ISSUE BRIEF

Cutting Carbon, Take Two

A Brief Guide to Federal Electricity-Sector Climate Policy without Cap-and-Trade

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Resources for the Future

The Center for Climate and Electricity Policy (CCEP) at Resources for the Future provides a framework for policymakers and stakeholders to better understand and address one of the most complex economic and environmental issues of our time—climate change—and to better understand the structure of and options for U.S. electricity generation, the main source of U.S. greenhouse gas emissions. The work of the Center is organized into three areas: 1) activities designed to support domestic policy development, 2) research on international climate policy strategies, 3) and analysis to anticipate the future needs of policymakers. Cross-cutting these areas are the three themes: mitigation, adaptation, and electricity policy.

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Joshua Linn and Nathan Richardson[1]

I. Introduction

In the United States, the electricity sector accounts for about 40 percent of carbon dioxide (CO_2) emissions, and is widely believed to contain some of the lowest-cost opportunities for reducing emissions. To cut emissions from this sector or the wider economy, most economists favor a carbon price (cap-and-trade or a carbon tax). But the failure of climate legislation in the Senate in 2010 and the current political makeup of the House of Representatives indicate that a federal carbon price is extremely improbable in the near future. In its place, the U.S. Environmental Protection Agency is in the process of regulating emissions under the existing Clean Air Act, and some states have moved ahead with state- or regional-level policies, some of which include carbon prices. Federal legislation is still possible too, so long as one is willing to look beyond a carbon price.

In fact, a broader set of policies in use and under consideration target investment in clean electricity technology without using an emissions price. These include technology mandates (such as renewable portfolio standards), feed-in tariffs, subsidies to investment and generation, and loan guarantees. One example is President Obama's recent proposal for a clean energy standard in his 2011 State of the Union address, which would require a share of national electricity generation to come from "clean" sources that emit less CO_2 for the electricity they generate than the most carbon-intensive, or "dirtiest," source of electricity, coal without carbon capture (a definition of clean vs. dirty sources we'll use here).

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There has been an intense debate over this and other recent proposals for new clean electricity policies, and over whether existing subsidies to renewable technologies should continue given the size of the federal deficit. The aim of this primer is to take a step back and, without focusing on the details of any specific policy or proposal, lay out the fundamental differences among the policy options. [2] We will discuss three types of policies: *technology mandates* (such as renewable portfolio or clean energy standards), *generation subsidies* (such as feed-in tariffs or fee-bates), and traditional *investment subsidies*. We focus on four main questions:

1. How do these policies create incentives for new investment?
2. How do they affect the mix of generation technologies and electricity prices?
3. What are the risks involved with each policy—and who bears them?
4. Can we identify some policies as clearly inferior to others?

This family of policies, which we refer to collectively as ***clean electricity policies***, shares the primary goal of creating incentives to use cleaner electricity sources, enabling them to compete with dirtier sources when they would not otherwise be able to. This in turn encourages clean electricity manufacturing and R&D. Supporters of these policies also tout ambiguous—and sometimes conflicting—environmental, employment, energy security, and international competitiveness benefits, complicating analysis and confounding efforts to identify an “ideal” policy.

Because of this, we will not advocate or even identify an ideal policy. Instead, our goal is simply to explain the basic policy choices and their economic implications. We have tried to avoid, where possible, alphabet-soup acronyms and excessive jargon. The policies themselves are not that complex when clearly described (as we have attempted to do), though the same often cannot be said for their wider implications, which are in some cases the subject of continuing controversy among economists. Our conclusions are qualitative but we hope to help navigate quantitative assessments of particular proposals, including recent analysis by researchers at Resources for the Future and elsewhere.

II. Creating Incentives: Clean Electricity Policies Explained

Electricity generation has long had a close relationship with government. Policymakers in other countries and at the federal and state level have often enacted policies aimed at changing the technologies used to generate electricity. A classic example is the use of government subsidies for nuclear and hydroelectric projects. More recently, governments have favored renewable electricity sources, such as wind, solar, and geothermal, largely due to their environmental benefits. The policy tools for doing this—clean electricity policies—are our subject here. We divide these policies into three broad categories: ***technology mandates***, ***generation subsidies***, and ***investment subsidies*** (see Figure 1, which shows policies discussed in this paper). This section describes how these policies work, and the next section discusses their effects on electricity markets.

