade system does not pre-specify or prohibit any technologies. Instead, like other markets, it rewards developers of technologies or operating practices that promise greater efficiency.

An RPS must also be evaluated in the context of existing environmental regulations that it will supplement (or possibly replace). Pollutants that are under cap-and-trade regimes may be particularly affected. If renewables reduce emissions of a capped pollutant, owners of conventional plants that remain in operation will be able to increase theirs. Allowance prices will fall and conventional plant owners will not need to make investments to further cut their emissions. Emissions will remain at the cap level, but the reduction due to the renewables could have been achieved more cheaply by the conventional generators.[143]

An RPS will also probably engender inefficiency in the control of emissions that are already regulated under design standards. If renewables further reduce the emission of pollutants regulated under those regimes, there will be inefficient *overcompliance*. A design standard implies an emission target that environmental regulators implicitly view as optimal, whether or not the amount is explicitly stated. Restoring efficiency may require that conventional plants be allowed to increase their emissions, or that new ones be built to less stringent standards.

Renewables and Global Warming

A national RPS will be a poor instrument for the control of criteria pollutants and a similarly poor one for the control of greenhouse gases (GHG).[144] Renewables are but one of many ways to displace GHG emissions, and only by coincidence will the conventional generators they replace be the sources that are cheapest to reduce. As noted above, if most renewables produce intermittently, they will primarily replace relatively benign gas-fired units. If some nonelectrical GHG source is cheaper to reduce, the job can be accomplished for less by spending to reduce it instead of building renewables.

Even if the source that matters is conventional generation, there are numerous technologies that may be cheaper than renewables to achieve a given reduction in the GHGs that it produces. As with criteria pollutants, an RPS can only reduce the efficiency of GHG control because it imposes another constraint on the efficient solution of an already complex problem and brings no new opportunities. An RPS that requires investment in certain renewables will almost certainly produce an inferior solution because those renewables will be less efficient at GHG control than non-renewables like hydroelectric and nuclear power, and (possibly) carbon sequestration.[145] RPS advocates' general refusal to consider expanding the first two is as much political as it is scientific. Arguments that RPS is a "second best" solution because carbon is unpriced will vanish as carbon pricing (or possibly taxation) and trading of allowances comes of age.

Geography further ensures that a national RPS is more a gesture of concern than a useful instrument for GHG control. If carbon emissions from any source diffuse through the entire atmosphere, an RPS in a single nation will have negligible benefits and potentially high costs to its residents.

The gesture becomes even more futile in smaller jurisdictions such as California where "leakages" are likely. In a typical year, California utilities import 20 percent or more of their power from other western states, mostly at peaks when in-state generation is expensive. If northwest hydropower is unavailable or transmission is constrained, they buy relatively cheap coal-fired power from generators in the southwest. California's emerging GHG standards will require that any coal-fired purchases, save in emergencies, come from plants that emit no more carbon dioxide than a new combined cycle gas turbine generator. Since these coal technologies do not yet exist, Californians will be forced to import more expensive gas-fired power. Instead of a reduction in GHGs, all that will happen is a reshuffling of contracts and no change in the generation mix that actually operates. Utilities in other states will purchase the coal-fired power on more attractive terms, while Californians pay more for power from sources that their state regulators approve of. As regards imported power, the outcome will be as if California had never instituted its GHG program.[146]

As of this writing, there is only one published analysis that compares the costs of using an RPS to reduce CO_2 emissions with those of alternatives.[147] Dobesova et al. examined wind investments used to satisfy Texas's RPS requirement in 2002. They considered direct costs, production tax credits, and a range of indirect costs and benefits including transmission investments, fuel and allowance savings at displaced plants, and increased integration costs due to intermittency. The alternative examined was an integrated coal gasification generator with carbon sequestration. The cost of CO_2 removal using wind plants (which produce none) was approximately 5.7 cents per kWh. Using a consensus of projections for the coal technology, they estimated its incremental removal costs at between 0.8 and 2.4 cents per kWh. The cost per metric ton of CO_2 avoided is $58.70 for a combined-cycle gas-fired plant, $51.20 for a pulverized coal-fired one, and $29.50 for coal gasification, all with sequestration. Only at a carbon price of $56 or more per ton would the wind generator (without a tax credit) be competitive with an older coal-fired plant using sequestration technology. Even under favorable assumptions, wind generation will often be uneconomic.

In a typical year, California utilities import 20 percent or more of their power from other western states.

Macroeconomic Rationales for an RPS

Some advocates claim that a national RPS will bring macroeconomic benefits, similar to those of a job-creating fiscal policy. That

In today's economy, renewable energy does not create jobs.

might happen in an extreme depression like that of the 1930s, with masses of willing workers unemployed because aggregate demand is deficient. If jobs open up in the renewables industry, some of these workers would take them at a negligible cost to society because their only alternative is unemployment.

Today's economy in no way resembles that one. Any compulsory investment in renewables simply takes funds from people and businesses that would have spent them on other goods. Job gains in the renewable energy sector will be offset by job losses in the industries that produce those other goods.

One typical job creation study published by the Renewable and Appropriate Energy Laboratory (RAEL) at the University of California, Berkeley tabulates estimates of the employment stimulus of an RPS, using figures from an unpublished document by a team of renewables advocates. That document summarizes 13 other studies and concludes that "the renewable energy sector generates more jobs per megawatt of power installed, per unit of energy produced, and per dollar of investment than the fossil fuel based energy sector."[148]

The RAEL analysis rests in part on a solar photovoltaic facility that produces 20 percent of the energy it is theoretically capable of producing under perfect conditions.[149] Disregarding the existence of night, its authors find that a coal-equivalent megawatt of solar power requires four megawatts of solar capacity. Building them requires four times the labor required for a coal-fired megawatt, and total labor requirements (construction plus operation) per megawatt-hour over the solar plant's lifespan are 10 times those of the coal-fired plant.[150] They conclude that inefficient solar plants are superior to efficient conventional ones at creating employment.

Of course, in today's economy, renewable energy does not create jobs. Renewable energy investments waste workers who would be more productive elsewhere absent the special regulatory treatment of renewable energy.[151] Calculations like these show little appreciation for the fluidity of actual labor markets.[152] In any case, even with an RPS, the production of renewables would be so small relative to total output that any impact on overall employment would likely be undetectable.

Rural Development

In a variant of the job creation logic, the geographic inconvenience of many renewable resources, particularly wind, has produced claims that a national RPS can revitalize rural areas that have lost population.

Rural residents have been a declining percentage of population since the Civil War, although their numbers have increased since 1970.[153] RPS advocates have never made clear why those who remain are in need of help. Between 2000 and 2003, 49 of North Dakota's 53 counties lost population. Nevertheless, the state's 2003 unemployment rate was 3.6 percent, slightly over half the national figure of 6.0 percent.[154] Local politicians may regret a loss of leverage that comes with population loss, but the population itself seems to be making the sometimes difficult adjustments on its own.

Some advocates view renewables as an instrument to de-corporatize electricity supply.[155] In particular, rural governments or local groups can take a more active role as owners of wind power installations.[156] The Worldwatch Institute apparently subscribes to the 18th century mercantilist fallacy that the purpose of trade is to accumulate money, favoring local ownership of rural renewables because "wealth remains in the local community."[157] In reality, farmers receive their incomes by selling crops to urbanites. Rural electric cooperatives are local nonprofit associations that own and operate distribution networks in sparsely populated areas, but their trade association is on record against an RPS at any level of government.[158]

Infant Industries

Another oft-heard rationale for a national RPS is that renewable energy is an "infant industry," and the RPS would ensure the industry's viability just as a tariff ensures that domestic producers are protected from foreign competition. The standard infant industry model begins by assuming that a nation starts as a small, high-cost cost producer of some internationally traded good. Costs are high either because producers cannot grow big enough to realize economies of scale or because achieving lower costs require the experience that comes with cumulated production. Either way, a tariff that makes imports more expensive will allow the domestic industry to lower its costs.[159] RPS proponents likewise argue that requiring the purchase of renewables that are currently expensive will bring their prices down and possibly turn the nation from an importer into an exporter of them.[160]

In fact, wind turbine manufacture is already thoroughly internationalized. General Electric supplied turbines for 47 percent of domestic wind installations in 2006. Most of the remainder came from overseas sources, including Siemens (Germany, 23 percent of the total), Vestas (Denmark, 19 percent) and Mitsubishi (Japan, 5 percent). Some foreign manufacturers have opened U.S. plants, and some of GE's U.S. components were manufactured abroad.[161]

U.S. renewable energy manufacturers are already competitive at the world level and hardly qualify as infants. No advocate has presented evidence that scale economies or experience are peculiarly important in renewables. Instead, the industry is experiencing the competition to innovate and imitate that exists in other technology-based activities. Competition already gives renewable energy producers clear incentives to keep costs low and improve their products.[162] In any case, half of the states (with most of the nation's population) already have RPS, and there is no evidence that a national standard would improve progress in cost reduction.[163]

Nor is there a valid risk-based justification for special treatment of renewables that might attract additional investment into them. The flows of both corporate and venture capital into renewables suggests that they are not discernibly riskier than other technology-based industries. Investors cope with risk by diversifying their holdings, and investors in renewables are no exception. Whether renewables are under a national RPS, assorted state RPSs, or no standards at all will not materially affect production risk.

