Coal Initiative Reports

White Paper Series

► A Performance Standards Approach to Reducing CO_2 Emissions from Electric Power Plants

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PEW CENTER ON Global CLIMATE CHANGE

Contents

Abstract

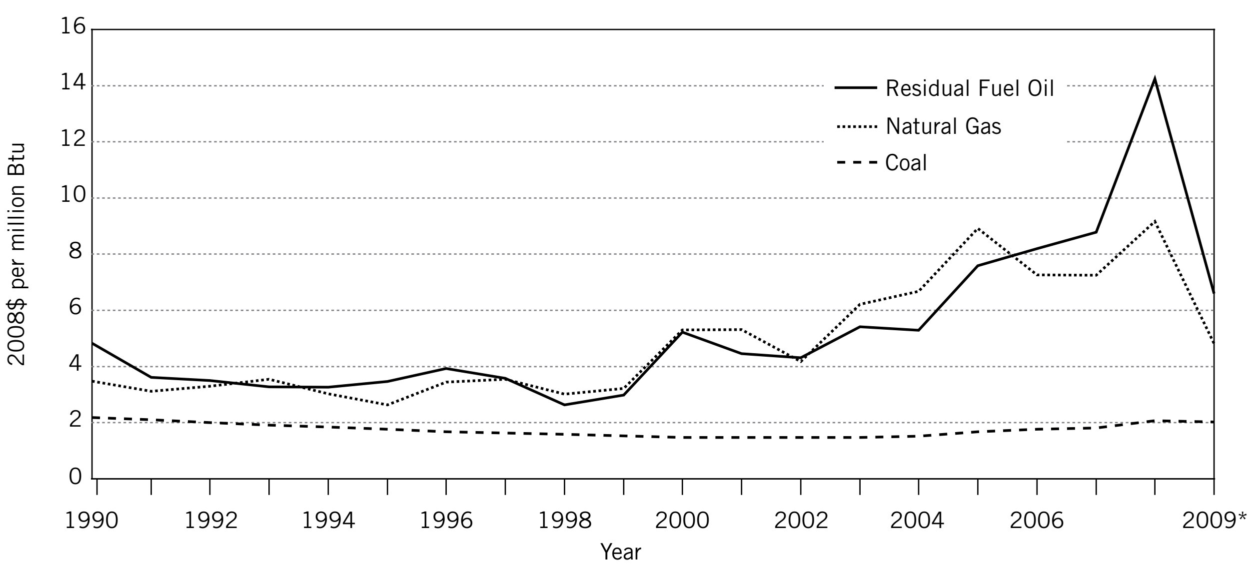
The premise of this paper is that significant reductions in the carbon dioxide (CO_2) emissions from fossil fuel power plants are urgently needed as part of a national effort to address global climate change. This paper describes one of several policy approaches for reducing CO_2 emissions from U.S. electric power plants, namely, the application of performance standards limiting CO_2 emissions from electric power generators. In contrast to a cap-and-trade policy that limits the total annual mass emissions of CO_2 from a collection of sources, a performance standard may apply to individual generating units or to a collection of plants. It typically specifies a maximum allowable rate of emissions per unit of product (e.g., pounds of CO_2 per megawatt-hour of electricity generated or sold), or a required percentage reduction in potential emissions. For new fossil fuel power plants that begin construction after a specified date, a New Source Performance Standard (NSPS) could restrict CO_2 emissions to levels achievable only with CO_2 capture and storage (CCS). For existing power plants, emissions could be restricted in any of several ways, including: age-based performance standards for individual units; fleet-wide performance standards that vary over time (with flexibility for emissions trading); or performance standards applied to electricity sales from either coal plants or all plant types (also varying over time). Several types of CO_2 performance standards are evaluated and compared to a cap-and-trade policy based on nine criteria established under the Pew Center Coal Initiative. Maintaining a significant role for coal in the U.S. generating mix emerges as an especially important criterion in evaluating alternative policy options.

Background

The use of fossil fuels to generate electricity in the United States results in roughly 2.3 billion metric tons (or gigatons, Gt) of carbon dioxide (CO_2) emissions per year—a third of total U.S. greenhouse gas (GHG) emissions (EPA 2008b). The bulk of these electric power sector emissions—more than 80 percent—come from coal-fired power plants.

The United States likely has sufficient coal reserves to support current levels of consumption for at least 100 years, and perhaps as long as 250 years or more (NRC 2007). Coal is a relatively inexpensive source of energy, and coal prices are generally less volatile than those of either oil or natural gas (see Figure 1). Unlike renewable energy technologies, such as wind and solar power, coal-fueled power plants can reliably provide large amounts of baseload electricity generation. While nuclear power also can provide reliable baseload generation without GHG emissions, nuclear power faces its own challenges, including public siting concerns, large and uncertain construction costs, and waste disposal and proliferation issues. Given the high rate of CO_2 emissions from coal combustion and coal's large contribution to total emissions, any effort to reduce GHG emissions to levels adequate to address climate change will need to achieve significant reductions in the emissions from coal use. Carbon capture and storage (CCS) technology offers an effective GHG mitigation

Figure 1: Cost of Fuels for Electric Power Generation (adjusted to 2008 dollars using GDP price deflator)



*2009 prices are projections
Source: Based on data from EIA 2009

option that enables the continued utilization of abundant domestic coal supplies for baseload electric power.

This paper is part of a Pew Center initiative focused on meeting the challenges of continued coal use while addressing the problem of climate change. A key focus of this effort is on options to accelerate the deployment of technologies for CCS (see Box). This is because CCS with geological storage offers the most promising method of achieving large reductions in emissions from coal-based power plants (IPCC 2005). At present, however, CCS is costly and not yet demonstrated in full-scale utility operations.

A SHORT PRIMER ON CCS

CCS consists of three separate steps—CO_2 capture, transport, and storage. The capture step accounts for most of the project cost. Power plants can use one of three approaches to capture CO_2. Today's coal-burning plants would utilize commercial "post-combustion" capture technology that can strip up to 90% of the CO_2 from flue gases. Another approach, called "pre-combustion" capture, can capture the CO_2 at lower cost, but requires a different and more expensive type of power plant, called an integrated gasification combined cycle (IGCC) system, that first converts coal or other solid fuel into a gaseous fuel, which is then cleaned and burned to generate electricity. A third approach, still under development, is called oxy-combustion. It uses nearly pure oxygen instead of air to burn coal, producing a concentrated CO_2 stream that is easy to capture. However, the oxygen plant adds considerably to the cost.

As part of the capture step, concentrated CO_2 is compressed to a liquid, then transported to a suitable storage site via pipeline—a mature technology for CO_2 transport. It is then injected deep underground into geological formations sealed by thick layers of impermeable rock. Over time, the CO_2 dissolves and slowly transforms into solids, further ensuring the permanence of storage. Several types of geological formations can be used to sequester the large amounts of CO_2 captured at a power plant. The most plentiful are deep saline formations—a layer of salt water, sand, and rock commonly found a mile or more beneath the surface. Depleted oil and gas fields also are potential storage sites but are more limited in total storage capacity. Careful site selection and monitoring are essential for effective use of CCS to mitigate climate change (for additional information on CCS see IPCC 2005).

PEW CENTER COAL INITIATIVE

The Pew Center Coal Initiative is evaluating a range of policy options to reduce power plant CO_2 emissions, including policies that accelerate the safe and effective deployment of CCS at coal-based plants. A Consultative Group composed of a broad cross-section of stakeholders and experts has assisted the Pew Center in this initiative. The policies under consideration vary in the degree to which government actions and private markets guide investments in relevant technologies, and the degree to which they rely on incentives versus standards and penalties.

Other Pew Center studies have focused on market-based policies for reducing greenhouse gas emissions. With guidance from the Consultative Group, two additional policy options were identified for elaboration under the Coal Initiative. One is the concept of a CCS Trust Fund that would pay the full cost of deploying CCS at approximately 10–30 commercial-scale power plants, supported by a small fee on fossil fuel electricity generation. This option is elaborated in other Pew Center reports (Pew Center 2007, 2008a). The second option is a performance standards approach, the subject of this paper.