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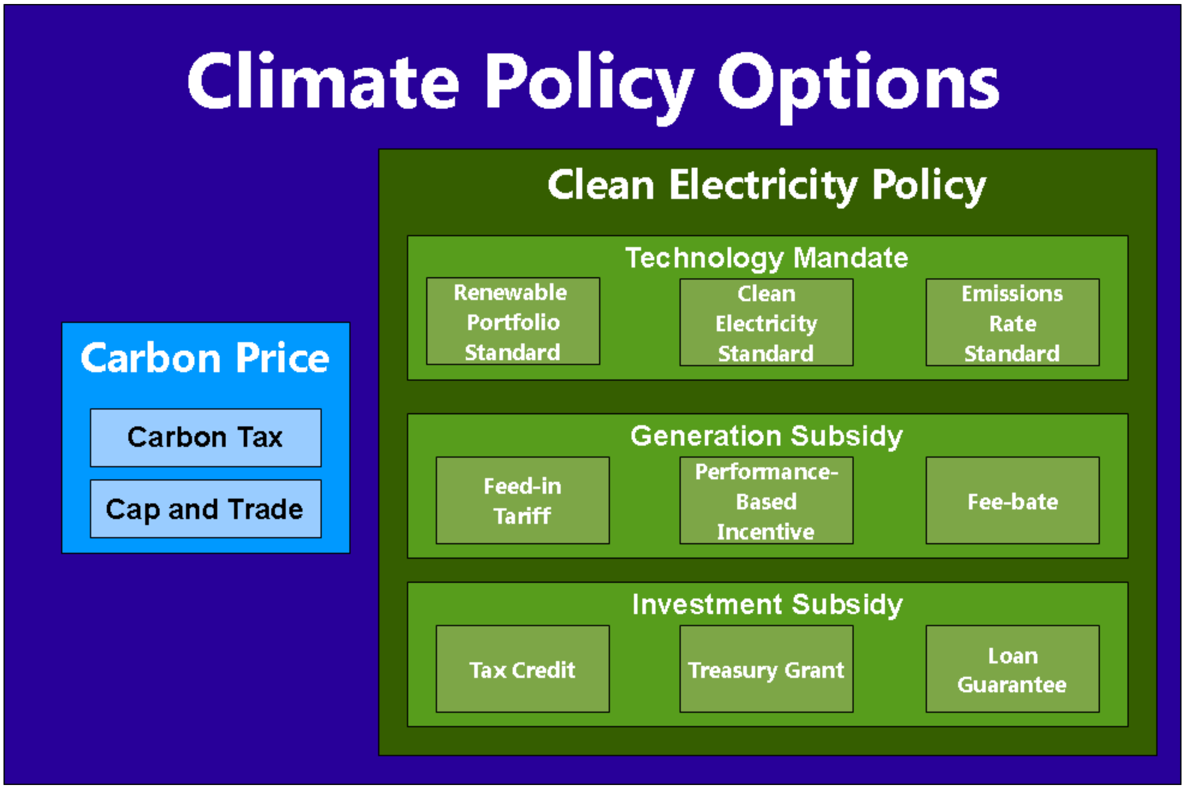
[2] For details of the many specific clean electricity policies enacted at the state level, a good place to start is the Database of State Incentives for Renewables and Efficiency, an ongoing project of the N.C. Solar Center and the Interstate Renewable Energy Council, online at http://www.dsireusa.org/.

Figure 1. Climate Policy Options



A. TECHNOLOGY MANDATES: RENEWABLE PORTFOLIO, CLEAN ENERGY, AND EMISSIONS RATE STANDARDS

Many states aiming to promote the use of renewables have implemented policies requiring that a certain percentage of electricity generation come from renewable sources. These ***renewable portfolio standards*** mandate a desired outcome and leave firms to meet it how they see fit.

Utilities generate their own electricity or buy it from generators before selling it to consumers. Under most renewable portfolio standards, utilities are required to generate or purchase a set share of their electricity from renewable sources—or buy renewable energy credits from other utilities that exceed the standard to make up the difference. This creates a market (and a price) for renewable electricity. For renewable electricity generators, selling the credits increases the revenue they earn above the market price of electricity.[3]

As of 2011, more than 30 states have implemented or planned renewable portfolio standards (see Figure 2), though the policies differ greatly in terms of their renewable targets, the sources they count as clean, and other details. For example, Ohio requires 12.5 percent renewable generation by 2020 (including nuclear), and New York has targeted 30 percent (including existing

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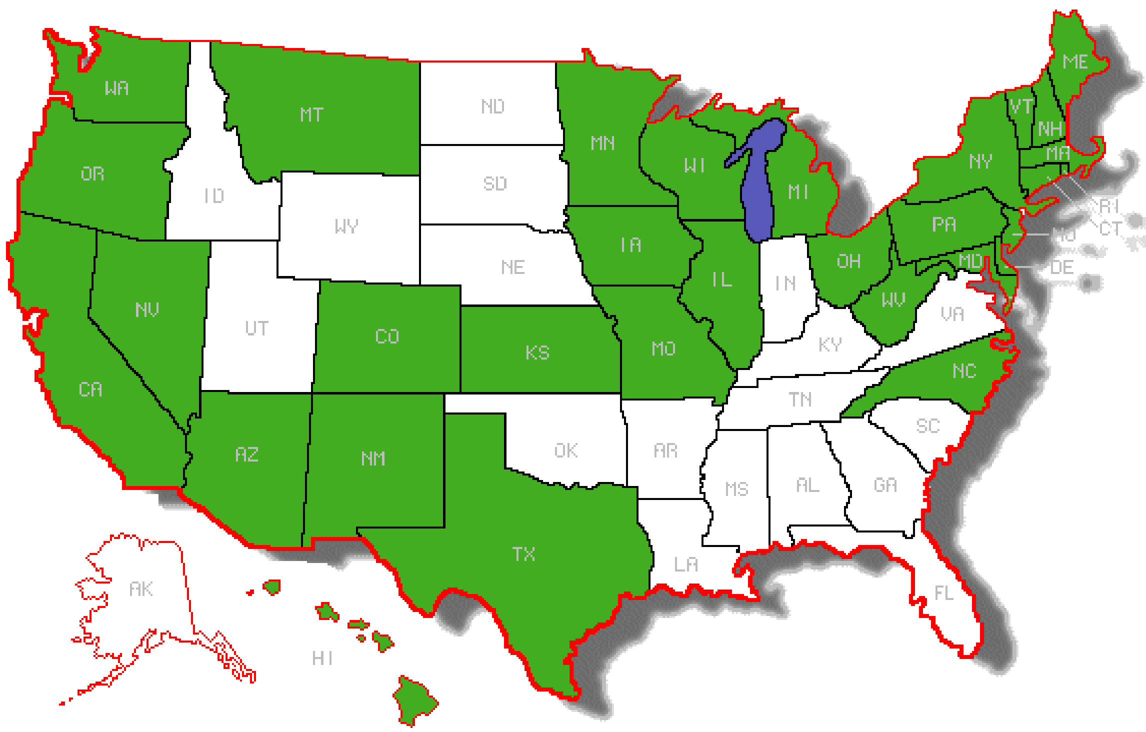
[3] To simplify the discussion, we focus on generators in regions with competitive wholesale markets for electricity rather than in traditionally regulated regions, where the state imposes a set rate on the cost of providing service. Most investment in renewable generators has occurred in such regions in recent years. There are important differences in cost-of-service regions that are beyond the scope of this paper.