In one final international variant, some hope that a national RPS will facilitate America's ascent to dominance of the world renewables markets. One advocate sees it as a necessary response to renewables-based export policies that are taking shape in Japan.[164] He believes Americans must emulate the cooperation between Japan's manufacturers and government planners. This popular vision of Japanese invincibility from the 1970s and 1980s died with its recession and banking crisis of the 1990s.[165]

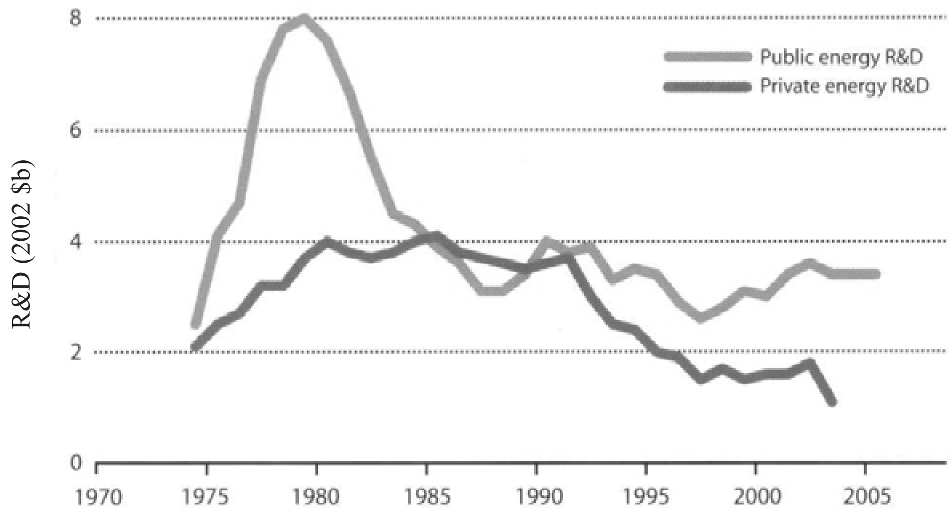
Experience gives little reason to expect that such policy planning ("picking winners") can make either nation preeminent in renewables, where the case for free trade is the same as in other industries.[166] Currently renewables and their components cross America's borders in both directions. Domestic renewable energy manufacturers will continue to export those in which it has a cost advantage and import those in which it does not.[167] International trade in renewables raises no security issues since they are ordinary manufactures that no nation can succeed in monopolizing.

Questions about the adequacy of support for research and development in renewables are closely akin to those of infant industry protection. Arguments from economic theory about how the "public goods" characteristics of research and development lead to inadequate private funding might apply to any industry. By itself, the theory provides little guidance for policy makers seeking to allocate limited funds, and the range of alternatives for protecting intellectual property is expanding rapidly.[168]

There is no doubt, however, that funding for energy R&D has fallen substantially in recent decades, from 10 percent of all R&D in 1980 to only 2 percent today. As figure 8 shows, private investment in all forms of energy R&D has declined since the mid-1980s, while government funding peaked during the "energy crises" of the late 1970s and has since settled down to relative constancy. Total R&D support for renewable power (not shown in the figure) has been roughly constant in real

Experience gives little reason to expect that "picking winners" can make either nation preeminent in renewables, where the case for free trade is the same as in other industries.

Figure 8
Publicly and Privately Funded Energy Research and Development



Source: Daniel Kammen and Gregory Nemet, “Reversing the Incredible Shrinking Energy R&D Budget,” *Issues in Science and Technology* 22, Fall 2005, p. 867.

dollars since the mid-1990s, while fossil-fuel and nuclear R&D have fallen.[169]

There are two reasons to be unconcerned about this seeming neglect of renewables. First, the funds may have more value elsewhere. A 2003 study by two renewable advocates examined trends in research funding and renewable technology improvements and concluded that the net present value of federal research support for them was -$30 billion.[170] Second, we can predict with some certainty that the great majority of generation capacity over the coming decades will continue to be fossil-fuel units. If they account for such a large fraction of production costs and renewables account for so little, it is possible that the latters’ current share of R&D is actually too large. At the margin, spending a given amount to develop technology that cuts fossil generation costs by 1 percent may produce consumer benefits whose present value exceeds that of spending the same amount to produce a 10 percent cut in renewable generation costs.

Any potential role for renewables as instruments for risk management can be filled by other energy sources with relatively stable prices.

RPS and the Case for Fuel Diversification

Even if electricity prices rise under a national RPS, some computer models project substantial drops in natural gas prices. As shown above, the actual effects of a lower price on gas consumers and producers as a group is zero, and the lower price will probably increase until all producers are at least breaking even. Still, if less power is generated from natural gas under an RPS, natural gas prices will become less sensitive to short-term forces such as weather. That reduction in price volatility is sometimes viewed as another benefit brought by the RPS.

A risk-averse consumer who buys at the spot market price benefits from lower volatility. Most small consumers are on fixed rates (possibly with monthly fuel price adjustments), however, and never see real-time price fluctuations. Large consumers can use derivatives transactions to manage their risks, and most have little reason to want fixed prices. Lower volatility is a consequence of tradeoffs that involve the higher expected price of power under an RPS and a lower expected price of natural gas.

Any potential role for renewables as instruments for risk management can also be filled by other energy sources with relatively stable prices. These include nuclear, coal, and hydroelectric plants, as well as demand management. Beyond investments in other conventional resources, a utility could diversify its renewables to reduce their intermittency risks, geographically disperse the ones whose output depends on weather, or use alternative technologies (currently in early phases of development) such as batteries or compressed air storage.[171]

Finally, renewable energy only appears to be a riskless source. Currently most contracts between wind energy producers and utilities set a fixed price for every kWh rather than the market value of the power it replaces at the moment it is produced. Fixed-price contracts, however, are risky for ratepayers. The longer a price is frozen, the larger the expected difference (either positive or negative) between it and the market price.[172] Only if consumers are exceedingly risk averse do such contracts benefit them.[173] We still lack studies of the benefits that more normal consumers will reap from mandated renewables.[174]

Long-term fixed-price contracts are almost exclusively seen in regulated industries, where small users have few if any choices. Utilities often favor them because, unlike most other businesses, they can throw the contract risks onto captive customers who have no choice but to bear them.[175]

Foreign Energy Dependence

One final rationale for a national RPS rests on a claim that renewables can make important contributions to national security because they produce power without the price and deliverability risks of imported fuels.[176] As a general principle, if fuel security is the problem it should be addressed directly, for example by strategic storage for military use. Attempts to justify (e.g.) tariffs on oil from risky sources are usually unconvincing and disregard the possibility of cheaper alternative policies. NEMS is just another in a line of demonstrations that have amply shown that governments have little if any superiority in predicting developments in energy markets. Futures traded on the New York Mercantile Exchange predict gas prices more accurately than the NEMS gas market module.[177]

Ever since Adam Smith first explained the mutual benefits of trade, economists have viewed self-sufficiency as a vastly overrated virtue. Markets allow persons and firms to specialize in producing those goods in which they have a comparative advantage and to diversify their consumption, and the benefits of this arrangement are as apparent in energy markets as they are elsewhere.

Even if "energy independence" is for some reason desirable, a national RPS will have little impact on it. If renewables produced 20 percent of the nation's power, there would be only minor changes in the allocation of conventional fuels between power production and other activities. Coal is almost entirely domestic, and about one-third of U.S. uranium is imported but easy to stockpile. Gas trades in a North American market and liquefied natural gas imports will be minimal over the near future. Interactions between the gas pipeline and electric transmission networks are becoming more complex but will probably remain manageable.[178]

Oil is America's only insecure energy import, but only 2 percent of its electricity comes from burning it. Oil-fired plants are restricted to a few regions and either are or can be made switchable to gas. There are few possibilities for substitution between oil and renewable electricity that do not also hold for conventionally generated power.

Renewable energy supply is sometimes thought to be less vulnerable to disruption than conventional generators, the apparent reason being that renewable energy facilities generally have smaller production capacity than the fossil fueled plants. But as noted earlier, if intermittent renewables (as most of them will be) become a larger presence the costs of maintaining reliability (and possibly the associated risks) will rise. Equipment malfunctions and lightning strikes occur regularly, but the grid continues to operate in all but extraordinary conditions. A 50 MW wind farm is a less attractive military or terrorist target than a 500 MW conventional generator, but in any situation short of a mass attack, either can be lost without a major (or even a minor) blackout ensuing. Heavier dependence on

Even if "energy independence" is for some reason desirable, a national RPS will have little impact on it.

location-specific renewables like wind and geothermal may increase risk since deliverability can depend on long and potentially vulnerable transmission lines.

Conclusion

A national Renewable Portfolio Standard is being sold as the policy equivalent of a Swiss Army Knife, capable of resolving or ameliorating almost any problem its supporters can envision. In reality, an RPS is either a redundant solution to problems that markets are already taking care of (high fossil fuel prices) or a poor intervention for resolving problems that markets can handle only imperfectly. Simple economics and straightforward observation suffice to make the arguments in favor of an RPS untenable.

An RPS is either a redundant solution to problems that markets are already taking care of or a poor intervention for resolving problems that markets can handle only imperfectly.