POLICY EVALUATION CRITERIA

The Consultative Group also suggested a number of criteria for evaluating policy options that would be acceptable to a variety of stakeholders. These criteria include:[1]

- Familiarity of the approach
- Effectiveness in reducing emissions
- Ease of implementation; ease of monitoring and enforcement; avoidance of complexity
- Timing issues: achieving action in the near term; operating across administrations; clarity of time for adoption; and not rewarding pre-program construction of coal plants without CCS
- Cost-effectiveness
- Linkage to other relevant policies within and outside of the electric utility sector
- Equity (fairness) in regard to regional impacts, company size, regulated versus non-regulated utilities, and technology options
- Ensuring coal continues to play a significant role in U.S. electricity generation
- Use of trading and market mechanisms

These criteria are used later in this paper to evaluate the performance standards approach described below.

1 These criteria were considered desirable by a variety of stakeholders in the Consultative Group. Several additional policy features were more likely to result in different preferences among stakeholders:

- Reliance on incentives versus regulations
- Whether cost burdens fall on the consumer or utilities, and if on utilities, whether it falls equally on all units or primarily on new, existing, or fully amortized plants
- Whether the program covers all fossil-fuel plants or only coal-fired units
- Whether the program supports other clean air objectives or addresses only GHG emissions.

Objectives and Description of CO_2 Performance Standards

The objective of a CO_2 performance standard is to reduce power plant emissions by directly or indirectly requiring designated sources to employ technology or other measures to control CO_2. Designated sources might include only new plants, only existing plants, or both. Various criteria can be used as the basis for a performance standard. For example, the standard might require individual coal-fired generators to use the "best available control technology" (BACT), or operate at the "lowest achievable emission rate" (LAER). Performance standards that limit the allowable rate of CO_2 emissions could apply to individual units, to a collection of generators, or to entities that sell (rather than generate) electric power. Whatever the basis, one or more quantitative measures would be established as outlined below.

PERFORMANCE STANDARDS FOR NEW SOURCES

The BACT criterion has been the basis of federal New Source Performance Standards (NSPS) under the federal Clean Air Act for new steam-electric generators since 1971 (see Table 1). These standards limit emissions of major air pollutants (sulfur dioxide, nitrogen oxides and particulates) but do not currently include CO_2. The standards are set by the U.S. Environmental Protection Agency (EPA) and are periodically revised, as seen in Table 1. LAER is a more stringent criterion that has been applied on a case-by-case basis to prevent significant deterioration of air quality in pristine areas and in regions not yet complying with national

Table 1: Federal New Source Performance Standards for fossil-fuel power plants

Plant Type and Vintage	Maximum Allowable Emissions[a]		
	SO_2	NO_x	PM
New plants built after August 17, 1971[b]:			
Coal-fired units	520 ng/J	300 ng/J	43 ng/J
Oil-fired units	340 ng/J	129 ng/J	—
Gas-fired units	—	86 ng/J	—
New coal plants built after September 18, 1978[b]	70%–90% reduction[c]	260 ng/J (bitum) 210 ng/J (sub-bit)	13 ng/J
All new plants built after July 9, 1997[b]	(no change)	0.72 g/kWh[d] or, 65 ng/J	(no change)

[a] SO_2 = sulfur dioxide; NO_x = nitrogen oxides (as equivalent NO_2); PM = particulate matter. Units of ng/J = nanograms of pollutant per joule of fuel heat input to the boiler. Conversion factor for English units: 433 ng/J = 1.0 lb/MBtu.

[b] Applies to steam-electric power plants with heat inputs greater than 73 MWe.

[c] Required reductions in SO_2 depends upon the coal sulfur content. Equivalent emission rate is approximately 260 ng/J for plants burning bituminous coal, and 100 ng/J for plants burning subbituminous coal. No emission rate can exceed of 520 ng/J.

[d] NO_x limit applies to all fuel types and is based on electrical output rather than heat input.

Source: Rubin 2001

air quality standards. Federal performance standards for power plants apply mainly to new sources of air pollution, with states having primary jurisdiction over existing sources.

Under the current Clean Air Act, additional performance standards could be promulgated to limit CO_2 emissions from new power plants. Such standards could apply to coal-based units as well as other types of plants constructed after a specified date (e.g., power plants using natural gas, oil, petroleum coke, or other carbonaceous fuels). As with existing NSPS requirements, a generator performance standard for CO_2 could be specified in terms of a:

- Maximum allowable emission rate (e.g., pounds CO_2 per megawatt-hour)
- Percentage reduction in potential CO_2 emissions
- Combination of an emission rate and percentage reduction.

NSPS limits for new power plants have employed all three approaches over the past several decades. The most recent standards, which apply to NO_X, are expressed in terms of the maximum allowable emissions per unit of net plant output (in megawatt-hours, MWh) rather than per unit of fuel energy input (e.g., British thermal units, Btu)—as had been the case prior to 1997 (see Table 1). An output-based standard is generally regarded as preferable since it rewards efficiency and relates emissions directly to a unit of desired product. Percentage reduction standards, in conjunction with a maximum allowable emission rate, were employed for sulfur dioxide (SO_2) control beginning in 1978, and reflect the capabilities of different desulfurization technologies and the wide (roughly ten-fold) variation in sulfur content of U.S. coals.

Given the need for large reductions in CO_2 emissions, a generator performance standard for CO_2 could be set at a level that coal-fired units could achieve only by employing CCS technologies—similar to the approach adopted in the 1977 NSPS for power plant SO_2 emissions. Generator performance standards based on the use of CCS also could apply to other carbon-bearing fuels such as natural gas-fired power plants, whose uncontrolled emission rates are approximately half that of coal-fired power plants.

Table 2 shows the levels of CO_2 reductions achievable with current CCS technology, according to recent studies (IPCC 2005, Rubin et al. 2007). These data reflect a range of power plant designs based on coal combustion, coal gasification, and natural gas combustion systems. CO_2 capture efficiencies are based on experience in a variety of industrial applications, including CO_2 captured from slip streams of power plant flue gases. Captured CO_2 is assumed to be stored in geological formations with no subsequent release to the atmosphere. While CO_2 capture efficiencies are typically 85 to 90 percent, the net CO_2 reduction per kilowatt-hour (kWh) of electricity generated averages about 85 percent after accounting for the additional energy needed to operate the CCS system (IPCC 2005). The absolute value of CO_2 emitted per kWh depends mainly on the fuel type (coal vs. natural gas), but also varies with CO_2 capture efficiency, coal carbon content, and net power plant efficiency.

Table 2 suggests that a generator performance standard requiring CO_2 emission reductions on the order of 85 percent could be achieved with current technology. However, because CO_2 capture has not yet been deployed at power plants at full scale (i.e., several million tons CO_2 captured per year), because current costs and energy penalties are relatively high, and because the U.S. does not currently have a well-defined

Table 2: Performance of current CCS systems for new power plants based on recent studies

Performance Measures		PC Plant Range	PC Plant *Rep. Value*	IGCC Plant Range	IGCC Plant *Rep. Value*	NGCC Plant Range	NGCC Plant *Rep. Value*
Emission rate w/o capture	**(kg CO_2 / MWh)**	736–811	***762***	682–846	***773***	344–379	***367***
	(lbs CO_2 / MWh)	(1619–1784)	*(1676)*	(1500–1861)	*(1701)*	(757–834)	*(807)*
Emission rate with capture	**(kg CO_2 / MWh)**	92–145	***112***	65–152	***108***	40–66	***52***
	(lbsCO_2 / MWh)	(202–319)	*(246)*	(143–334)	*(238)*	(88–145)	*(114)*
Percentage of flue gas CO_2 captured (%)		85–90	***89***	85–91	***88***	85–90	***88***
Percentage CO_2 reduction per net kWh (%)		81–88	***85***	81–91	***86***	83–88	***86***

* Notes: PC = pulverized coal; IGCC = integrated gasification combined cycle; NGCC = natural gas combined cycle.
Rep. Value = Representative value based on the average of values reported in the studies reviewed. PC values are based on supercritical boilers; all coal plants use bituminous coals.

Source: IPCC 2005, Rubin et al. 2007

regulatory structure or experience with large-scale geological CO_2 storage, the timing and stringency of a new source performance standard for CO_2 must be carefully considered.

PERFORMANCE STANDARDS FOR EXISTING SOURCES

Another important issue is how to reduce CO_2 emissions from existing power plants, which will continue to operate for years to come. In part because of the current NSPS requirements, the life of many existing power plants has been extended far beyond the 30 to 40 year retirement age anticipated in the 1970s when NSPS rules were first adopted. Subject only to state-level emission standards, many existing plants continue to emit air pollutants at higher levels than new plants.