hydroelectric) by 2015. As these examples illustrate, the definition of "renewable" and other design features vary a lot across programs, and the actual share of generation from renewable sources may differ from the stated target. Some state markets are connected and allow interstate trading. But there is no federal renewable portfolio standard, despite several proposals in Congress in recent years.

Figure 2. Technology Mandates in the United States



Source: Pew Center on Global Climate Change, last updated July 2011.

Recently, attention in Washington has turned to an evolution of the renewable portfolio standard with a broader scope: the ***clean energy standard***. In addition to renewables, a clean energy standard allows any electricity generator defined as "clean" to count towards meeting the goal. Not just renewables but also nuclear and to some extent natural gas are treated as clean, with coal (sans carbon capture) alone classed as "dirty." The president's proposed clean energy standard aims for generation of 80 percent of U.S. electricity from clean sources by 2035.

It is possible to tailor a clean energy standard even further by instituting an ***emissions rate standard*** (also known as a tradable performance standard). Under this scheme, a target emissions rate (a measure of generators' efficiency) is set, and generators are given credits equivalent to that rate. If their emissions rate is below the target, they will have extra credits they can sell to generators whose rates exceed the target (adjusted for the generators' relative size). This differs from a basic clean energy standard, which provides the same tax or subsidy to all generators of a given technology. Emissions rate standards can take advantage of the fact that emissions rates vary across generators of the same technology—for example, operating efficiency of coal generation units can vary by quite a lot. Under such a policy, generators have an incentive not just to produce more electricity from clean sources but also to produce electricity more efficiently.

B. GENERATION SUBSIDIES: FEED-IN TARIFFS, PERFORMANCE-BASED INCENTIVES, AND FEEBATES

Technology mandates achieve their goals by setting a target quantity of clean generation or a target emissions rate. This allows the price of credits to fluctuate—if meeting the target is expensive, credit prices will rise. But there is an alternative approach. It is possible to set a price for clean electricity sources and let the market determine the quantity that will be supplied. This is analogous to the relationship between cap-and-trade, which sets a target quantity of emissions (the cap), and a carbon tax, which sets a target emissions price (the tax).

Generation subsidies target price rather than quantity. They are substantially more popular in Europe than in the United States (see Figure 3, which shows European countries that offer generation subsidies for clean electricity technologies).

Figure 3. Generation Subsidies in Europe

Source: International Feed-In Cooperation, November 2010.

Variants are somewhat cryptically called ***feed-in tariffs*** or ***performance-based incentives***. In essence, these policies guarantee providers of specified kinds of electricity generation a subsidized price for the electricity they generate. Feed-in tariffs fix the total price received by the renewable generator—generators receive a subsidy if the market price of electricity is below the guaranteed price. Under current policies and proposals, generators also forgo any additional revenue when the market price exceeds the guarantee. Performance-based incentives, on the other hand, subsidize each unit of electricity by a fixed amount, so that the generator earns the subsidy plus the market price of electricity for each kilowatt hour (kWh) of electricity generated. [4] It is possible to give the same level of subsidy with either policy. For example, if the market price of electricity is 5 cents per kWh, a feed-in tariff of 7 cents per kWh results in the same revenue for generators as a performance-based incentive of 2 cents per kWh. Note that the equivalence breaks down as electricity prices change—the feed-in tariff offers a fixed price, whereas the performance based incentive offers a subsidy above the market price.

A major difference between generation subsidies and technology mandates is that the subsidies reduce generators' uncertainty about the revenue they will receive. With a feed-in tariff, generators have no uncertainty over future revenue. With a performance-based incentive, they are uncertain how much revenue they will earn from the electricity market, but they know exactly how much they will receive from the government per kWh of clean electricity they generate. With a technology mandate, generators have uncertainty over both electricity prices and credit prices. In short, there is a clean electricity uncertainty principle—you can have certainty about the amount of renewable (or clean) electricity, or about its price, but not both at the same time.