After 35 years of governmental and corporate support, renewable energy remains largely unable to pass a market test. Wind alone will account for most of the compliance with state standards (to the limited extent that such compliance is occurring), and even wind power's more enthusiastic advocates recognize that it will continue to be uneconomic unless given substantial subsidies. Solar power is a popular dream, encouraged by the media, but the reality will be wind turbines taller than the Statue of Liberty.

Renewables currently produce under 3 percent of America's power, close to their market share of 15 years ago. The sheer size and durability of the installed generation base ensures that even if renewables become competitive, they will remain a small part of the power supply mix for decades. Their effects on reliability are at best ambiguous, and the intermittent units that will account for most RPS compliance impose additional capital (transmission) and operating (reserves) costs on a power system. Attempts to project their impact 20 years ahead are plagued by inadequate data applied to grandiose models whose forecasting abilities remain poor.

It is hard to imagine an instrument more poorly suited than an RPS for the implementation of environmental policy. Few if any proposals have been accompanied by a reasoned cost-benefit analysis. An RPS does not set objectives for individual pollutants, applies to only one industry, takes the inefficient path of setting design standards, has little respect for geographic differences, and is largely incompatible with the growing rationality of environmental regulation.

Non-environmental rationales for a national RPS fare just as poorly. One easy way to appreciate the gulf between RPS and coherent policy is to examine RPS advocates' frequent emphasis on "jobs" that are "created" by increasing the number of workers assigned to less productive tasks. Equally striking are the elementary fallacies offered by RPS advocates about international trade policy and domestic population movements. All energy sources carry risks that cannot be eliminated by contracting at fixed prices, but can be concealed.

Regulation has long been a stage on which interest groups play out their wealth-transferring dramas. Renewables and RPS are just the latest scripts for them to improvise from. Instead of putting regulation on a more rational basis, RPS will further politicize it. There is little reason to expect that utilities' responses to a national program will differ from their noncompliance with state standards, and every reason to expect that those in deficit will pay few penalties. Finally, any debate over a federal RPS will take place against a backdrop of a largely unjustified public disillusion with experiments in electrical competition. The behavior of California's legislators, regulators and utilities as they manipulate their state's RPS law has one important message for the nation: If formulated and managed well, an RPS can be of great aid in reestablishing the same utility monopolies and regulatory coalitions that made competition necessary in the first place.

Notes

1. Forty-one percent of respondents to a 2004 survey by the Kentucky Environmental Education Council identified coal, steel, and oil as renewable energy. The percentage of those deeming solar energy and trees "renewable" actually fell between 1999

and 2004. See http://keec.ky.gov/documents/2004environmentalsurvey12705.pdf. Detailed knowledge of electricity production is similarly sparse. A January 2007 survey by Enviromedia Social Marketing asked 1,000 people, "When you turn on your light switch, what is the source of your electricity?" 35 percent said they didn't know, and 23 percent actually said "the electric company." 16 percent named coal (50 percent of U.S. production), 7 percent said gas (19 percent), 7 said nuclear (15 percent), and 12 percent renewables (9 percent if hydroelectric power is included, 2 percent if not). http://www.enviromedia.com/news_releases_020107.php. For a summary of questionnaire results, see Rosalynn McKeown, "Energy Myth Two—The Public Is Well Informed About Energy," in *Energy and American Society—Thirteen Myths*, Benjamin Sovacool and Marilyn Brown (eds.), (Springer: 2007), pp. 51–74.

2. All data in these graphics are from the U.S. Energy Information Administration.

3. The relatively high 2006 figure is very recent and subject to revision. It is 10 percent higher than any of the previous five years' percentages and appears inconsistent with investment trends.

4. Figure 4 shows 1991 data rather than 1990. The latter do not separate biomass generation into waste burning and wood burning.

5. Prior to the Energy Policy Act of 2005, only wind enjoyed the credit. Its value is indexed and currently equals 1.9 cents per kWh.

6. See California Energy Commission, Implementing California's Loading Order for Electricity Resources, CEC 400-2005-043 (July 2005). http://www.energy.ca.gov/2005publications/CEC-400-2005-043/CEC-400-2005-043.PDF

7. Gilbert Metcalf, "Federal Tax Policy Toward Energy," Working Paper 12568, National Bureau of Economic Research, October, 2006, Table 8, p. 36.

8. Andy S. Kydes, "Impacts of a Renewable Portfolio Generation Standard on US Energy Markets, *Energy Policy* 35, 2007, p. 814.

9. Katherine Ling, "Transmission Woes Loom as Utilities Prepare for Mandates," *Greenwire*, August 24, 2007.

10. Clean Renewable Energy and Economic Development Act, (S.2076). Hearings have not yet been scheduled. Additional information is available at http://thomas.loc.gov/cgi-bin/bdquery/z?d110:SN02076:@@@L&summ2=m&.

11. U.S. Department of Energy, Energy Efficiency and Renewable Energy (DOE/EERE), GPRA07 Wind Technologies Program Documentation, 2007, p. E-4. http://www1.eere.energy.gov/ba/pdfs/39684_app_E.pdf.

12. Database of State Incentives for Renewables and Efficiency [DSIRE], *Rules, Regulations & Policies for Renewable Energy*, http://www.dsireusa.org/summarytables/reg1.cfm?&CurrentPageID=7&EE=1&RE=1. Updated materials also appear in Pew Center for Global Climate Change, "States with Renewable Portfolio Standards." http://www.pewclimate.org/what_s_being_done/in_the_states/rps.cfm.

13. An RPS has the political virtue of not being directly funded by government but having the same effects as a tax. On his last vote as a California Public Utilities Commissioner, Geoffrey Brown was the lone dissenter to a $9 billion solar-related rate increase, and the only Commissioner to characterize its action as an unlegislated tax increase. See Robert Michaels, "We Are the World, We Are the Commissioners," *The Desk*, March 30, 2007, pp. 1–2.

14. Christopher Cooper and Benjamin Sovacool, *Renewing America: The Case for Federal Leadership on a National Renewable Portfolio Standard (RPS)*, Network for New Energy Choices, Report No. 01-07, June, 2007, p. 17. http://www.newenergychoices.org/dev/uploads/RPS%20Report_Cooper_Sovacool_FINAL_HILL.pdf

15. H.R. 3221, 110th Cong. (2007), Subtitle H, § 9611.

16. H.R. 6, 110th Cong. (2007).

17. For representative publications, see Alan Nogee et al., "Clean Energy Blueprint: Increasing Energy Security, Saving Money and Protecting the Environment with Energy Efficiency and Renewable Energy," *Bulletin of Science, Technology and Society* 22, April, 2002, pp. 100-109, Cooper and Sovacool (2007), and Worldwatch Institute and Center for American Progress, *American Energy The Renewable Path to Energy Security*, September, 2006. Major organizational support for RPS is provided by The American Council on Renewable Energy, an umbrella organization of RPS supporters including include the American Wind Energy Association, Geothermal Energy Association, Worldwatch Institute, and the Union of Concerned Scientists. See American Council on Renewable Energy, *The Outlook on Renewable Energy in America, Vol. II: Joint Summary Report*, March, 2007, p. 9.

18. National Commission on Energy Policy, *Energy Policy Recommendations to the President and the 110th Congress*, April, 2007, pp. 23–24. http://www.energycommission.org/files/contentFiles/NCEP_Recommendations_April_2007_462f66ac56e08.pdf

19. See Wood Mackenzie, "Impact of a Federal

Renewable Portfolio Standard," abstracted at http://www.woodmacresearch.com/cgi-bin/corp/portal/corp/corpPressDetail.jsp?oid=826210.

20. A striking example of the pull RPS has on policy elites is the fact that it finds support from Joseph Stanislaw, co-author of *The Commanding Heights*, a cogent and sympathetic account of how late in the twentieth century the ideas of market economics came to challenge those of collective intervention. Stanislaw has since taken the opposite side. He sees today's energy crisis as so immense that only government can resolve it. A population "addicted" to energy needs "leadership to muster the collective will . . . to designate what might be called the authorizing force to address these challenges." Joseph Stanislaw, *Energy in Flux: The 21st Century's Greatest Challenge*, Report for Deloitte Development LLC, 2006, p. 5. http://www.deloitte.com/dtt/cda/doc/content/Energy_in_Flux(2).pdf. Likewise, Sovacool and Cooper's "holistic" analysis shows that a national standard would "cut prices, "empower states," and "provide a host of important ancillary services to consumers, utilities, and society as a whole." Benjamin Sovacool and Christopher Cooper, "Green Means 'Go?'—A Colorful Approach to a U.S. National Renewable Portfolio Standard," *Electricity Journal* 19, August, 2006, p. 20.

21. See "Renewable Portfolio Standards; An Effective Policy to Support Clean Energy Supply." http://www.epa.gov/chp/pdf/rps_factsheet_123006.pdf. On the Agency's web site, its "Combined Heat and Power Partnership" likewise urges corporate members to push for RPS in states that do not currently have it.

22. Daniel Cusick, "Southern Utilities Led Effort to Squash Senate RPS Proposal," *Greenwire*, June 26, 2007.

23. A more detailed exposition of specification choices appears in Trent Berry and Mark Jaccard, "The Renewable Portfolio Standard: Design Considerations and an Implementation Survey," *Energy Policy* 29, 2001, pp. 263-277.