State regulations can nonetheless be shaped or superseded by new federal requirements. One example is the federal cap-and-trade program for SO_2 emissions established in 1990 for acid rain control under Title IV of the Clean Air Act. In order to meet the national cap, total SO_2 emissions from existing plants had to be reduced by roughly half. In this case, the policy driver adopted was an emissions cap-and-trade program rather than a performance standard.

Recent federal requirements for nitrogen oxide (NO_x) reductions from existing power plants include both a generator performance standard and a cap-and-trade system (Yeh et al. 2005). These requirements were imposed both for acid rain compliance and attainment of ground-level ozone air quality standards (under Title II of the Clean Air Act). Further ratcheting down of SO_2 and NO_x emissions from existing power plants is now underway to achieve national air quality standards for fine particulate matter.[2] Existing sources also are facing new requirements to reduce mercury emissions. Several states have adopted emission rate performance standards for mercury. While EPA previously proposed a cap-and-trade program for mercury, it too will now develop performance standards.[3] All of these precedents offer models for reducing CO_2 emissions from existing power plants.

2 Recent court rulings may affect the nature and pace of these efforts.
3 In 2008, the D.C. Circuit court vacated the proposed Clean Air Mercury Rule and its cap-and-trade program.

State-Level Performance Standards for CO_2

The state of California has pioneered the introduction of a CO_2 performance standard to reduce coal plant CO_2 emissions, with several other western states following (Table 3). In California, load-serving entities and publicly-owned utilities are now prohibited from entering into long-term financial commitments[4] for baseload power unless the power supplied meets an emission standard that is "no higher than the GHG emissions levels of a combined-cycle natural gas turbine." In 2006, that maximum emission level was codified at 1,100 pounds of CO_2 per megawatt-hour (lbs/MWh) of electricity produced (CA 2006).

Table 2 shows that the California standard is higher than the typical emission rate of about 800 lbs CO_2/MWh for a new natural gas combined cycle (NGCC) plant. Rather, the standard more closely resembles the emission levels of older, less efficient NGCC plants that are currently in operation. Meeting that emission level at an efficient new coal plant would require a reduction in CO_2 emissions per MWh of roughly 30 to 40 percent—a reduction that could only be achieved by the application of CCS technology. Since current capture technology can remove about 85 percent of the CO_2 (see Table 2), a coal-fueled power plant could meet the California standard by capturing only a portion (roughly half) of its CO_2 emissions. That would significantly reduce the overall cost impact of a CCS system.

Note that the California performance standard applies to load-serving entities—i.e., those who sell electricity to customers—and not to individual generators (as with federal new source standards). While this distinction is important for purposes of implementation and enforcement, it does not materially affect the requirement to deploy CCS to meet the standard.

4 Long-term financial commitments are defined as new ownership investments in baseload generation, major investments in existing baseload power plants, or contracts with a term of five years or more.

Table 3: Summary of state-level performance standards for power plant CO_2 emissions (as of April 2009)

State	Status	Date effective	Plants affected	Performance standard (allowable emissions)	Trading allowed?	Incentives	Comments
Illinois (SB 1987)	Law	In effect as of 2009	New coal-fueled power plants (performance standard); new and existing coal-fueled power plants (clean coal portfolio standard)	From 2009–2015, 50 percent CO_2 capture; from 2016-2017, 70 percent capture; and, after 2017, 90 percent capture (where capture rates refer to the amount of CO_2 that would otherwise be emitted)	No		
California (CASB 1368)	Law	In effect as of 2006	New baseload generation for electricity generated in-state or out-of-state	1100 lbs CO_2 / MWh	No	(1) Timely cost recovery by treating compliance costs as procurement costs incurred pursuant to an approved procurement plan. (2) An increased return on investment of 0.5 to 1.0 percent for the party "entering into the contract with an electrical corporation" that meets the emissions performance standard	
Montana (HB0025)	Law	In effect as of 2007	Equity interest or lease in a facility or equipment used to generate electricity that is primarily fueled by coal and that is constructed after January 1, 2007	CCS for at least 50% of carbon emissions	No		"Until the state or federal government has adopted uniformly applicable statewide standards for the capture and sequestration of carbon dioxide, the [public service] commission may not approve an application for the acquisition of" an affected plant, unless it meets the standard
Washington (SSB 6001)	Law	July 1, 2008	New baseload generation for electricity generated in-state or out-of-state	1100 lbs CO_2 /MWh; standard to be reviewed and adjusted by Energy Policy Division of the Department of Community, Trade and Economic Development every five years to match the average rate of emissions of new combined-cycle natural gas electric power generation turbines.	No		Enforced by Washington Utilities and Transportation Commission (for IOUs) and COU governing boards (for COUs)
Oregon (ORS 469.503 and OAR 345-024-0500 et seq)	Law	In effect as of 2007	New generating plants	675 lbs CO_2 / MWh for natural gas-fired plants; standards pending for other fuel types	Standards may be met by offsets or by paying a fee per ton of carbon dioxide		Standards set and reviewed by Oregon Energy Facility Siting Council
New Mexico (SB 994)	Proposed (2007)	January 1, 2017 or plants 18 months after construction	New or modified plants that utilize technology to reduce CO_2 emissions that subject the plant to increased financial risk due to lack of commercial experience (first-movers)	1100 lbs CO_2 / MWh	No	Allows for increased costs to be accounted for in rate structure; tax credits available; allows commission to consider performance-based incentives.	

Proposed Federal Performance Standards

Table 4 summarizes the provisions of two bills in the 110th Congress that would have limited emissions from coal-fueled power plants to 250 to 285 lbs CO_2/MWh. These emission rates are similar to the representative values shown in Table 2 for new pulverized coal (PC) and integrated gasification combined cycle (IGCC) power plants with CCS. The proposed Kerry bill (S.1227) standard of 285 lbs CO_2/MWh would have applied immediately to proposed new coal plants. To comply with such a standard, plants would require CCS systems that capture and store approximately 85 to 90 percent of the CO_2 generated.

In contrast, the Sanders-Boxer bill (S.309) proposed a performance standard for existing as well as new sources of CO_2. Beginning in 2015, this bill would have phased in a "low carbon" portfolio standard of 250 lbs CO_2/MWh based on the total quantity of electricity produced for sale by affected generators using coal, petroleum coke, or lignite (or any combination of those fuels) during the calendar year immediately preceding a compliance year. A specified percentage of the electricity would have to meet the low-carbon standard (see Table 4), and that percentage would increase over time.[5] The portfolio standard could be met by either using CCS to generate low-carbon electricity or by purchasing low-carbon generation credits that would be issued and traded under the program. Together with other provisions, the Sanders-Boxer bill was projected to decrease U.S. CO_2 emissions significantly over time (see Figure 2).

5 The annual percentage increase is not explicitly tied to projected increases in new builds, and can be increased if necessary to meet the overall emission reduction goals of the bill.