Subsidies to clean electricity producers can be funded either from a general charge on all electricity bills or from general government revenues. For example, Germany has instituted generation subsidies supported by a general electricity rate charge, while Washington and other states have implemented them as tax credits, essentially supporting them out of general revenue. The a federal production tax credit is a performance-based incentive, currently 2.2 cents per kWh but indexed to inflation, for wind and many other technologies in the United States; feed-in tariffs are much less common in the United States than in Europe.

A ***feebate*** linked to generators' emissions rate is the generation subsidy analog of an emissions rate standard. Just as an emissions rate standard is an extension of a clean energy standard, a feebate is an extension of a performance based incentive. Under a feebate, a benchmark emissions rate is first chosen. Then, a joint tax and subsidy are imposed. All generators with emissions rates above the set level are taxed, and all generators below that level are subsidized, each in proportion to its emissions rate. Just like an emissions rate standard, a feebate encourages efficiency improvements and directly links the tax or subsidy to the emissions rate rather than aggregating by technology.

C. INVESTMENT SUBSIDIES

Generation subsidies subsidize generated electricity, encouraging investment by promising higher revenues. But it is of course possible to subsidize investment directly—doing so has been the traditional policy used to change the electricity mix. Perhaps unsurprisingly given their political appeal, classic investment subsidies have not been displaced by more flexible policies, such as technology mandates or generation subsidies. Almost all current federal policies to promote

[4] In practice, the difference between a feed-in tariff and a performance based incentive is not so clear-cut. Some feed-in tariffs provide time-varying prices, as in California, or a flat subsidy over the market price. We use this terminology in this paper to distinguish the two types of policies.

renewable electricity are investment subsidies, most notably a 30 percent subsidy for renewable investments. Loan guarantees and tax incentives, really subsidies in disguise, are also available.[5]

Investment subsidies have important disadvantages relative to other clean electricity policies, and are not generally favored by economists. This is in part because investment subsidies are not tied in any way to the economic or environmental value of the investment. They are typically offered as a fraction of a project's total capital cost. Wasteful investments are rewarded as much as effective ones—if a new wind turbine fails often, is poorly located, or is simply not efficient, it receives the same subsidy as a well-designed and well-sited turbine. In contrast, technology mandates and generation subsidies link their explicit or implicit subsidies to the amount of electricity actually generated. As a result, investment subsidies are generally less efficient than the alternatives, despite their long tradition as a policy instrument.

III. Shaping the Electric Future: Effects on the Electricity Mix and Electricity Prices

Figuring out the likely costs and benefits of clean electricity policies requires a closer look at how they affect electricity markets. It is impossible to crown any particular class of policies as the most desirable because outcomes depend on the stringency, timing, and scope of the policies, and on the makeup of the existing power system. Nonetheless, some general conclusions emerge.

A. BASIC CHOICES: STRINGENCY, TIME, AND SCOPE

First, it is useful to look at some basic design choices that are common to all clean electricity policies. These can be understood as switches and dials on the policy control panel, with the power to greatly influence programs' costs, benefits, and effect. Fundamentally, these choices define the reach of the program. For technology mandates and price guarantees alike, these basic settings are stringency, timing, and scope. Clean electricity policies can be modest, requiring only a limited increase in clean electricity over a long period of time, or ambitious, requiring rapid and fundamental change to the electricity mix. The ambition of programs is defined by their stringency and compliance timing.

For technology mandates, stringency is usually the percentage of electricity generation that the policy says must come from clean electricity sources, either in absolute terms or compared to some baseline. For price guarantees, stringency is the level of the guaranteed price. Higher percentages or higher guaranteed prices lead to more clean electricity.

Compliance timing for technology mandates is the pathway over time toward a particular target stringency. Price guarantees can also have a planned pathway. Often the price guarantee decreases over time under the assumption that the cost, and therefore the required subsidy, of clean technologies also decreases.

The other fundamental element of a clean electricity policy is its scope—that is, what technologies are treated as clean? The difference between renewable portfolio and clean energy standards is one of scope—indeed a renewable portfolio standard can be viewed as simply a special case of a clean energy standard.

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[5] In the last few years, investors have had the opportunity to receive a cash grant rather than a tax credit because of the difficulty of finding investors with sufficient tax liability to take advantage of the credit. Some projects are eligible for the performance based incentive and investment tax credit or cash grant, but only one may be claimed.

But the choice of scope can be more nuanced than simply which technologies to include. In most discussions of a clean energy standard, for example, technologies are credited according to the average level of carbon they emit. Cleanliness is defined relative to coal without carbon capture, and technologies with comparatively lower greenhouse gas emissions receive greater credits. A relatively simple clean electricity standard might, for each unit of electricity generated, give coal no credits, nuclear one credit, and gas a half credit (because it emits roughly half the greenhouse gases of coal for the same power output). Some proposals offer additional credits for favored technologies, such as solar. It's also possible to adjust policy scope by excluding technologies (such as nuclear) or firms (such as small utilities) entirely. This has side effects—it can reduce the stringency of the policy, depending on which firms or technologies are excluded. Generation subsidies face similar choices about which technologies to subsidize, and at what levels.

B. EFFECTS ON THE ELECTRICITY MIX

Once these fundamental design choices have been made and a clean electricity policy put into place, the policy will affect electricity markets. We focus on two such effects: changes to the mix of generation technologies and changes in the price of electricity. We will first look at a renewable portfolio standard, then describe how other policies would have different effects.