24. One exception comes from New York. See Robert C. Grace, "Modeling the Impacts of a NY Renewable Portfolio Standard," NY RPS Modeling Workshop, June 27, 2003. http://www.dps.state.ny.us/rps/RCG_Modeling_Workshop_062703.pdf The consultant represents a firm with interests in expanding renewable use. See http://www.dps.state.ny.us/rps/RCG_Modeling_Workshop_062703.pdf. There are numerous other state-level studies that claim to analyze costs and benefits, most of which examine little more than the bills of small consumers, and not (e.g.) the health benefits of cleaner air that the renewables will produce. A list of 23 studies undertaken prior to mid-2005 shows 16 authored by pro-renewables organizations. See Ryan Wiser, "An Overview of the Results and Methods of State RPS Cost-Benefit Projections," Presentation Graphics, June 7, 2005. http://www.keystone.org/spp/documents/Wiser_RPS%20Cost%20Studies.ppt#448,1, An Overview of the Results and Methods of State RPS Cost-Benefit Projections.

25. States appear to compete to set the most ambitious goals, whether or not they can be fulfilled. Oregon's Governor recently announced (incorrectly) that his state's RPS would make it one of only two with a 25 percent requirement. At roughly the same time, California's State Senate passed a bill with a 33 percent standard, generally agreed-upon as impossible to meet at reasonable cost. "Governor Presses Legislature to Support Renewable Energy Standard for Oregon," States News Service, March 6, 2007, and "California Senate Gives Nod to 33 Percent RPS Requirements Bill," *Electric Utility Week*, May 21, 2007, p. 24.

26. As will be seen below, some California utilities' decisions to invest in unproven renewables reflect the reality that failure to comply with their state's RPS is unlikely to bring penalties, while success will bring them additional revenue and reputations for innovation.

27. In some states (e.g. Massachusetts) a utility unable to find renewables at low prices is required to contribute to renewables research.

28. The U.S. Environmental Protection Agency's Combined Heat and Power Partnership contains a table of eligible renewables, at http://www.epa.gov/chp/state-policy/renewable_fs.html. Even its definitions have gradations. Connecticut accepts only "sustainable" biomass (from crops that are replanted) and Massachusetts only allows low-emission biomass as fuel. Thomas Petersik, *State Renewable Energy Requirements and Goals: Status Through 2003*, U.S Department of Energy, Energy Information Administration (subsequently DOE/EIA), Working Paper, 2004, p. 2. http://www.eia.doe.gov/oiaf/analysispaper/rps/index.html.

29. 2003 data on hydroelectric capacity appear in Petersik, p. 2. Nevada's Hoover Dam has a capacity of 2,080 MW and Washington's Grand Coulee Dam has 6,800 MW. http://www.usbr.gov/lc/hooverdam/faqs/powerfaq.html, http://www.usbr.gov/power/data/sites/grandcou/grandcou.html.

30. A demand management program that permanently reduces load by a megawatt will have the same effect on emissions as investment in a megawatt of renewable generation. An efficient RPS, however, must contain dissimilar provisions for demand management and renewable generation. Under a 20 percent RPS a utility that cuts load by 1 MW reduces its obligation by only 0.2 MW, but an additional MW of renewable capacity

counts fully for compliance. Renewable generation interest groups will generally be hostile to demand management, and currently only three states treat the two symmetrically. The RPS recently passed by the U.S. House attempted to treat demand reduction symmetrically with renewables, but even if it became law there would be lengthy rulemakings necessary to fill in the details.

31. The California Energy Commission, normally a strong supporter of demand management, disfavors the inclusion of "non-generation" power sources in a federal RPS on grounds that "one of [its purposes] is to provide a market for renewable energy and ultimately reduce the cost of renewable technologies." California Energy Commission, "Responses to Questions from House Energy Committees," June 18, 2007, p. 6. http://www.energy.ca.gov/papers/2007-06-18_CONGRESSMAN_DINGELL_LETTER PDF.

32. Energy Research Center of the Netherlands, *Review of International Experience with Renewable Energy Obligation Support Mechanisms,* ECN-05-025, March, 2005, pp. 9–14. http://eetd.lbl.gov/ea/ems/reports/57666.pdf. Dominique Finon and Phillipe Menanteau, "The Static and Dynamic Efficiency of Instruments of Promotion of Renewables," CIRED Working Paper, 2004. http://econpapers.repec.org/scripts/redir.pl?u=http%3A%2F%2Fhalshs.archives-ouvertes.fr%2Fdocs%2F00%2F00%2F13%2F00%2FPDF%2FDF_PM_ESR-vol12n1.pdf;h=repec:hal:papers:halshs-00001300_v1.

33. Strictly speaking, optimality requires a second-price auction in which the highest accepted bid receives the value of the lowest rejected bid.

34. Worldwatch Institute and Center for American Progress, p. 35. http://www.worldwatch.org/node/4405. For a more substantial defense of feed-in tariffs against alternatives and a discussion of their allegedly superior performance in Europe, see Wilson H. Rickerson et al., "If the Shoe FITs: Using Feed-in Tariffs to Meet U.S. Renewable Targets," *Electricity Journal* 20, May, 2007, pp. 73–86.

35. The law required state regulators to set the price they would pay small power producers at the "avoided cost of utility-supplied power." At the high end, California's projections assumed that the world price of oil would go to over $100 a barrel (in then-current dollars) by 1990 and that natural gas would be in perpetual shortage. New York's "Six-Cent Law" likewise guaranteed its IPPs prices that turned out far above market. At the low end, states with abundant industrial cogeneration opportunities like Michigan and Pennsylvania set prices so low that very few qualifying facilities were built.

36. Finon and Menineau, p. 17.

37. See Caroline Fischer and Richard Newell, *Environmental and Technology Policies for Climate Change and Renewable Energy*, Revised February, 2007, DP 04-05, Resources for the Future, pp. 21, 24. http://www.rff.org/Documents/RFF-DP-04-05-REV.pdf.

38. PA Consulting Group, "The Renewable Energy Credit Markets," September 19, 2005. http://www.paconsulting.com/news/about_pa/2005/news_about_pa_SNLi_Q_A_Frank_Stern_interview.htm.

39. Several states in the graph allow retail customers to choose between utilities and alternative servers, who must also obtain renewables or RECs. Retail competition is likely to render these markets more liquid. It originally appeared in Ryan Wiser et al., *Renewables Portfolio Standards: A Factual Introduction to Experience from the United States*, LBNL-62569, Lawrence Berkeley National Laboratory, April, 2007, p. 11. http://eetd.lbl.gov/ea/EMP/reports/62569.pdf Additional data on prices in five state REC markets appear in CEC, *Integrated Energy Policy Report Update*, 2006, pp. 66–68.

40. Wiser et al. (2007), p. 12.

41. David Berry, "The Market for Tradable Renewable Energy Credits," *Ecological Economics* 42, 2002, pp. 369–379. Other unresolved technical questions involve credits from distributed generation and PURPA qualifying facilities. Should their owners also own the valuable credits (which can be sold to their purchasing utility or to others), or should the credits revert to the purchasing utility? See CPUC, *Renewable Energy Certificates and the California Renewable Portfolio Standards Program*, Staff White Paper, April 20, 2006. http://www.cpuc.ca.gov/published/Report/55606.htm.

42. California's 2002 RPS legislation contemplated but did not require an REC market. It cautioned that a market "must not exacerbate environmental justice problems," not dilute the environmental benefits of renewables, and not be prone to manipulation. See CPUC, "Order Instituting Implementation of Senate Bill 1078 Renewable Portfolio Standards Program, Decision D," 03-06-071, June 19, 2003, pp. 8–11.

43. "Hillary Boyce, *et al*, "An Analysis of Tradable Credits as a Potential Cost Minimization Tool for California RPS Implementation," Unpublished Thesis, University of California, Santa Barbara, 2004. http://www.bren.ucsb.edu/research/2004Group_Projects/electricity/electricity_brief.pdf.

44. Two RPS proponents suggest that the "elimination" of the Public Utility Holding Company Act in the Energy Policy Act of 2005 ends the inequality problem by removing restrictions on long-distance

mergers of holding company utilities. Mergers will allow a renewable-rich operating company to "send" (actually, sell) power to a deficient one in the same organization. Sovacool and Cooper, p. 22. The scenario, however, assumes a fortuitous pattern of mergers, disregards continuing oversight by the Federal Energy Regulatory Commission (FERC), and assumes that regulators in losing states will passively watch as customer bills increase. Recent attempts by low-cost Entergy Arkansas (supported by state regulators) to withdraw from the holding company's System Agreement may be illustrative. See "FERC Rejects Louisiana PSC's Request that Entergy Arkansas Not Be Allowed to Withdraw from Entergy System Agreement," *Foster Electric Report*, June 6, 2007, p. 8. Sovacool and Cooper also fail to consider how states might protect their ratepayers from merger-related costs and how they might continue to carry out their own environmental policies. Robert Gee, "After PUHCA Repeal: The State Response," *Public Utilities Fortnightly*, March, 2006, pp. 43–48, and Robert Burns and Michael Murphy, "Repeal of the Public Utility Holding Company Act of 1935: Implications and Options for State Commissions," *Electricity Journal* 19, October, 2006, pp. 32–42.