Figure 2: Illustration of Economy-wide Emission Reduction Targets

Legislative Proposals Introduced in the 110th Congress as of December 1, 2008

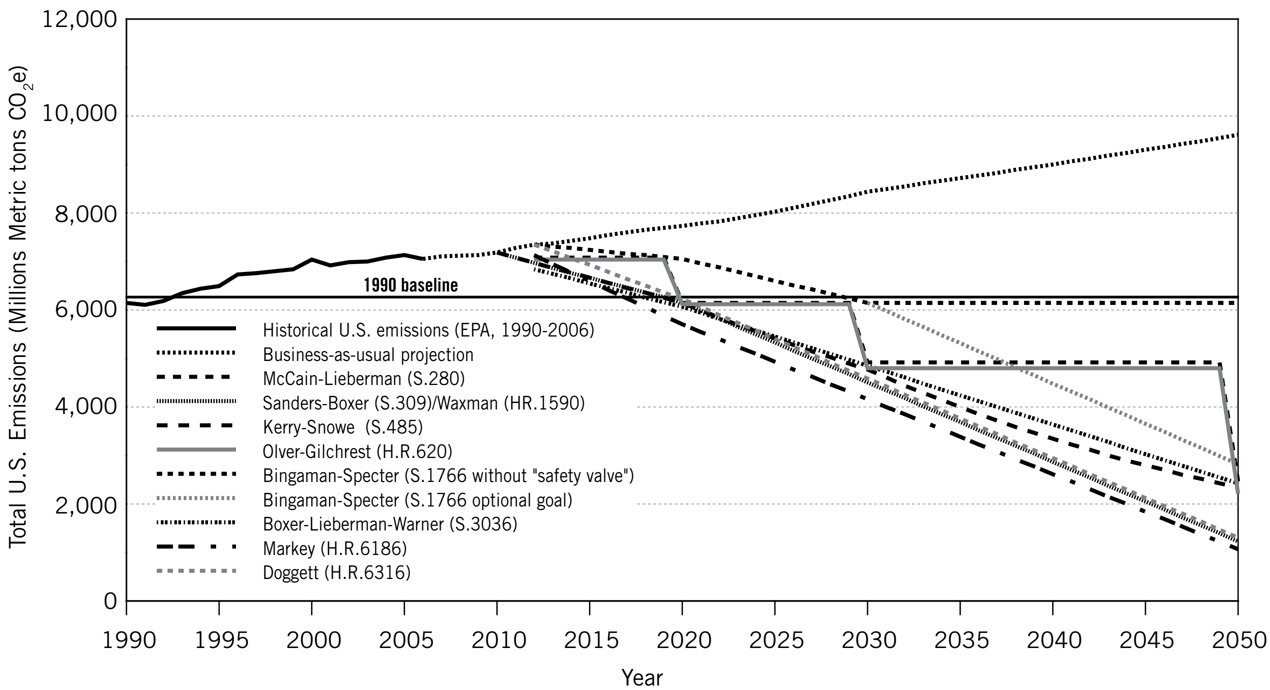


Table 4: Summary of proposed federal performance standards for power plant CO_2 emissions

Proposed by	Status (Date)	Date effective	Plants affected	Performance standard (allowable emissions)	Trading allowed?	Incentives	Comments
U.S. Climate Action Partnership (USCAP) www.us-cap.org/blueprint/index.asp	Business-NGO coalition proposal (January 2009)	Phase I: 2015 Phase II: 2020 Phase III: (see Comments)	Phases I & II: new coal and other solid fueled plants permitted after effective dates that emit more than 10k metric tons per year of CO_2. Phase III: plants permitted between 2009 and 2015 that emit more than 10k metric tons per year of CO_2.	Phase I: 1100 lbs CO_2 /MWh Phase II: 800 lbs CO_2 /MWh Phase III: retrofit of affected plants to comply with 1100 lbs CO_2 /MWh	Performance standard recommended as a complementary policy to economy-wide cap and trade.	Direct cash payments for captured and stored CO_2 for early projects. Additional incentives for replacement of high-emitting units.	Phase III: effective within 4 years of cumulative deployment of 2.5 GW of CCS in U.S with annual storage of 5 million metric tons of CO_2 or 5 GW of CCS globally with annual storage of 10 million metric tons of CO_2 (whichever comes first)
Waxman-Markey Discussion Draft, The American Clean Energy and Security Act	US House discussion draft (2009)	Phase I: 2015 Phase II: 2020 Phase III: (see Comments)	Electricity generating units issued permits under title V of the Clean Air Act and that derive at least 30 percent of annual heat input from coal or petcoke that are finally permitted after January 1, 2009.	Phase I: 1100 lbs CO_2 /MWh Phase II: 800 lbs CO_2 /MWh Phase III: retrofit of affected plants to comply with 1100 lbs CO_2 /MWh	No. Performance standard is part of a draft bill that includes cap-and-trade and complementary policies.		Phase III: effective within 4 years of cumulative deployment of 2.5 GW of CCS in U.S with annual storage of 5 million metric tons of CO_2 or 5 GW of CCS globally with annual storage of 10 million metric tons of CO_2 or in 2025 (whichever comes first)
Sanders-Boxer (S.309)	US Senate proposed (2007)	2015	Units greater than 25 MWe capacity with 50% or more fuel input from coal, petroleum coke, lignite, or any combination of those fuels	Low carbon means 250 lbs CO_2 /MWh; Year (minimum annual percentage low carbon): 2015 (0.5), 2016 (1.0), 2017 (2.0), 2018 (3.0), 2019 (4.0), 2020 (5.0); 2021–2025 (increases of up to 2% per year to achieve emission reduction goal); 2026–2030 (increases of up to 3% per year to achieve emission reduction goal)	Yes. Low-carbon generation credit trading program; generating electric energy using low-carbon generation; purchasing electric energy generated by low-carbon generation; purchasing low-carbon generation credits issued under the program	None	Low carbon means: results in an emission rate into the atmosphere of not more than 250 lbs CO_2 / MWh (after adjustment for CO_2 from the electric generating unit that is geologically sequestered in a geological repository)
Kerry (S.1227)	US Senate proposed (2007)	Immediately	New coal-fired electric generating units (including cogeneration facilities) that commence construction on or after April 26, 2007.	285 lbs CO_2 / MWh. Update standard every 5 years if a reduced level is achievable through application of the best technological system of continuous emission reduction demonstrated at the time of the revision.	No	None	CCS can be used to meet the goal
Natural Resources Defense Council (NRDC) www.nrdc.org/globalWarming/coal/coalclimate.pdf	NGO proposal (2007)	Phased-in standard	New plants	250 lbs CO_2 /MWh. Phased-in standard at a rate corresponding to new plants construction and the replacement of older units	Yes	None	Combined with low-emissions obligation across coal generating units to spread cost across all generators
Center for American Progress www.americanprogress.org/issues/2007/05/coal_report.html	NGO proposal (2007)	January 1, 2008	New plants built after January 1, 2008	CCS required; no numerical value specified	Yes. Performance std for new plants combined with cap-and-trade for existing plants. Start cap at 100% emissions and then decrease cap over time	None	Three year phase-in (until 2011) allowing new coal plants to comply by: improving efficiency at existing plants; or, retiring older coal or natural gas plants; or constructing previously unplanned renewable fuel power plants representing up to 25 percent of the generation capacity of the new coal plant

Also shown in Table 4 are the national performance standards proposed by the U.S. Climate Action Partnership (USCAP), an alliance of businesses, environmental organizations, and climate groups (USCAP 2009). As a complement to an economy-wide cap-and-trade program, USCAP proposes a performance standard of 1,100 lbs CO_2/MWh for new coal-fueled power plants permitted between 2015 and 2019. For new plants permitted after 2019, the standard would be 800 lbs CO_2/MWh. USCAP further recommends that plants without CCS permitted between 2009 and 2014 should be retrofitted to meet the 1,100 lbs CO_2/MWh standard within four years after commercial-scale CCS deployment exceeds a certain capacity threshold. The performance standard implementation dates would be contingent upon development of regulations governing CO_2 transport and storage and the enactment of financial incentives for initial CCS projects in the form of direct cash payments for captured and stored CO_2 to cover the incremental cost of CCS.

In summary, several types of performance standards have been proposed to reduce CO_2 emissions from coal-fueled power plants. Proposals differ in the maximum allowable emission rate specified and the timetable for implementation. Some apply only to new plants while others include existing facilities. In general, however, all of the proposed standards would require the introduction of CCS technology at power plants that continue to use coal as an energy source.

Evaluation of Performance Standard Policy Options

Here, the pros and cons of a CO_2 performance standard for new and existing power plants are discussed in the context of the nine evaluation criteria listed above. In some cases, two related criteria are discussed in tandem.

FAMILIARITY OF THE APPROACH

A familiar policy approach is the first desirable attribute listed by the Pew Center Consultative Group. As noted earlier, fossil fuel power plants have been subject to New Source Performance Standards for air emissions for over 35 years (Table 1). Thus, an NSPS for CO_2 would be an approach that is familiar to regulators and affected utilities. Furthermore, as a result of the recent U.S. Supreme Court decision in which CO_2 was held to be a pollutant that could be regulated under the current Clean Air Act (Massachusetts v. EPA, 2007), the authority to impose a CO_2 NSPS already resides with EPA; thus, no new action by Congress would be required (CAP 2007, Hawkins 2007).

Generator performance standards also are a familiar and widely used approach to regulate air pollutant emissions from existing sources. Most such standards are imposed by states under the State Implementation Plan (SIP) framework of the Clean Air Act, with the goal of attaining and maintaining national ambient air quality standards. This framework is therefore not readily applicable to CO_2 emissions since there are no air quality standards for CO_2.[6]

Emission performance standards that apply to a collection of plants, or to sellers of electricity, have not been used at the federal level in the past to control power plant emissions and thus are less familiar to the utility industry. Nonetheless, this type of regulation has been used successfully in other industries—most notably the automotive industry, which is required to meet fuel economy standards across fleet-wide sales of new cars each year. Similarly, CO_2 performance standards such as proposed in the Sanders-Boxer bill (Table 4) are similar in concept and design to renewable portfolio standards (RPS) that require utilities or load-serving entities to generate or sell a specified portion of their electricity from qualified renewable energy sources. This type of performance standard is thus generally familiar to the industry, although not all utilities have direct experience with an RPS since they are state-level policies, which some states have not enacted.