The purpose of clean electricity policies is to change the mix of electricity generation. But different policies achieve this goal in different ways. In addition to changing the technologies used to generate electricity, some existing and proposed policies also include subsidies to energy efficiency. This relationship is complex, however, and we do not discuss it here.

Under a basic renewable portfolio standard, each generator receives a credit for each unit of renewable electricity it produces. When a utility purchases electricity from a renewable generator, it also purchases a credit from the generator at the prevailing market price. Therefore, the policy functions as an implicit subsidy for each kWh of electricity generation.

Conversely, the renewable portfolio standard implicitly taxes non-renewable generation: for each unit of non-renewable generation that the utility purchases, it must also purchase a fraction of a credit to remain in compliance, since the utility's overall percentage of clean electricity must match the policy target.

These taxes and subsidies affect the mix of electricity generation. As the table illustrates, a renewable portfolio standard is a relatively blunt instrument—it taxes coal and gas, but does so indiscriminately. Gas gets no credit for being cleaner. This is different from what happens under a carbon price, which would explicitly or implicitly tax all generation in proportion to its CO_2 emissions rate—with the higher emissions rate of coal leading to a higher implicit tax.

A more nuanced clean energy standard, in which technologies are credited in proportion to their average emissions rates, addresses this limitation. The higher emissions rate of coal leads to a greater implicit tax. A clean energy standard therefore will be generally less costly than a renewable portfolio standard per ton of emissions reduction, with costs that are closer to those from a carbon price.

Taxes and Subsidies Under Clean Electricity Policies[6]

	Coal	Natural Gas	Renewables	Nuclear/Hydro
Renewable portfolio standard	⇧	⇧	⇩	⇧
Clean electricity standard	⇧⇧	⇧	⇩	⇩
Carbon price	↑↑	↑	↔	↔
Generation or investment subsidy	↔	↔	↓	↔

↑- explicit tax ⇧- implicit tax ↓ - explicit subsidy ⇩ - implicit subsidy ↔ – no tax/subsidy

This illustrates a general point about clean electricity policies—there is often a tradeoff between cost-effectiveness and complexity. By increasing complexity—tuning credits to the emissions rate—it is possible to target the most cost-effective technologies. But doing so might make the program harder to administer and harder for politicians or the public to understand.

C. EFFECTS ON ELECTRICITY PRICES

How clean electricity policies affect the electricity mix is important for determining how effective they are. But how the same policies affect actual electricity prices is a different question—and one that is politically critical.

Under a carbon price, electricity prices would go up, because coal and gas are explicitly or implicitly taxed (though revenues might be directed back to consumers to compensate for this). In contrast, with a technology mandate, some technologies are implicitly taxed, but other technologies are implicitly subsidized. The subsidy leads to investment that, over time, tends to decrease prices. The overall effect on prices is ambiguous—in theory, electricity prices will not rise as much with a technology mandate as with an emissions price, and electricity prices may even decrease.

From a political perspective, lower electricity prices under a technology mandate are an advantage over a carbon price. However, they do reduce the policies' cost-effectiveness. The reason is that higher electricity prices stimulate energy efficiency investments—people will use less electricity if it is more expensive. The importance of this consideration depends on the net economic cost of energy efficiency investments, which may be anywhere from very high to negative (that is, worth doing even without considering environmental benefits). Estimating these costs is an area of active research.

Generation subsidies are simpler to analyze than technology mandates because they subsidize renewable technologies without explicitly or implicitly taxing anything else. As a result, electricity prices unambiguously decrease. Likewise, investment subsidies lower the costs of generating

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[6] The table assumes that new and existing generators of each type are treated similarly, that hydro power is not included in an RPS and does not receive investment or generation subsidies, and that under the clean energy standard natural gas is treated as dirty compared to the average, but not as dirty as coal.

clean electricity. But remember that we are only looking at electricity prices here—money for subsidies has to come from somewhere, raising overall costs to society. Electricity consumers will pay these costs, either directly if electricity use is taxed or indirectly if general taxes fund the subsidies.

IV. Sharing Risk

Even with a federal clean electricity policy, private players (and the government itself) must continue to make decisions about investment in different technologies. These decisions necessarily carry risk. But policy choices do affect who bears this risk. While different policies distribute risk differently, none eliminate it. A policy that reduces risk to one group increases it elsewhere.

The most obvious group bearing risk is the owners of electricity generators, who make large bets on future trends in the electricity market and government policy when they decide to build new generators. From the perspective of such investors, a feed-in tariff presents much less risk than a technology mandate or a performance based incentive. By fixing the revenue a project earns per unit of electricity generated, the policy eliminates a large portion of the associated risk; only the risk associated with construction costs (or a future policy change) remains. Technology mandates do provide an implicit subsidy, but its value is uncertain because it depends on the market price of renewable or clean energy credits. The market revenue for a technology mandate or performance based incentive may also be uncertain.[7]

Many in the clean electricity industry favor a feed-in tariff because of this risk-reducing effect. But this does not mean that such a policy is better from a societal perspective. A feed-in tariff does not eliminate risk, but merely transfers the risk to electricity consumers and perhaps the government (depending on how the policy is financed). For example, suppose that a feed-in tariff is offered for solar and that, due to technological breakthroughs, solar turns out to be more economical than other renewables. Because solar investment would have proliferated in the absence of the policy, the feed-in tariff would be very costly: electricity consumers would be paying generators when they would have received the benefits of the solar electricity anyway.