45. Jeffrey Zabel and Katherine Kiel, "Estimating the Demand for Air Quality in Four U.S. Cities," *Land Economics* 76, May, 2000, pp. 174–194.

46. Cooper and Sovacool, p. 74.

47. Robert Michaels, "Where Renewables Come From—and Don't," *New Power Executive*, February 28, 2007, p. 1. Regression equations were of logit form, significance was taken at a 5 percent level, and the 30 percent is a psuedo-R^2.

48. A table appears in Karlynn Cory and Blair Sweezy, "Renewable Portfolio Standards in the States: Balancing Goals and Rules," *Electricity Journal* 20, May, 2007, p. 28.

49. Maine has no cap, but compliance is not an important issue thanks to the state's legacy of forest-based biomass conversion and regulators' classification of efficient gas-fired units as renewables. Some caps are set as ceilings on the prices at which utilities must purchase renewables, while others are in the form of set fees or percentage impacts on customer bills. See Cory and Sweezy, pp. 28–29.

50. The RPS in the 2007 House-passed bill, however, does not contemplate a price cap or specify other ways in which a utility can gain exemption.

51. Overseas, the United Kingdom and Sweden are out of compliance with their RPSs and becoming more so with the passage of time. Energy Research Center of the Netherlands, "Review of International Experience with Renewable Energy Obligation Support Mechanisms," ECN-05-025, March, 2005, pp. 9–14. http://eetd.lbl.gov/ea/ems/reports/57666.pdf.

52. Sovacool and Cooper, p. 20. Most of California's progress (see below) was actually made before enactment of its RPS and renewables have stagnated since then. Nevada is currently not in compliance with its industry standard or its solar setaside requirerment. New York's program is administered by the New York State Energy Resources and Development Authority (NYSERDA). In 2004, 19.3 percent of the state's power came from renewables (including hydro). The RPS set a goal of 25 percent by 2013, largely funded by production subsidies. The program has two "tiers," one consisting of large-scale projects that will sell into the New York Independent System Operator's markets, and the other consisting of small resources that operate "behind the meter," i.e. as supplemental sources for individual users. The latter is approximately 3 percent of the former. Newly built first-tier sources were targeted to produce 1.1 million MWh in 2006, the first year of targets. Failure of some contracts meant that non-failures were expected to produce 0.86 million, and delay in putting one facility on line led to an actual output of 0.58 million, 52 percent of the target amount. See NYSERDA, New York State Renewable Portfolio Standard, *Performance Report, Program Period Ending March 2007*, August, 2007, pp. 4–8. http://www.nyserda.org/rps/2006RPSPerformanceReport.pdf.

53. Barry Rabe, *Race to the Top: The Expanding Role of U.S. Renewable Portfolio Standards*, Pew Center on Global Climate Change, 2006, p. vi.

54. Rabe, p. 10.

55. In 1999, 880 MW of renewables were already in place. Competition and RPS applied to the 80 percent of the load served by the five utilities making up the Electricity Reliability Council of Texas (ERCOT). ERCOT operates in almost complete electrical isolation from the other national networks and is exempt from rate regulation by the Federal Energy Regulatory Commission. For more see Robert Michaels, *Electricity in Texas*, Texas Public Policy Foundation, February, 2007. http://www.texaspolicy.com/pdf/2007-02-RR04-electricity-rm.pdf.

56. Some authors argue that Texas's RPS itself has helped to lower risks because satisfying it requires that a retailer make a long-term contract with a generator. See Ole Langniss and Ryan Wiser, "The Renewables Standard in Texas: An Early Assessment," *Energy Policy* 31, May, 2003, pp. 527–35.

57. Mike Sloan, "Renewable Energy Credits: A

Success in Texas," *Environmental Finance*, April, 2000, p. 23. http://www.emissions.org/publications/member_articles/ef04ema.pdf.

58. Lawrence Risman and Joan Ward, "Winds of Change Freshen Resource Adequacy," *Public Utilities Fortnightly*, May, 2007, p. 18.

59. After 2009 there is an open-ended requirement for an additional 1 percent per year until regulators choose to terminate it.

60. Expectations that biomass might take the place of some missing wind resources may also not be realized because of local political factors. See Rabe, p. 15.

61. Massachusetts Division of Energy Resources, *Massachusetts Renewable Energy Portfolio Standard Annual RPS Compliance Report for 2005*, February 20, 2007, p. 9. http://www.mass.gov/doer/rps/rps-2005annual-rpt.pdf.

62. Ibid, p. 4.

63. Rabe, p. 15.

64. Original Filing, Nevada Power Co., Docket No. 07-04005 (Pub. Utilities Comm'n of Nev., April 2, 2007), at http://pucweb1.state.nv.us.

65. Ibid, p. 18.

66. Pennsylvania Public Utility Commission, Implementation Order, Docket M-00051865, Mar. 23, 2005, at http://www.puc.state.pa.us/PcDocs/534798.doc ; and Electric Power Outlook for Pennsylvania 2006-2011 9 (2007), at http://www.puc.state.pa.us/General/publications_reports/pdf/EPO_2007.pdf

67. Pennsylvania Public Utility Commission, Implementation Order, Docket M-00051865, *Op. Cit.*.

68. Washington State subsequently passed a renewables referendum in 2006, for a 15 percent requirement by 2020.

69. The figure is from California Energy Commission (CEC), *2007 Integrated Energy Policy Report*, Final Commission Report No. 100-2007-008-CMF, p. 126. http://www.energy.ca.gov/2007publications/ CEC-100-2007-008/CEC-100-2007-008-CMF.PDF. All CPUC-jurisdictional load serving entities must satisfy a renewables requirement, but the state has yet to finalize a rule for marketers that continue to serve "Direct Access" customers that bypassed their utilities when doing so was legal in the late 1990s. The municipal utilities that sell 20 percent of the state's power have been encouraged to initiate their own RPS programs, but the state has little enforcement power over them.

70. Per capita power use in California, unlike most other states, has changed very little since the early 1990s, less a consequence of effective conservation than of higher prices, departing industrial loads and increases in the average number of persons per residence.

71. "The trend since 2003 is increasing load growth without the required increases in the amount of renewable generation." CEC, *2007 Integrated Energy Policy Report*, pg. 166. The 242 MW figure does not appear directly in this report, but can be found in CEC *Integrated Energy Policy Report, 2006 Update*, p. 4.

72. CPUC, *Progress of the California Renewable Portfolio Standard, Report to the Legislature*, January, 2007, p. 2. http://www.cpuc.ca.gov/PUBLISHED/GRAPHICS/63854.PDF.

73. CEC, 2007 *Integrated Energy Policy Report* at 168. Over 1,000 MW of this figure consists of build-out options in some of the contracts.

74. The manufacturer claims a capacity factor of 23.9 percent. See http://www.stirlingenergy.com/breaking_news.htm. The CEC notes that "Capital costs of Stirling technologies are relatively high ($2,000–$50,000/kw) and are not generally cost competitive with other [distributed resource] technologies." CEC, *Distributed Energy Resource Guide* (2002) at http://www.energy.ca.gov/distgen/equipment/stirling_engines/cost.html

75. "Powerlink's Supply Called into Question," *San Diego Union-Tribune*, July 11, 2007.

76. Pacific Gas & Electric, which serves northern California, is also planning a major solar installation, but its technology has already been shown to be feasible. "California Large Scale Solar Competition Heats Up," *Natural Gas Intelligence*, September 17, 2007.

77. California Energy Commission, *Intermittency Analysis Project, Final Report*, CEC-500-2007-081, July, 2007, p. 26. Total transmission investment (both new and replacement) by U.S. corporate utilities in 2005 was $5.8 billion. See the Edison Electric Institute data at http://www.eei.org/common/images/industry_issues/Energy_Data_Alert/bar_Transmission_Investment.jpg.

78. KEMA, Inc. *Building a 'Margin of Safety' into Renewable Energy Procurements*, Report for the California Energy Commission, CEC-300-2006-004, July, 2006. In KEMA's national sample of renewable contracts (which included failures), only half of the capacity was actually on track for timely completion.

79. CPUC, *RPS Contracts—CPUC Approved or Pending as of January 2008*, http://www.cpuc.ca.gov/PUC/energy/electric/RenewableEnergy/rpsprojects.htm.

80. CPUC, *Renewables Portfolio Standard Quarterly Report, April 2008*, 7 http://www.cpuc.ca.gov/NR/rdonlyres/2DBB287C-6DE9-4574-97D4-AA7F16996D3B/0/RPS_Rpt_to_Legislature_April_2008.DOC.

81. CEC, *2006 Integrated Energy Policy Update*, p. 27.

82. For a typical group report, see the report on Southern California Edison's 2006–2008 plans, at http://www.sce.com/NR/rdonlyres/C9F82120-52F5-45D2-B300-B66926CA4A21/0/SCEPeerReviewAssessment.pdf. The group's members include two CPUC employees, one Energy Commission employee, one appointee from the Natural Resources Defense Counsel, and one from small-consumer advocacy group TURN.

83. CEC, *2006 Integrated Energy Policy Report Update*, p. 37.

84. Ibid.

85. CPUC, "Opinion Conditionally Approving Procurement Plans for 2006 RPS Solicitations," Decision D.06-05-039, May 25, 2006, p. 25. http://www.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/56685.htm.