EFFECTIVENESS IN REDUCING EMISSIONS

The effectiveness of performance standards in reducing emissions must be considered in the context of both new and existing power plants. For new power plants, the strongest advantage of a CO_2 performance stan-

6 EPA has issued an Advance Notice of Proposed Rulemaking (EPA-HQ-OAR-2008-0318) laying out a broad range of possible actions it could take to regulate new and existing greenhouse gas emission sources under the current Clean Air Act without additional Congressional action. It is unclear which, if any, of these approaches will be undertaken, or whether Congress will take action in this area.

dard is its ability to achieve significant (e.g., 85 percent or more) emission reductions from all future units by effectively requiring the use of CCS technology. Such a requirement also would ensure that no new coal plants are constructed without CCS—an advantage no other policy options can readily claim.[7] A CCS-based NSPS also could apply (initially or in the future) to other carbonaceous fuels, including new natural gas-fired plants, whose emissions contribute to the total GHG burden and thus may warrant further control. As with current NSPS requirements (which specify different maximum emission rates for coal, oil and gas-fired plants) the allowable level of CO_2 emissions also could vary with fuel type.

One of the strongest criticisms of an NSPS approach is that it would not reduce emissions from currently operating plants—the source of one third of current U.S. CO_2 emissions. This concern stems from the fact that under current NSPS rules electric utility companies have prolonged the use of existing plants in order to avoid or delay building more costly new units requiring more stringent emission controls. Under the current Clean Air Act, existing power plants must be upgraded to meet NSPS requirements if they undergo a "major modification"—a phrase whose interpretation has led to protracted litigation and delayed progress in reducing emissions from existing facilities. The addition of a new source performance standard for CO_2 would likely have a similar effect under the current rules—i.e., encourage utilities to indefinitely extend the life of existing coal plants. The construction of new plants with CCS could be substantially curtailed or delayed, with little reduction in CO_2 emissions.

There are at least three policy approaches that could more effectively reduce CO_2 emissions from existing power plants. Two involve performance standards while the third relies on market mechanisms.

One performance standard approach is simply to change the current NSPS requirements to unambiguously specify the point at which continued operation of an existing unit would trigger compliance with new plant performance standards. For example, a specific plant age (e.g., 30 or 40 years after initial online date) or number of years after promulgation of the NSPS could be specified. Given the age profile of current U.S. coal plants (most are 20 to 50 years old), this approach could soon begin to curtail current plant emissions.

Another performance standard option is a low-carbon portfolio standard. This could take any of several forms. One is to specify a percentage of all coal-based power generation or electricity sales that must not exceed a specified CO_2 emission rate (requiring the use of CCS) in a given year. That percentage would increase over time so that by some future date (e.g., 20–30 years hence) all coal plants still in service would be using CCS. Another variant of this approach is to require that a specified fraction of electricity sales be from coal plants with CCS. This option is akin to the RPS, except that coal would be the favored energy source. This option also would ensure that coal remains in the generation mix (which is another policy evaluation criterion, discussed below). Alternatively, a fuel-neutral low-carbon portfolio standard could apply more generally to all electricity sales. In this case, coal would compete directly with renewables, nuclear, and natural gas, with the outcome dependent upon the level of CO_2 reduction required and the cost of alternative generation options, including coal with CCS.

7 In principle, either an emissions tax or a cap-and-trade program could be structured to provide a strong economic incentive for installation of a CCS system. However, market mechanisms are not guaranteed to result in deployment of CCS at all new coal plants.

A third general approach—typically viewed as an alternative to performance standards—is a cap-and-trade system that specifies for a class of sources (not individual sources) an overall maximum allowable level of CO_2 (and other greenhouse gas) emissions per year, similar to the current cap-and-trade program for SO_2.[8] This would require a mechanism such as an auction or allocation scheme to distribute allowances initially. Regulated entities might include all large stationary sources of CO_2 (including electric power plants), transportation fuel providers, and natural gas distributors.[9] As with a performance-based portfolio standard, the emissions cap would be lowered over time to reduce total emissions. The pace and effectiveness of this approach in reducing CO_2 emissions from existing power plants would be governed by the stringency of the emissions cap and the resulting price of carbon allowances.

Under cap and trade, carbon prices in an efficient market reflect the marginal cost of achieving the required level of emission reductions. In the early years of cap and trade, at low carbon prices, the economical solution for most existing coal-fired power plants would simply be to purchase allowances and continue to emit CO_2, though perhaps at lower levels due to reductions in electricity demand. As the lowest-cost GHG mitigation options are exploited, carbon prices would increase, and lower-carbon energy sources (such as natural gas, nuclear, wind, and biomass) would likely begin to displace coal as they become more cost-competitive. The specific technologies that would displace coal and the extent to which they would do so depend on the relative costs of electricity generation technologies under a carbon price. Only at higher carbon prices would CCS become economically attractive for either existing or new coal plants. Recent engineering cost studies suggest allowance prices of roughly $40–$80 per ton CO_2 would make CCS economical for new power plants (NETL 2007a, EPRI 2008). For many existing plants, the required allowance price could exceed $100 per ton (NETL 2007b, SFA Pacific 2009). There is considerable uncertainty, however, as to whether future CCS costs will continue to escalate, or whether costs might begin to fall given the rapid power plant capital cost escalation prior to the current economic downturn and recent signs of cost moderation (CERA 2008). To promote early deployment of CCS, some Congressional cap-and-trade proposals include financial incentives in the form of bonus allowances for initial CCS projects (Pew Center 2008b). Whatever its impact on coal plant emissions, the effectiveness of a cap-and-trade program in reducing overall CO_2 emissions will depend—by definition—on the level of the emissions cap imposed.

Similarly, the effectiveness of CCS in reducing emissions from coal plants hinges on the viability and public acceptance of geologic storage of CO_2 and the development of legal and regulatory frameworks to support geological sequestration. The timetable and requirements for developing an effective CCS-based regulatory program are discussed in the next section.

TIMING AND EASE OF IMPLEMENTATION

The timing and ease of implementing any of the performance standard options discussed earlier depends mainly on the pace of developments related to CCS. It will likely take at least five to ten years before a fully developed regulatory system for CCS is in place and the first few coal-fueled power plants have deployed and operated CCS technologies. Early deployment and demonstration of full-scale CCS at power plants is needed to validate system performance, reliability, safety, and cost (Pew Center 2008a). Assuming success

8 For an overview of cap and trade, see Pew Center 2008b.

9 Proposals for a U.S. cap-and-trade program differ in their requirements and approach. For a summary of recent proposals (see Pew Center 2008c).

of the initial projects, adoption of a federal performance standard requiring CCS at all new coal plants (or all new fossil-fueled plants) as of some future date could help accelerate future CCS deployment, in part by providing certainty that the costs of CCS could be recovered through traditional rate-setting processes in states with cost-of-service electricity regulation. This also would provide confidence to financial markets of positive returns on CCS investments.

As noted earlier, a CO_2 NSPS could be implemented under current EPA regulatory authority, but that process is typically lengthy and may require additional time to resolve legal and regulatory issues regarding geological sequestration sites (Wilson et al. 2008). Technical and economic uncertainties also could slow the widespread acceptance of CCS for utility applications unless measures are taken to overcome those obstacles (Pew Center 2007, 2008a). The choice of a compliance date for a CO_2 NSPS is therefore a tricky issue, as too early a date could discourage the use of coal if technical, legal, and regulatory issues regarding CCS are not yet resolved. Nonetheless, in light of current programs to bring CCS to commercial acceptance (both in the U.S. and internationally), a standard that applies to plants receiving operating permits in the 2015–2020 time frame appears reasonable.

If an earlier implementation date for CCS were selected (as in some Congressional bills), it might be advisable to include provisions that can help ameliorate current risks and uncertainties. One such option is to require only partial capture and storage of CO_2 initially (e.g., a level similar to the current California standard), with more stringent reduction requirements phased in over a period of time, as in the USCAP proposal (Table 4). Implementation of a regulatory framework for CO_2 transport and storage also is a prerequisite.