Innovators also bear significant risks. One objective of clean electricity policies is to stimulate private R&D in clean electricity. If innovators face less risk, they will devote greater resources to innovation. Generally, investors will finance R&D projects if they expect a fair return on the investment. For clean electricity, this return depends on the expected price paid for each clean electricity plant or component, as well as the quantity of electricity generation that is installed. Uncertainty over either the price or quantity results in less R&D because the R&D investment is riskier.

It is unclear whether a production subsidy or technology mandate does a better job of reducing these risks to innovators. As noted above, choosing between the two involves trading certainty about prices for certainty about quantity—and innovators would prefer both.[8] There is little real-

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[7] Uncertainty in the market electricity price depends on whether the renewable electricity is sold into a wholesale market or purchased by a utility, and the terms of the purchase agreement.

[8] Measures designed to reduce consumer risk, such as an alternative compliance payment, do not necessarily reduce risk to innovators because these measures increase uncertainty over quantity.

world evidence for which type of certainty is more important and therefore which policy would better encourage innovation.

Consumers also bear some risk—if meeting technology mandate goals is more expensive than anticipated, consumers will face higher electricity prices. An alternative compliance payment is one approach to reducing this risk. This allows utilities to pay a fee rather than purchase renewable energy credits, effectively creating a ceiling for credit prices and reducing the risk to consumers. The downside is that since the utilities paying this fee continue using dirty electricity sources, the original clean energy target will not be met. By capping the price of credits and the amount of investment in new technologies, an alternative compliance payment also limits incentives to invest in R&D and construction. Similar tradeoffs exist for price caps in cap-and-trade programs (such as California's)—anything that reduces risk by reducing the stringency of the policy has this effect.

Fiscal risk to the government is also important, particularly given widespread public concern about the federal deficit. As noted above, investment or generation subsidies carry some risk, since subsidies could be set too high. If these are financed by consumers via a charge on electricity bills, as is common in other countries, consumers will obviously bear the risks. But in the United States, subsidies are often implemented as tax credits or rebates. This places the risk of high subsidy costs on the government. Technology mandates don't impose a fiscal risk since their joint taxes and subsidies balance out, with no government outlays needed.

Like alternative compliance payments under a technology mandate, policy tools exist to reduce this fiscal risk. For example, a cap could be imposed on the amount of generation capacity that is eligible to receive the subsidy each year. This approach is often used for feed-in tariffs and could be extended to other generation and investment subsidies.

V. Deeper Issues

As the above discussions show, the effects of clean electricity policies are complex and difficult to predict. Efforts by economists to better understand these policies and their implications are underway. Even just to summarize all of the important issues would be impossible. Nevertheless, it is worth looking at two issues identified by this research. If the above discussion was Clean Electricity Policies 101, consider this a preview of level 201.

A. THE PROBLEM OF EXISTING CLEAN ELECTRICITY

So far, we have focused on how policymakers decide to treat different types of *new* electricity generators. But a substantial amount of clean electricity is already available. Some of it is in the form of wind farms and solar facilities. But a much larger portion of U.S. electricity comes from other clean(er) sources: natural gas, hydroelectric, and nuclear. Should any of these generators receive support under clean electricity policies?

Superficially, the answer appears to be no. The aim of clean electricity policies is to create incentives to invest in new, clean electricity. Existing facilities need no such incentive. They have already been built, and particularly for renewables, hydroelectric, and nuclear, their owners will probably operate them anyway because their fuel costs are very low or zero. In economic terms, their costs are mostly sunk. If only new clean power is counted in the program, there will be much more of it (assuming the target is the same)—and therefore more innovation and "green" jobs, if those are important goals.

But a problem arises. Treating existing clean electricity sources as dirty electricity can create perverse outcomes. Replacing existing clean electricity plants with similarly clean new sources would be rewarded by the program but is wasteful if the goal is to reduce CO_2 emissions at low cost. In other words, the incentives for new clean electricity to replace existing clean electricity would be just as strong as those to replace dirty coal. Hydro and nuclear plants have such low fuel costs that they are not likely to be replaced even if they are implicitly taxed by a clean electricity standard that treats them as dirty. But that may not be true for natural gas. Clean electricity policies should give at least some credit to existing clean generators, particularly natural gas—something a CO_2 price implicitly does, by treating new and existing generation sources equally.

B. MORE THOUGHTS ON THE ELECTRICITY MIX: MARKETS, TECHNOLOGIES, AND INVESTOR INCENTIVES

An often-underappreciated feature of the market for electricity is that both the productivity of different generating technologies and the demand for electricity vary over time. Solar is useful only during the day (unless electricity can be cheaply stored), while winds often blow harder at night. Demand is highest during the day and in the summer, as are prices, since relatively high marginal cost generators are brought online to meet that demand. For sake of simplicity in the above discussions, we've ignored the implications of these factors for clean electricity policies.

But these factors are important for understanding the policies and their effects on investment in different generating technologies. Investors will always seek to maximize their profits—that is, the revenue they expect from a project minus its cost. If electricity prices were constant, then investors would simply seek to minimize cost. They would simply build the lowest-cost projects—which for renewable electricity in the United States usually means wind.