86. CPUC, *Progress of the California Renewable Portfolio Standard, Report to the Legislature*, January, 2007, p. 2. http://www.cpuc.ca.gov/PUBLISHED/GRAPHICS/63854.PDF

87. Ibid.

88. CPUC, *Renewables Portfolio Standard Quarterly Report, April 2008*, 7 http://www.cpuc.ca.gov/NR/rdonlyres/2DBB287C-6DE9-4574-97D4-AA7F16996D3B/0/RPS_Rpt_to_Legislature_April_2008.DOC.

89. They retained their hydroelectric, nuclear and coal-fired plants, but gas-fired generators generally set the market price in California. The third utility, San Diego Gas & Electric, was not required to divest but did so later in order to obtain approval of its parent's acquisition of Southern California Gas Company.

90. California Energy Commission, "Energy Facility Status," updated Sept. 17, 2007. 6,900 MW are "on hold," which the CEC calls "available for construction," and 1,300 were abandoned or their permits lapsed. http://www.energy.ca.gov/sitingcases/all_projects.html#approved. Only 700 MW was added between the summers of 2006 and 2007 in the territories operated by the ISO. California ISO, 2007 *Summer Loads and Resources Operations Assessment*, p. 51. http://www.caiso.com/1b95/1b95abb649df4.pdf.

91. Ahmad Faruqui and Ryan Hledik, *California's Next Generation of Load Management Standards*, Prepared for California Energy Commission, CEC 200-2007 -007D, May, 2007. http://www.brattle.com/_documents/News/News366.pdf.

92. "SoCal Ed to Boost Generation, Demand Response," *Electric Power Daily*, August 18, 2006, p. 4. The events that led to issuance of the order are not on the public record. The northern half of the state currently has adequate capacity but the southern is facing tighter constraints that the CEC sees as threats to reliability.

93. The company also claimed that some of the generation was necessary because lack of a line would stymie its plans to attain certain renewable and demand management goals. See Initial Brief of Southern California Edison Company, CPUC Rulemaking 06-02-13, August 1, 2007, p. 26.

94. "Powerlink's Supply Called into Question," *San Diego Union-Tribune*, July 11, 2007.

95. A list appears in Alan Nogee et al, "The Projected Impacts of a National Renewable Portfolio Standard," *Electricity Journal* 20, May, 2007, p. 35.

96. NEMS was first introduced in 1994, but continues to change. Over 3,500 pages of documentation were issued in 2006 and the first half of 2007 alone. See http://tonto.eia.doe.gov/reports/reports_kindD.asp?type=model%20documentation.

97. Using the 2004 version of NEMS to analyze a national RPS, Nogee *et al* (pp. 36-38) say that they "generally used more pessimistic assumptions about available renewable energy supply, but more optimistic assumptions about costs and performance." They did not show what happens if the optimism and pessimism are reversed. Other researchers using the 1999 NEMS found that assumptions about future technology and costs are more important determinants of wind power deployment than assumptions about site availability. See Julie Osborn *et al*, *A Sensitivity Analysis of the Treatment of Wind Energy in the AEO99 Version of NEMS*, Lawrence Berkeley National Laboratory, LBNL-44070, January, 2001. http://repositories.cdlib.org/cgi/viewcontent.cgi?article=2121&context=lbnl.

98. Some renewables advocates who do not use NEMS nevertheless cite it favorably. Cooper and Sovacool (p. 33) say that it "is so rigorous that it is used as a benchmark for models employed by the [Union of Concerned Scientists] and the Tellus Institute in their own projections of renewable energy production." In fact, Tellus simply ran NEMS as part of a 2002 UCS study, and neither organization appears to have its own model to project the effects of an RPS. See Nogee *et al* (2002), p. 104.

99. In five-year forecasts between 1982 and 1988, the mean percentage error of NEMS for total energy consumption was an impressive 0.1 percent. Looking more closely, this is a consequence of overestimating industrial use by an average 5.9 percent and transportation use by 4.5 percent. Extrapolation of simple trends often provides superior results. James Winebrake and Denys Sakva, "An Evaluation of Errors in U.S. Energy Forecasts: 1982–2003," *Energy Policy* 34, 2006, p. 3482. Likewise, a seemingly accurate forecast for energy intensity per dollar of gross domestic project is the product of substantial offsetting forecast errors for energy use and GDP. Brian O'Neill and Mausami Desai, "Accuracy of Past Projections of US Energy Consumption," *Energy Policy* 33, 2005, pp. 979–93.

100. From the 1960s through the 1980s, such models consistently overestimated both U.S. and world energy consumption by factors ranging from 10 to 200 percent. "Long-range energy forecasters have missed every important shift of the past two generations." Vaclav Smil, "Perils of Long-Range Energy Forecasting: Perils of Looking Far Ahead," *Technological Forecasting and Social Change* 65, 2000, p. 262.

101. Gabrielle Wong-Parodi et al, *Natural Gas Prices Forecast Comparison: AEO vs. Natural Gas Markets*, LBNL-55701, Lawrence Berkeley National Laboratory, 2005. The most distant futures contracts, however, run only five years ahead. http://repositories.cdlib.org/cgi/viewcontent.cgi?article=2880&context=lbnl.

102. EIA, *Impacts of a 15-Percent Renewable Portfolio Standard*, SR/OIAF/2007-03, June, 2007, p. 9. Exemplifying sensitivity to technological and cost assumptions, Nogee *et al* (pg. 39, 41) use slightly different assumptions to get a NEMS estimate that a "20 percent by 2020" national RPS will yield 28.5 percent of production from biomass and 58.9 percent from wind. This study also predicts decreases in both power and gas prices in all regions. http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Testimony&Hearing_ID=1403&Witness_ID=4034&SuppressLayouts=True.

103. EIA, *Assumptions to the Annual Energy Outlook 2007, Electricity Market Module*, DOE/EIA 0554, 2007, pg. 76, 78. http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/electricity.pdf#page=3. The future of biomass may be unclear, but "mature" technologies (as wind is becoming) have significantly slower rates of improvement than less mature ones. Karen Palmer and Dallas Burtraw, "Cost-Effectiveness of Renewable Energy Policies," *Energy Economics* 27, 2005, p. 887.

104. EIA, "Proposed U.S. Electric Generating Units by Year, Month, Company and Plant," http://www.eia.doe.gov/cneaf/electricity/epa/epat2p2.html.

105. EIA maintains its legally required neutrality by assuming (unless otherwise requested) that existing legislation, regulation and policy remain unchanged. Andy S. Kydes, "Impacts of a Renewable Portfolio Generation Standard on US Energy Markets," *Energy Policy* 35, 2007, p. 814. The Union of Concerned Scientists believes that EIA's assumptions are far too stringent. See Nogee *et al* (2007).

106. NEMS also projects the amounts and dates of future additions to nuclear capacity.

107. EIA, *Annual Energy Outlook 2007*, DOE/EIA 0383, 2007, p. 86. The models assume no new environmental laws beyond passage of the Bush administration's Clear Skies Act in 2010. http://www.eia.doe.gov/oiaf/aeo/pdf/0383(2007).pdf.

108. *Annual Energy Outlook 2007*, p. 87. The low figure reflects the fact that many of the renewables put in place under business-as-usual are in RPS states.

109. In April 2007, 27.3 percent of gas deliveries went to generators. See EIA at http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_dcu_nus_m.htm.

110. The commission has recommended a national RPS, but these NEMS runs did not assume it.

111. EIA, *Impact of Modeled Recommendations of the National Commission on Energy Policy*, SR/OIAF/2005-02, April, 2005, p. 33. http://www.energycommission.org/files/contentFiles/EIA%20Analysis%20of%20NCEP%20Recommendations_440cc3e92e86e.pdf.

112. Karen Palmer and Dallas Burtraw, *Electricity, Renewables and Climate Change: Searching for a Cost-Effective Policy*, Resources for the Future, May, 2004, p. 3. http://www.rff.org/rff/News/Features/Electricity-Renewables-and-Climate-Change.cfm.

113. W. David Montgomery, "Renewable Portfolio Standards: A Solution in Search of Problem?" Presentation Graphics, Harvard Electricity Policy Group, May 20, 2005, p. 8. http://www.ksg.harvard.edu/hepg/Papers/Montgomery%20Renewable%20Portfolio%20Standards.pdf.

114. Karen Palmer and Dallas Burtraw (2004), p. 34. This happens because there are high- and low-cost nuclear plants, and when renewable capacity is high a utility minimizes cost by closing inefficient nuclear units and keeping coal-fired units in operation. This document also discusses the results of several other RPS studies not mentioned here. http://www.rff.org/rff/News/Features/Electricity-Renewables-and-Climate-Change.cfm.

115. One tabulation of sixteen studies showed gas

prices falling by amounts that ranged from zero to $1.58 per million BTUs with a mean of 18.6 cents (the source omits two extremely high estimates made by RPS advocacy groups). Price changes per kilowatt-hour (KWh) of electricity ranged from an 0.18 cent drop (i.e. 1.8 mills) to an 0.21 cent increase. Ryan Wiser *et al, Putting Downward Pressure on Natural Gas Prices: The Impact of Renewable Energy and Energy Efficiency*, LBNL-54971, Lawrence Berkeley National Laboratory, 2004, p. 6. http://repositories.cdlib.org/lbnl/LBNL-54971/.