In general, the same timing and implementation issues discussed above for new plants would apply to policies aimed at existing plants. For power plant performance standard options, the key policy issue that Congress must address is the pace of required CO_2 emission reductions from existing coal plants.

COST-EFFECTIVENESS AND USE OF MARKET MECHANISMS

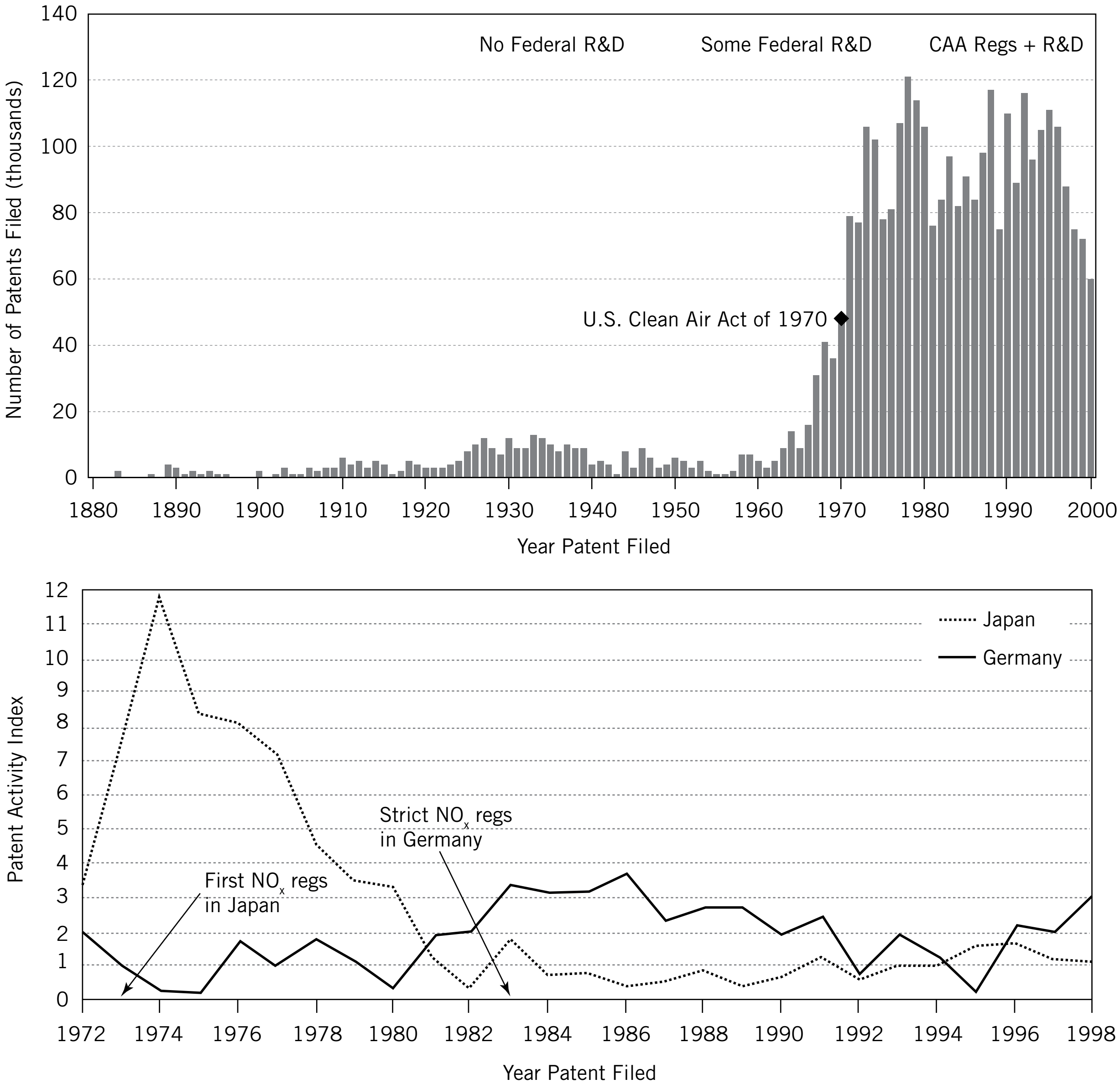
As used here, cost-effectiveness means the cost of reducing a unit of CO_2 emissions from a collection of power plants. In this context, market-based approaches are generally viewed as more economically efficient than traditional "command-and-control" policies such as generator performance standards. Market mechanisms first require a price for emitting CO_2—such as that created by cap and trade. The market then determines the most cost-effective way to achieve the desired result. In contrast, performance standards impose requirements on individual facilities—or groups of facilities in the case of a portfolio standard—whose characteristics and costs of compliance may vary widely. As a result, the cost-effectiveness of emission reductions also varies across facilities, with overall costs of performance standards typically exceeding those of efficient emission pricing policies achieving the same level of emissions reduction.

Rather than putting an explicit price on carbon and relying on that price signal to drive emission reductions, performance standards set technical requirements. Politically, such prescriptive regulations have often been more palatable than explicit charges since the costs of such regulation are less transparent to the public than those of market-based policies. Effectively, however, a performance standard requiring CCS on power plants could impose on utility companies a relatively high cost per ton of CO_2 avoided before all lower-cost GHG mitigation options in the economy have been fully exploited.

Importantly, power plant performance standards also have been shown to be powerful drivers of technology innovations that significantly reduce the cost of emissions control. Retrospective studies credit the introduction of stringent new source performance standards for major advances in flue gas desulfurization (FGD) systems for SO_2 control (Taylor et al. 2003). Stringent standards for power plant NO_x emissions in Japan and Germany in the 1970s and '80s (and more recently in the U.S.) led to similarly dramatic reductions in the cost (and thus improvements in the cost-effectiveness) of selective catalytic reduction (SCR) technology (Yeh et al. 2005). In both cases, analysis of patent data for SO_2 and NO_x capture systems (Figure 3) showed

Figure 3: Patenting activity in SO_2 control technologies (top) and flue gas nitrogen oxide controls (bottom)

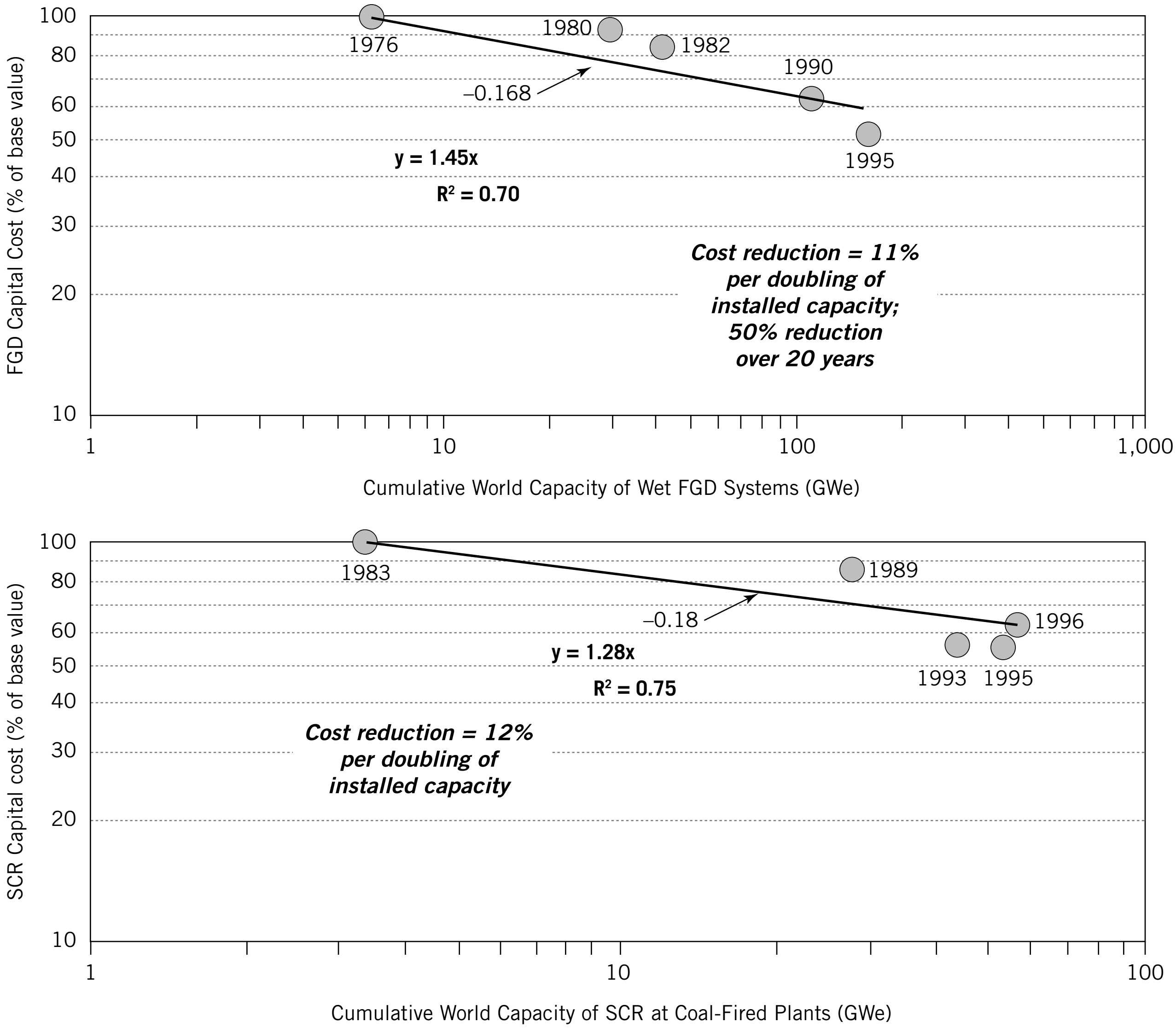
Increased activity coincided with the introduction of stringent standards requiring use of FGD systems in the U.S. beginning in the early 1970s, and SCR systems in Japan (beginning early 1970s) and Germany (beginning early 1980s). The U.S. did not require stringent NO_x controls on power plants until the early 1990s.