But since electricity prices do vary over time, projects which have a higher initial cost but which generate more electricity when it is expensive will have higher associated revenues. These projects generate higher value, more needed electricity. Investors, seeing this larger expected revenue stream, will consider building such higher-cost projects. This partially explains investment in solar generation, which currently has higher initial costs than wind.

Imposing a renewable portfolio standard or a performance-based incentive has relatively little effect on these investor decisions, since it simply creates a subsidy (real or implied) that is equal for all renewable generators. The result, unsurprisingly, is greater investment in renewables, but investors still look to maximize profits by comparing project cost with expected revenues, and these revenues continue to vary with electricity prices.

Under a feed-in tariff, on the other hand, the influence of electricity prices on expected revenues from renewables is blunted, and investors make different decisions. Recall that a feed-in tariff guarantees renewable generators a set revenue for every unit of electricity they generate. The difference between this level of revenue and the market price of electricity is made up by a subsidy, which will vary depending on that price. With revenues guaranteed to be the same for all renewable technologies, cost is the only factor in investors' profit-maximizing decisions. In other words, a feed-in tariff eliminates one type of risk for investors. The degree to which investment patterns differ under a feed-in tariff depends on how great of a mismatch there is between the lowest-cost technologies and those that are productive when prices are highest, something which may change over time due to innovation. In practice, a feed-in tariff means greater investment in wind at the expense of other renewables, at least with current technology.

This difference in investors' decisions matters. Electricity generated when market prices are high is more valuable, so policies that encourage investment in sources that are productive at that time (or, more accurately, policies that leave the market's incentives to build such sources intact) will likely be more cost-effective. Put differently, renewable portfolio standards or performance-based incentives are likely to lead to investment in renewable generation that has a higher market value than that under a feed-in tariff, and that market value reflects a greater usefulness to society.

It is also possible to tailor policies to promote specific technologies regardless of their underlying costs by rewarding the favored technologies with additional credits or subsidies. This is useful if one considers it wise to diversify investments across different clean technologies, though it does also result in higher costs for the same amount of clean generation.

Finally, if the goal is to promote renewable electricity for its own sake, as opposed to reducing overall emissions, a clean energy standard is less effective than alternatives since it does not specifically target renewables. For example, if natural gas prices are low, a clean energy standard could cause a large-scale switch from coal to natural gas generation but little investment in renewables. Very different levels of renewable generation for the same level of emissions reductions could emerge under a clean energy standard compared to a renewable portfolio standard.

VI. Conclusions

A. WHAT WE KNOW

Clearly, the implications of clean electricity policy can be complex. Different jurisdictions currently use different tools, and neither politics nor efficiency seem to dictate that any particular option be adopted at the federal level (if we are to have a federal policy at all). Nevertheless, we have learned certain core insights from economic analysis of these policies.

1) **The clean electricity uncertainty principle**

It's possible to be certain about the price clean electricity generators receive (by using a production subsidy), or the quantity of clean electricity they supply (by using a technology mandate)—but not both.

2) **Investment subsidies are generally a poor choice.**

Primarily because they do not distinguish between good and bad investments, investment subsidies are much less cost effective than other options.

3) **Comparing a clean energy standard and renewable portfolio standard, there are tradeoffs between cost-effectiveness and complexity.**

More complex policies can target the cleanest and/or most cost-effective technologies but may be harder to administer or understand.

4) Consumer electricity prices could fall under clean electricity policies—or at least increase less than under a carbon price.

In theory, a production subsidy and possibly a technology mandate causes electricity prices to decrease. Even if a technology mandate leads to higher prices, the price increase will be smaller than with a simple carbon price.

5) Excluding existing clean electricity creates perverse incentives.

If existing clean electricity sources are included in a policy but aren't given credits or generation subsidies, they are effectively treated as dirty. As a result, they may generate less electricity, shut down, or be replaced by new clean electricity with no reduction in overall emissions.

6) Different clean electricity policies cause different mixes of investment in renewable electricity.

Feed-in tariffs lead to investment in the *lowest-cost* renewable technology, but renewable portfolio standards and performance-based incentives lead to investment in the *most profitable* technology. This difference reduces the cost effectiveness of a feed-in tariff.

B. WHAT WE DON'T KNOW

The answers to other questions about the impact of clean electricity policy choices remain unclear. Two seem particularly important.

1) It is unclear which policy would be most effective at encouraging innovation in clean electricity.

Policymakers can choose between certainty about the price generators receive for clean electricity and the quantity they will supply. But it is unclear which type of certainty would better promote innovation. It is quite possible that investment subsidies for basic R&D, as opposed to clean electricity policies, would have the greatest impact on innovation; if researchers aren't able to capture the benefits of their breakthroughs, policies that increase the demand for clean electricity technologies won't have much effect on innovation.

2) Effects on employment—"green jobs"—are not straightforward.

One popular claim is that clean electricity policies could create more jobs. But it's not clear whether technology mandates, production subsidies, or investment subsidies would lead to job growth, much less which of the three would do the most. Technologies differ in terms of their labor intensity. If adding jobs is the goal, more labor-intensive technologies should be promoted at the expense of more capital-intensive ones. Adding more jobs, however green, doesn't necessarily lead to greater environmental benefits. As noted above, if credits are denied to existing sources of clean electricity under a technology mandate, new clean electricity sources might be built only to replace those existing sources. This is inefficient from an emissions perspective, but it would undoubtedly create nominally-green construction jobs.