116. Assume for simplicity that a fixed amount of gas goes to market each month regardless of price, i.e. its supply curve is vertical. A national RPS shifts the demand curve for gas inward and reduces its price. The same volume per month changes hands, but the amount saved by the buyer of a unit equals the amount lost by its suppliers. The same reasoning holds for an upward-sloping supply curve. For a graphical demonstration see Ryan Wiser *et al* (2004), p. 6. http://repositories.cdlib.org/lbnl/LBNL-54971/.

117. New annual wind investments in the tax credit years of 2001, 2002 and 2005 were 1,697, 1,687, and 2,431 MW. In non-credit years of 2000, 2002 and 2004 they were 67, 446 and 389 MW. See DOE/EERE (2007), p. E-6.

118. There are concerns that the best wind sites in some areas are already taken and that unless costs continue to fall a permanent PTC will be necessary to sustain investment. See DOE/EERE (2007), p. E-4.

119. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2006*, May, 2007, pg. 15, 16. http://www.nrel.gov/docs/fy07osti/41435.pdf.

120. Renewable advocates commonly cite Denmark's 20 percent of power obtained from wind as a counterexample, and some claim that backup capacity is almost unneeded. (Worldwatch Institute and Center for American Progress, p. 16) In reality, Denmark operates within a unified hydroelectric-based Scandinavian grid and also has strong interconnections with Germany. Wind produces about 2 percent of the power in this multi-nation region, which serves as a sink when Denmark's winds are strong and a source of non-wind generation (largely nuclear and hydroelectric) when they are not. Denmark must pay premium prices for imports when the wind is not blowing, and receives only discounted prices (sometimes zero) for most exported wind power. Approximately half of its wind-generated power must be exported. See Techconsult, Analysis of Wind Power in The Danish Electricity Supply, 2005–2006, at http://www.wind-watch.org/documents/wp-content/uploads/dk-analysis-wind.pdf; World Nuclear Organization, *Nuclear Energy in Denmark*, December, 2005 at http://www.world-nuclear.org/info/inf99.html and California Energy Commission, *Review of International Experience Integrating Variable Renewable Generation*, 2007, Appendix A. http://www.energy.ca.gov/2007publications/CEC-500-2007-029/CEC-500-2007-029-APA.PDF. Denmark's average cost per kwh of power is among the world's highest, at 24 U.S. cents in 2007. Comparable figures for the U.S. are 9 cents, nuclear-heavy France is 8 cents, and hydro-based Sweden is 6 cents. Richard Soultanian, Global Electricity Pricing, *Power Engineering International*, July 2007.

121. Edward Kahn, "Effective Load Carrying Capability of Wind Generation: Initial Results with Public Data," *Electricity Journal* 17, December, 2004, pp. 85–95, and Michael Milligan and Kevin Porter, "The Capacity Value of Wind in the United States: Methods and Implementation," *Electricity Journal* 19, March, 2006, pp. 91–99.

122. Eric Hirst and Jeffrey Hild, "The Value of Wind Energy as a Function of Wind Capacity," *Electricity Journal* 17, July, 2004, pp. 11–20.

123. California Public Utilities Commission, *2006 Resource Adequacy Report*, February, 2007, p. 34. By contrast, on all but one of the five peaks solar units were operating between 88 and 108 percent of capacity. Ibid, p. 36. http://www.cpuc.ca.gov/word_pdf/REPORT/65960.doc

124. California ISO, 2007 *Summer Loads and Resources Operations Assessment*, March, 2007, pp. 33–34. http://www.caiso.com/1b95/1b95abb649df4.pdf.

125. Lawrence Risman and Joan Ward, "Winds of Change Freshen Resource Adequacy," *Public Utilities Fortnightly*, May, 2007, p. 18, and ERCOT, *Transmission Issues Associated with Renewable Energy in Texas, Informal White Paper for the Texas Legislature*, March 28, 2005, p. 7. http://www.ercot.com/news/presentations/2006/RenewablesTransmissi.pdf.

126. ERCOT, pg. 7, 10. Actual average output of Texas wind resources is 16.8 percent of capacity, but winds are generally strongest at off-peak hours when it is not needed to support reliability. http://www.ercot.com/news/presentations/2006/RenewablesTransmissi.pdf.

127. California Energy Commission, *Intermittency Analysis Project, Final Report*, CEC-500-2007-081, 2007, p. 26.

128. Edison Electric Institute, *Actual and Planned Investment by Shareholder-Owned Electric Companies, 2000–2009*. Transmission is defined as voltages above 33 kv. http://www.eei.org/common/images/industry_issues/Energy_Data_Alert/bar_Transmission_Investment.jpg.

129. A good example can be found in California's "Energy Action Plan," which gives near-unconditional dispatch priority to renewables. In reality, the requirement is not as stringent as it appears because the plan specifies that its dispatch order must be consistent with sound operating practices. See California Public Utilities Commission, *Energy Action Plan II, Implementation Roadmap for Energy Policies*, August 25, 2005. http://www.cpuc.ca.gov/word_pdf/REPORT/49078.pdf.

130. It is important to understand that energy itself is only one necessary component of reliably delivered electricity. This fact appears to be forgotten in claims like "a household powered by renewables with zero marginal costs will save almost the entire 17 cents it used to pay for conventional power." The substantially overstates the alleged savings, even if renewables do not require the reserve investments described above. Renewable energy replaces only conventional energy, and no other component of delivered power. The energy replaced probably comes from a gas-fired generator and costs approximately 10 cents per KWh. The remaining 7 cents covers fixed costs of transmission, distribution, and system operation that will remain largely unchanged whether or not renewables are present. In any regulatory environment, someone will still have to pay those fixed costs. For more on fixed costs in the context of GHG emissions policies, see Robert N. Stavins *et al*, "Too Good to Be True? An Examination of Three Economic Assessments of California Climate Change Policy," January, 2007. http://ssrn.com/abstract=973836.

131. Of course, some public-spirited consumers choose to pay their utilities a small premium for "green" power. Their choices, however, do not carry enough weight to make the environment cleaner or to push the cost of renewables down.

132. Their RPS proposal was restricted to the state level. Richard Norgaard and Nancy Rader, "Efficiency and Sustainability in Restructured Electricity Markets: The Renewables Portfolio Standard," *Electricity Journal* 9, July, 1996, pp. 37–49. Also see Brent Haddad and Paul Jefferiss, "Forging Consensus on National Renewables Policy: The Renewables Portfolio Standard and the National Public Benefits Trust Fund," *Electricity Journal* 12, March, 1999, pp. 68–80.

133. The choosers will surely include interested parties like Norgaard and Rader, who nevertheless claim that "[f]or choices about equity and sustainability, we must rely on democratic processes, including commissions to whom public authority has been delegated." Norgaard and Rader, p. 38. They never specify exactly who comprises "we," important in light of the markedly differing degrees of *de facto* access to commissions enjoyed by different subsets of the population.

134. The U.S. Supreme Court recently ruled that EPA has rulemaking powers over carbon dioxide and other greenhouse gases, whose status as pollutants was previously unclear.

135. For more on criteria pollutants and their control, see http://www.epa.gov/air/urbanair/.

136. See Montgomery, http://www.ksg.harvard.edu/hepg/Papers/Montgomery%20Renewable%20Portfolio%20Standards.pdf.

137. As noted above, a few studies have estimated the reductions in greenhouse gases and other pollutants that a national RPS would bring. No study by an advocacy group has examined alternative policies at similar depth.

138. This study does not address the currently contentious topic of whether greenhouse gas emissions are most efficiently controlled by a cap-and-trade system or by a carbon tax.

139. By one estimate, allowance trading has reduced the cost of compliance for electric utilities by $700–$800 million per year. See Curtis Carlson *et al*, "Sulfur Dioxide Control by Electric Utilities: What Are the Gains from Trade?" *Journal of Political Economy* 108, November, 2000, pp. 1292–1326. These programs are currently restricted to electric generators, contrary to the efficiency maxims discussed above. For sulfur dioxide, this reflects the fact that most emissions of it come from coal-burning facilities, and that power generation accounts for over 80 percent of the nation's annual coal burn. Motor vehicles are an important source of nitrogen oxides but are individually too small to efficiently participate in the program. Geographically the sulfur permit market is restricted to the eastern U.S. where most pollution from coal-fired plants originates and remains in the area thanks to prevailing winds.

140. A summary of current markets and upcoming developments appears in Sam Napolitano et al, "A New Roadmap for the Power Sector," *Public Utilities Fortnightly*, June, 2007, pp. 53–59.

141. The still-definitive statement of these principles appears in F.A. Hayek, "The Use of Knowledge in Society," *American Economic Review* 35, September, 1945, 519–530.

142. The 2005 expansion of the PTC affected only renewables that are less viable than wind and did not alter their relative desirability. The owners of older plants might even attempt to make claims of "stranded investment" on grounds that the RPS was a part of the "regulatory compact, as occurred in some market-oriented state restructurings during the 1990s.

143. If renewables were the cheapest way to do the

job, allowance holders could build them and profitably use or sell their allowances.