Source: Taylor, et al 2003, Yeh et al 2005 dramatic increases in inventive activity in response to stringent emission control requirements. Sizeable new markets for FGD and SCR technologies stimulated learning-by-doing and major private-sector investments in R&D that substantially reduced the cost of these technologies (Figure 4). Economic advantages also accrued in the form of increased employment and sales for the innovating firms (including export and licensing of equipment to other countries).

Figure 4: Reduction in capital cost of FGD systems (top) and SCR systems (bottom) with increased deployment

FGD costs are for 90% SO_2 removal from a 500 MW plant burning high-sulfur coal. SCR costs are for 80% NO_x removal from a 500 MW plant burning a medium-sulfur coal. Additional cost reductions in operating and maintenance costs also occurred during this period.



(Source: Rubin, et al 2007a)

The technology innovation literature documents many other examples of cost reductions achieved with increased technology deployment—the basis for so-called learning curves or experience curves. While most of this literature deals with technologies and services that are widely sought in a market economy, the evidence above strongly suggests that significant reductions in real CCS costs and cost-effectiveness also would be realized once sustained markets for such technologies develop (Rubin et al. 2007a). Since there is no "natural" demand for emission control technologies like CCS in a market economy, government action to limit environmental emissions—be it through regulation, cap-and-trade, or other policy mechanisms—is essential to establishing such markets.

It should be noted, however, that performance standards are not alone in promoting innovation—economic theory predicts that market-based environmental regulation (such as cap and trade) also can provide a continual incentive for innovation. For example, in the case of SO_2 control, evidence from patent data indicates that enactment of the U.S. SO_2 cap-and-trade program in 1990 fostered innovations that both lowered the cost of operating FGD units and improved the SO_2 removal rates (i.e., the environmental benefit) of such units (Popp 2003). Studies also found that the SO_2 cap-and-trade program promoted not only improvements in FGD systems but also changes in regulated firms' processes as well as innovations and investments by upstream suppliers (Burtraw et al. 2005). For both market-based and standards-based approaches to emissions control, the stringency of the emission reduction requirement is identified as a major factor affecting the nature and pace of technology innovation.

LINKAGE TO OTHER POLICY MECHANISMS

A CO_2 performance standard for power plants would not preclude the adoption of other policy measures to reduce power plant GHG emissions. Indeed, a combination of policy mechanisms may be the most effective way to achieve the most rapid and substantial CO_2 emission reductions from both new and existing plants.

CO_2 performance standards are compatible with a market-based cap-and-trade system. In addition, a generator performance standard (NSPS) for new coal-fired power plants could be combined with a low-carbon portfolio requirement for existing plants. As noted earlier, the latter might specify a decreasing rate of allowable CO_2 emissions (lbs/MWh) applied to all coal-based electricity generated or sold. Alternatively, it could require that a gradually increasing percentage of electricity sales come from coal-based plants with CCS. Performance standards could also encompass other plant and fuel types.

EQUITY ISSUES

In the context of policies to reduce power plant emissions, issues of equity arise in regard to factors such as differences in regional characteristics, company size, and regulated versus non-regulated utilities. In general, such factors must be evaluated in the context of specific policy proposals. This is especially true of performance standard options aimed at existing power plants, since plant characteristics, fuel mix, and other key factors vary considerably across the country. In many cases, political factors as well as equity considerations may be involved, for example in evaluating the merits of a fuel-neutral performance standard versus one that favors a particular energy source. Inevitably, such issues must be resolved through political and legislative processes.

Equity issues related to CO_2 performance standards for new power plants also need to be evaluated. In particular, the availability of suitable geological sequestration sites for CO_2 in different regions of the country must be assessed to identify and remedy any serious problems or issues raised by a requirement to deploy CCS. For example, CCS could prove more expensive to deploy in regions where captured CO_2 must be transported long distances to suitable storage sites. Past and ongoing research by the U.S. Department of Energy and other organizations can provide the technical basis for such evaluations.

ENSURING A SIGNIFICANT ROLE FOR COAL

This criterion of the Pew Center Consultative Group reflects a desire to preserve a significant role for coal as an abundant and secure domestic energy source for power generation. Coal is currently the only major commercial energy source for which the U.S. is a net exporter—domestic supplies of oil, uranium, and natural gas all rely on net imports. Modeling studies of recent Congressional proposals, however, suggest that a fuel-neutral cap-and-trade policy to reduce CO_2 emissions could result in significant reductions in domestic coal use. As a consequence, there would be greater reliance on nuclear energy, renewables, and natural gas—with the potential for significantly increased dependence on natural gas imports in the form of liquefied natural gas (LNG) from politically volatile regions of the world (NRC 2007). Other scenarios with much higher carbon prices indicated that coal-fueled electricity generation with CCS can be a cost-effective component of a portfolio of low-carbon energy sources in a carbon-constrained future (IPCC 2007). The weight given to the criterion of ensuring a significant role for coal will thus be an important determinant of how aggressively policies incentivize or mandate the use of CCS.

A carbon price alone cannot ensure a significant role for coal, nor can performance standards (with one notable exception discussed below) "guarantee" a certain level of coal consumption. Thus, if coal use is to receive a degree of favor, but must also have low CO_2 emissions to address climate change, additional incentives to stimulate CCS deployment may be required.[10] For example, some recent cap-and-trade proposals included bonus allowances or subsidies for captured and stored CO_2 (EPA 2008a, EPA 2009). The total value of these extra allowances offsets the cost of CCS, though the project must be completed and operating to receive the subsidy.

The only policy mechanism able to "guarantee" that coal provides a significant share of U.S. electricity with low CO_2 emissions is a portfolio performance standard requiring that a specified fraction of electricity sales (or generation) come from coal-based plants with CCS—i.e., a standard akin to the renewable portfolio standards (RPS) adopted by a number of states to foster certain forms of renewable energy. The political viability of such a policy for coal, however, remains questionable in light of regional differences in energy resources and divergent views about coal use across the United States. Conceivably, however, such a policy could be adopted by individual states that rely heavily on coal, provided that such actions are not precluded by federal policies.[11] For example, in January 2009 Illinois enacted a Clean Coal Portfolio Standard requiring CO_2 capture and storage at proposed clean coal projects in the state (ILGA 2009).

10 The option of keeping coal plants in the mix by not imposing any emission reduction requirements is considered to be unrealistic in the context of current U.S. policy deliberations.
11 The ability of state and regional authorities to pursue greenhouse gas reduction policies that differ in some respect from federal policies is a generic issue that applies to all climate policies and is outside the scope of this paper.