C. LESSONS FOR POLICYMAKERS

In theory, clean electricity policies are second-best to a carbon price. Among other limitations, they lack a price's simplicity, are probably more costly, and are harder to link to other sectors to create an economy-wide (and therefore less costly) carbon policy. But the political reality is that a carbon price appears to be off the table for at least the near future. Moreover, it is important to compare policy options with each other rather than with ideal chalkboard alternatives—and as the Waxman-Markey bill of 2010 illustrates, a carbon price itself would require compromises, carve-outs, and concessions, making it more complex and probably less efficient. And from a (somewhat cynical) political standpoint, clean electricity policies have several advantages over a carbon price: compliance costs are harder to observe, the policies are less likely to increase electricity prices, and it is not as easy to characterize them as a tax (or cap-and-trade, for that matter).

But the politics of clean electricity policies also make them harder to evaluate. Comparisons between different options are complicated by the fact that goals are unclear and sometimes at odds. Is emissions reduction the aim? Advancing certain favored technologies? International competitiveness? Jobs? If the goal is to reduce emissions, the best approach is to tailor a policy's subsidy or tax to emissions. But clean electricity policies are politically viable in large part due to their chameleonic character. One that is framed as purely a climate policy, rather than an energy, security, and jobs policy may be much harder to pass.

Clean electricity policies are in widespread use already in a number of U.S. states and around the world. Policy options have important differences, with significant impacts on the future electricity mix, electricity prices, and other important considerations. Navigating this complexity to reach an efficient and effective policy requires policymakers, as always, to make smart choices.

Glossary

1. **Alternative compliance payment**
   A payment that can be made in lieu of compliance with a policy requirement. For policies with tradable credits, such as renewable portfolio standards, the payment functions as a price cap on those credits.

2. **Carbon price**
   A policy under which a price is effectively imposed on greenhouse gas emissions. The most common forms are a carbon tax and cap-and-trade. Under a carbon tax, emitters must pay a tax proportional to their emissions, with the tax functioning as the price on carbon. Under cap-and-trade, a maximum level of emissions (the cap) is set, and credits are allocated equal to that level. Emitters must surrender credits equivalent to their emissions, and can buy or sell those credits as needed, with the market price of credits functioning as the price on carbon.

3. **Clean electricity policy**
   Any of a number of policies discussed in this paper*,* that seeks to increase generation of electricity from renewable or other clean technologies by enabling those technologies to compete with dirty generation when they would not otherwise be able to, without pricing carbon emissions directly. Technology mandates, generation subsidies, and investment subsidies are all types of clean electricity policies.

4. **Clean energy standard**
   A type of technology mandate under which utilities are required to generate or buy a set portion of their electricity from technologies defined as clean. Utilities that do not meet the standard can buy credits from utilities that exceed it. In most proposals, coal without carbon capture-and-storage is defined as dirty since it has the highest greenhouse gas emissions for the energy it produces. Other technologies are defined as clean, though not all necessarily receive the same credit. Natural gas, for example, might receive half-credit since it has roughly half the emissions rate of uncontrolled coal. President Obama proposed a clean energy standard in early 2011, and the policy has been the subject of some debate in Congress.

5. **Emissions rate standard**
   A type of technology mandate under which utilities or generators are required to demonstrate a set emissions rate (emissions per unit of electricity generated). Performance toward this goal may be tradable: utilities/generators that do not meet the target rate can purchase credits from those who are more efficient than required, proportional to their size. Also called a tradable performance standard.

6. **Fee-bate**
   A type of generation subsidy under which a benchmark emissions rate (emissions per unit of electricity generated) is chosen, and emitters are either taxed, if their rate exceeds the benchmark, or subsidized, if their rate is less than the benchmark.

7. **Feed-in tariff**
   A type of generation subsidy under which generators of specified clean technologies receive a guaranteed revenue per unit of electricity they generate, with the difference between the market price and the guaranteed price made up via a subsidy. Revenue is guaranteed but the amount of the subsidy varies with the market price of electricity.

8. **Generation subsidy**
   A set of policies under which generators of specified clean technologies are subsidized for every unit of electricity they generate. The subsidy can be funded from general government revenue or a tax/fee on electricity consumers.

9. **Investment subsidy**
   A set of policies under which investments in clean electricity generation—construction and/or R&D—are directly subsidized, regardless of the amount of electricity actually generated. The traditional policy for promoting investment in favored energy technologies.

10. **Performance-based incentive**
    A type of generation subsidy under which generators of clean electricity receive a set subsidy for each unit of electricity they generate. The amount of the subsidy is guaranteed, but revenue still varies depending on the market price of electricity. There is currently a federal performance-based incentive of 2.2 cents per kWh for wind and certain other technologies.

11. **Renewable portfolio standard**
    A type of technology mandate under which utilities are required to generate or buy a set portion of their electricity from renewable sources. Utilities that do not meet the standard can buy credits from utilities that exceed it. Many U.S. states have renewable performance standards.

12. **Technology mandate**
    A set of policies under which utilities are required to meet certain technology-based standards. These standards may require that a certain percentage of generation come from specified technologies, or that a certain average emissions rate be met. Progress toward the standard is usually tradable, so that utilities that are not able to meet it can purchase credits to make up for the difference from other utilities that exceed it.

13. **Tradable Performance Standard**
    See emissions rate standard.

Related Work by RFF Scholars

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