144. This study does not attempt to evaluate any other questions about the importance of climate change, the costs and benefits of mitigation, and the likely success of mitigation policies. Instead, I take a mitigation program as given and ask about the potential contribution of an RPS. All too many pro-RPS studies (by authors with no scientific qualifications) contain selective discussions of the harm that warming will cause, and their similarly situated anti-RPS counterparts make similar claims that warming is harmless. Compare Lloyd J. Dumas, "Seeds of Change: Climate Change Challenges and Solutions," Civil Society Institute, April 2006; http://www.resultsforamerica.org/calendar/files/041906%20Seeds%20of%20Oppty%20Dumas%20report%20FINAL.pdf, and Bryan Leyland, "Is Renewable Energy A Safe, Long Term Investment—or Will It Soon Crash?" at http://www.energypulse.net/centers/article/article_display.cfm?a_id=1501.

145. Montgomery, p. 7.

146. James Bushnell, *et al, California's Greenhouse Gas Policies: Local Solutions to a Global Problem?* Center for Study of Energy Markets, WP-166, University of California Energy Institute, April, 2007. http://www.ucei.berkeley.edu/PDF/csemwp166.pdf.

147. Katerina Dobesova *et al*, "Are Renewables Portfolio Standards Cost-Effective Emission Abatement Policy?" *Environmental Science and Technology* 39, 2005, pp. 8578–8583.

148. Daniel Kammen *et al, Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?* Renewable and Appropriate Energy Laboratory, University of California, Berkeley, 2006, pp. 3–4; http://rael.berkeley.edu/files/2004/Kammen-Renewable-Jobs-2004.pdf. Nine of the thirteen studies came from environmental or renewables groups, two from Ralph Nader organizations, and one from the European Commission. The final one is an untraceable "study for Kerry/Kennedy." Only one appeared in a peer-reviewed journal. For similar projections, see Worldwatch Institute and Center for American Progress, p. 10, and R.K. Schweir and M. Riddel, *The Potential Economic Impact of Constructing and Operating Solar Power Facilities in Nevada*, National Renewable Energy Laboratory, NREL/SR-550-35037, 2004. http://www.nrel.gov/csp/pdfs/35037.pdf.

149. A typical coal-fired plant is available to run between 80 and 90 percent of the time.

150. Kammen *et al*, p. 10.

151. I do not address the question of whether the alleged existence of subsidies for conventional energy justifies giving them to renewables. RPS advocates almost uniformly take that position despite the fact that economic theory provides no definitive answer to the question.

152. In a typical month, over 10 percent of all workers change employers, enter, or leave the labor force, or enter or leave unemployment. Steven J. Davis *et al*, "The Flow Approach to Labor Markets: New Data Sources and Micro-Macro Links," *Journal of Economic Perspectives* 20, Summer, 2006, pg. 6, 10–11.

153. Figures are from the U.S. Census Bureau, at http://www.census.gov/population/censusdata/table-4.pdf.

154. U.S. Department of Agriculture, Economic Research Service, County Level Unemployment and Median Household Income for the United States. http://www.ers.usda.gov/Data/Unemployment/RDList2.asp?ST=US.

155. Others favor renewables on grounds that they represent an opportunity for the display of corporate social responsibility, and cite research showing its favorable effect on stock prices. See J.E. Pater, *A Framework for Evaluating the Value Proposition of Clean Energy Technologies*, National Renewable Energy Laboratory Technical Report NREL/TP-620-38597, February, 2006, pp. 50–51. A large body of research has yet to reach a conclusion about any possible relationship between stock prices and social responsibility. See Abagail McWilliams *et al*, "Issues in the Use of the Event Study Methodology: A Critical Analysis of Corporate Social Responsibility Studies," *Organiational Research Methods* 2:4, 1999, pp. 340–365.

156. Mark Bolinger, *Community Wind Power Ownership Schemes in Europe and Their Relevance to the United States*, Lawrence Berkeley National Laboratory, Publication LBNL-48357, 2001, and Mark Bolinger and Ryan Wiser, *A Comparative Analysis of Business Structures Suitable for Farmer-Owned Wind Power Projects in the United States*, Lawrence Berkeley National Laboratory, Publication LBNL-56703, 2004. Also see John Dunlop, *Wind Clusters: Expanding the Market Appeal of Wind Energy Systems*, prepared for Renewable Energy Policy Project, 1996. http://www.repp.org/repp_pubs/articles/issuebr4/issuebr4.pdf.

157. Worldwatch Institute, p. 15. Worldwatch also sees renewables as a defense against falling crop prices. A diversified portfolio of financial assets is a far superior tool for managing such risks.

158. National Rural Electric Cooperative Association, *White Paper on Wind Power*, 2003. http://www.nreca.org/Documents/PublicPolicy/Windwhitepaper.pdf.

159. Even if the theoretical justifications for tariff protection were sound, there are more efficient and

less disruptive ways to obtain the same benefits a tariff might provide. Robert E. Baldwin, "The Case Against Infant Industry Tariff Protection," *Journal of Political Economy* 77, May, 1969, pp. 295–305.

160. See, e.g. Dumas, pp. 21–23, and Ken Silverstein, "Steering Renewable Energy Policy," *Energy Biz Insider*, September 29, 2006. http://www.energycentral.com/centers/energybiz/ebi_detail.cfm?id=214.

161. Annual Report on U.S. Wind Power (2007), pp. 6–7.

162. The same goes for conventional generators. In the 1980s, small gas-fired plants saw a large jump in fuel efficiency as new designs took advantage of newly abundant gas following wellhead price decontrol.

163. Some have also posed an objection that differing definitions of eligible resources under state standards inhibit industry growth and that replacing them with a uniform federal standard would lower uncertainties and thus the costs of renewables. It is hard to see how technical differences in what constitutes a wind or biomass resource notably discourage innovation in those industries, particularly if the equipment can cross a national boundary in either direction. Compare Benjamin Sovacool and Christopher Cooper, "Big *Is* Beautiful: The Case for Federal Leadership on a National Renewable Portfolio Standard," *Electricity Journal* 20, June, 2007, p. 50.

164. Stanislaw, p. 18.

165. That vision of the Japanese economy was almost entirely a fiction. Yoshiro Miwa and J. Mark Ramseyer, *The Fable of the Keiretsu: Urban Legends of the Japanese Economy* (University of Chicago Press, 2006).

166. Paul Krugman, *Pop Internationalism* (MIT Press, 1997).

167. Absent special circumstances, the Worldwatch Institute has little reason to be alarmed over its discovery that the U.S. share of world solar collector production fell from 44 percent in 1996 to below 9 percent in 2005. The U.S. can only import renewables if it pays for them with the proceeds from exports or foreign investments. Worldwatch Institute and Center for American Progress, p. 11.

168. See, for instance, Ronald Sutherland and Jerry Taylor, "Time to Overhaul Federal Energy R&D," Policy Analysis 424, Cato Institute, February 7, 2002.

169. Daniel Kammen and Gregory Nemet, "Reversing the Incredible Shrinking Energy R&D Budget," *Issues in Science and Technology* 22, Fall, 2005, p. 86.

170. The sensitivity of figures like these to different assumptions can be substantial. If option value is taken into account, the figure in the text becomes +$35 billion. Graham Davis and Brandon Owens, "Optimizing the Level of Renewable Electric R&D Expenditures Using Real Options Analysis," *Energy Policy* 31, 2003, pp. 1589–1608.

171. For a progress report on storage, see Christopher Schaber *et al*, "Utility-Scale Storage of Renewable Energy," *Electricity Journal* 17, July, 2004, pp. 21–29.

172. For an example of the risks of fixed-price contracts, consider California's "avoided cost" payments to non-utility generators under the Public Utility Regulatory Policies Act of 1978. Its regulators determined fixed payments for 10 years under an assumption that by the mid-1980s oil would be at $100 a barrel and gas would be nearly exhausted. See EIA, *Policies to Promote Non-hydro Renewable Energy in the U.S. and Other Countries*, 2005, p. 10. http://tonto.eia.doe.gov/FTPROOT/features/nonhydrorenewablespaper_final.pdf.

173. Consumers in many areas have the option of "level pay" plans that give them the same bill every month, with reconciliation at year's end. Most utilities enroll few customers in these programs.

174. For a study that assumes fixed wind prices and high risk aversion, see Mark Bolinger *et al, Quantifying the Benefits that Wind Power Provides as a Hedge Against Volatile Natural Gas Prices*, Lawrence Berkeley National Laboratory, Publication LBL-50484, September, 2002. http://eetd.lbl.gov/EA/EMS/reports/50484.pdf.

175. See Robert Michaels, "Reducing Risk, Shifting Risk, and Concealing Risk: Why Are There Long-Term Gas Contracts?" in Joseph Kalt and Jerry Ellig (eds.), *New Horizons in Natural Gas Deregulation* (Praeger, 1996), pp. 195–208.

176. See, e.g. Worldwatch Institute, p. 7.

177. Gabrielle Wong-Parodi et al, "Natural Gas Prices Forecast Comparison: AEO vs. Natural Gas Markets, Lawrence Berkeley National Laboratory LBNL-55701 (2005). http://repositories.cdlib.org/cgi/viewcontent.cgi?article=2880&context=lbnl

178. See Ken Costello, "Increased Dependence on Natural Gas for Electric Generation: Meeting the Challenge," *Electricity Journal* 17, June, 2004, pp. 10–29.

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