Other types of CO_2 performance standards discussed earlier also could foster—but would not necessarily ensure—the use of coal with CCS. At the very least, a performance standard would establish clear ground rules for future coal use, providing utilities with a degree of certainty that is important for future planning. The history of solving past environmental problems via improved coal use technologies suggests that a well-crafted set of CO_2 performance standards, addressing both new and existing power plants, also could be effective in significantly reducing CO_2 emissions, while maintaining a significant role for coal. On the other hand, performance standards mandating capture levels and/or compliance deadlines that are perceived as too risky or too costly may actually hinder the use of coal and push utilities and other power producers to other technologies, such as natural gas. One way to address this issue would be to phase in a performance standard that initially requires only a moderate level of CO_2 capture (such as the current California standard). Plants constructed in later years would be subject to tighter standards after more experience is gained with CCS technology. In addition, financial incentives (such as cash payments for captured and stored CO_2 for initial CCS projects) coupled with CO_2 performance standards could overcome barriers related to risk and cost.

Including natural gas-fired power plants in the scope of new source performance standards for CO_2 would further help ensure continued coal use by removing a cost advantage that new NGCC plants otherwise would have if allowed to emit CO_2 with no controls. The uncontrolled emissions rate of a new NGCC plant is approximately 800 lbs CO_2/MWh, which is roughly half that of a new coal-fired plant without CCS, but this would be roughly three times greater than the emissions from a coal plant with 85–90 percent CO_2 capture. Requiring CCS on new NGCC plants would thus "level the playing field" with regard to CO_2 emissions. This would require roughly 70 percent CO_2 capture to meet the same performance standards proposed for coal plants requiring 85 percent capture or more (see Table 4).[12]

Credits toward compliance with a performance standard also could be given to coal combustion or gasification plants that use biomass as a supplemental fuel, together with CCS. In this case, sequestering the carbon in biomass represents "negative emissions" since biomass removes CO_2 from the atmosphere by photosynthesis during its growth. Credits could take the form of either a modified performance standard (that would not require capture of biomass carbon) or additional allowances in conjunction with an emissions trading program. Credits of either type would help reduce the cost of CCS.

12 Because NGCC plants start from a lower level of CO_2 emission, the cost per unit of CO_2 reduced is typically higher than for coal plants. However, the incremental cost of electricity for NGCC is typically much lower because less CO_2 must be captured and sequestered to achieve a target emission rate with CCS,

Conclusions

This paper has described several types of CO_2 performance standards that could be adopted to reduce CO_2 emissions from new and existing coal-based power plants. One is a New Source Performance Standard (NSPS) modeled on current federal requirements for regulated air pollutants. The NSPS would specify a maximum allowable rate of CO_2 emissions per MWh, and/or a required percentage reduction in potential CO_2 emissions, set at a level that would require the use of CO_2 capture and storage (CCS) technologies to comply. The NSPS could apply not only to coal-based power plants but to new generators using any type of carbon-bearing fuel (such as natural gas or petroleum coke). Recent studies indicate that a CO_2 emission rate for coal plants on the order of 250 lbs CO_2/MWh (requiring a net CO_2 reduction of about 85 to 90 percent) is achievable with current CO_2 capture systems for both combustion-based and gasification-based power plants. However, less stringent requirements might be preferred initially to minimize risk and cost impacts and allow utilities and other power producers to gain needed experience with CCS technologies.

Consistent with current NSPS requirements, a new source standard for CO_2 also would apply to existing power plants that undergo major modifications. However, in light of the past problems encountered with that criterion, a revised (for example, age-based) definition would be needed in order to apply an NSPS to existing power plants.

An alternative option for existing coal-fired plants is a low-carbon portfolio standard that would require an increasing percentage of all electricity generated, or all electricity sold by designated entities, to meet a performance standard similar to that proposed above for new units. As the specified percentage increases over time (perhaps a few decades), existing coal-based power plants would be gradually replaced or retrofitted with units that employ CCS. A low-carbon portfolio standard could apply exclusively to coal-based entities, or more generally to all types of power generators (i.e., a fuel-neutral standard).

Another variant of a low-carbon portfolio standard would require that a specified fraction of electricity sales come from coal-based plants with CCS—akin to the renewable energy portfolio standards adopted by a number of states. This is the only policy approach that would ensure that coal continues to provide a significant share of U.S. electricity with low CO_2 emissions.

Authority to add a new source performance standard for CO_2 to the existing NSPS limits for regulated air pollutants already resides with EPA under the Clean Air Act. EPA also has other authorities under the existing Clean Air Act that it potentially could use to regulate new and existing CO_2 sources. However, new Congressional action is preferable to addressing CO_2 under the existing Clean Air Act since new legislation could provide a more comprehensive and cost-effective approach to reducing greenhouse gas emissions.

EVALUATION OF OPTIONS

The performance standard approaches outlined above were evaluated using a set of nine criteria developed by a Consultative Group to the Pew Center on Global Climate Change. Performance standards have the advantage of being familiar to both utility companies and regulators, and effective in reducing emissions. Relative to a cap-and-trade approach of comparable stringency, however, CO_2 performance standards are likely to be more costly because they are less flexible in their requirements for use of CCS technologies. On the other hand, a cap-and-trade program with gradually increasing allowance prices would require more time to achieve large reductions in coal plant emissions. Thus, groups such as USCAP advocate the early adoption of performance standards as a complement to cap-and-trade.

The criterion of maintaining a significant role for coal as a domestic energy resource weighs heavily in judging the merits of alternate policy measures. A fuel-neutral cap-and-trade program with carbon prices below the cost of CCS would likely result in a large decrease in U.S. coal use, according to most recent modeling studies. Utility companies would instead turn mainly to imported natural gas and nuclear power for electricity generation, according to these projections. Higher carbon prices, or incentives such as bonus allowances and financial subsidies for early CCS deployment, could, in principle, keep coal prominent in the generation mix. Modeling studies forecast this result (e.g., EPA 2008a), though the actual effectiveness of such measures remains uncertain.

In this regard, the only policy mechanism able to "guarantee" that coal provides a significant share of U.S. electricity with low CO_2 emissions is a portfolio performance standard requiring that a specified fraction of electricity sales (or generation) come from coal-based plants with CCS—i.e., a standard akin to the renewable portfolio standards (RPS) adopted by a number of states to foster certain forms of renewable energy. The political feasibility of such an approach at a national level, however, remains questionable.

A stringent cap-and-trade program by itself would not address concerns over energy security, technology development, and potentially disruptive increases in the price of natural gas from large-scale fuel-switching. A program combining cap-and-trade with targeted performance standards may be a more viable approach to achieve large and timely CO_2 reductions from power plants—while also stimulating development of CCS technology, avoiding large-scale fuel-switching to natural gas, and enabling continued reliance on an abundant domestic energy resource.

Performance standards could include a traditional new source performance standard (NSPS) for fossil fuel power plants, coupled with a low-carbon portfolio standard for existing coal plants. This would offer a more flexible and cost-effective approach to reducing coal plant emissions than requiring all existing coal units to at some point meet the NSPS (or else retire). CO_2 abatement costs would be further reduced if plants that over-complied with a performance standard could earn emission credits that could be traded or sold in an allowance market. While such a scheme would be somewhat more complex than either a pure cap-and-trade system or a traditional "command-and-control" regulatory program, it might achieve environmental outcomes not otherwise attainable, while fostering technology innovations that reduce future costs.

All of the options that maintain a significant role for coal with low CO_2 emissions require that geological storage of CO_2 become a publicly acceptable method of greenhouse gas abatement, and that the legal, regulatory, and technical issues related to CCS be resolved in a timely fashion. To overcome the near-term risks and impediments to CCS-based performance standards, an accelerated program to demonstrate CCS technologies in a variety of full-scale power plant applications is essential. Such a program would also accelerate the learning-by-doing needed to reduce CCS costs. Two recent Pew Center studies (Pew Center 2007, 2008a) elaborate on policies to achieve this goal.

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This paper describes options for setting CO_2 emission performance standards for coal-fueled electric power plants that would spur the deployment of carbon capture and storage and examines the rationale for and benefits from such standards. It is part of a Pew Center on Global Climate Change Coal Initiative, a series of reports examining and identifying policy options for reducing coal-related GHG emissions. The Pew Center brings a cooperative approach and critical scientific, economic, technological, business, and policy expertise to the global climate change debate at the state, federal, and international levels.

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