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Greenhouse Gas Regulation under the Clean Air Act

A Guide for Economists

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RESOURCES FOR THE FUTURE

Greenhouse Gas Regulation under the Clean Air Act: A Guide for Economists

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Abstract

Until recently, most attention to U.S. climate policy has focused on legislative efforts to introduce a price on carbon through cap and trade. In the absence of such legislation, the Clean Air Act is a potentially potent alternative. Decisions regarding existing stationary sources will have the greatest effect on emissions reductions. The magnitude is uncertain, but plausibly 10 percent reductions in greenhouse gas emissions from 2005 levels could be achieved at moderate costs by 2020. This is comparable to the reductions that would have been achieved under the Waxman-Markey legislation in the domestic economy. These measures do not include the switching of fuels, which could yield further reductions. The ultimate cost of regulation under the act hinges on the stringency of standards and the flexibility allowed. A broad-based tradable performance standard is legally plausible and would provide incentives comparable to the proposed legislation, at least in the near term.

Key Words: climate policy, efficiency, EPA, Clean Air Act, NAAQS, coal

JEL Classification Numbers: K32, Q54, Q58

Contents

Greenhouse Gas Regulation under the Clean Air Act: A Guide for Economists

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1. Introduction

Until recently, it has been widely assumed that U.S. action on climate change would come, if at all, through new legislation—most likely by pricing carbon within a broad cap-and-trade system. Although almost all economists and policy experts still agree that such legislation (or potentially an emissions tax) remains the best long-term option, it failed to pass Congress in 2010 and seems unlikely to do so anytime soon. That leaves any near-future federal action on carbon emissions in familiar hands: the Clean Air Act (CAA).

The CAA is an old law that took its modern form under President Richard Nixon in 1970. It has been amended only twice since then, in 1977 and again in 1990. Throughout most of the last decade, the Bush administration argued that greenhouse gases were not "pollutants" as intended under the Act, but in 2007, in *Massachusetts v. EPA*, the Supreme Court confirmed the authority of the Environmental Protection Agency (EPA) to regulate greenhouse gases (GHGs) under the CAA.[1] Subsequently, the agency made a formal, science-based determination that GHGs were dangerous to human health and the environment. This "endangerment finding" compelled the agency to mitigate the harm and formed the basis for the agency's first regulation of carbon emissions under the Act—new corporate average fuel efficiency (CAFE) standards for cars and trucks. Although these regulations focus on transportation-sector emissions, they commit EPA to regulating stationary sources (power plants and industrial facilities) as well.[2] As

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[1] 549 U.S. 497 (2007).

[2] The link between these two is legally complex. EPA under successive administrations has confirmed an interpretation of language in the CAA creating the link. See EPA, Memorandum: EPA's Interpretation of Regulations That Determine Pollutants Covered by Federal Prevention of Significant Deterioration (PSD) Permit Program (the "Johnson Memo"), December 18, 2008, available online at http://www.epa.gov/NSR/documents/psd_interpretive_memo_12.18.08.pdf. This memo was recently revised; see EPA, Reconsideration of Interpretation of Regulations That Determine Pollutants Covered by Clean Air Act Permitting Programs, 75 FR 17004, April 2, 2010.

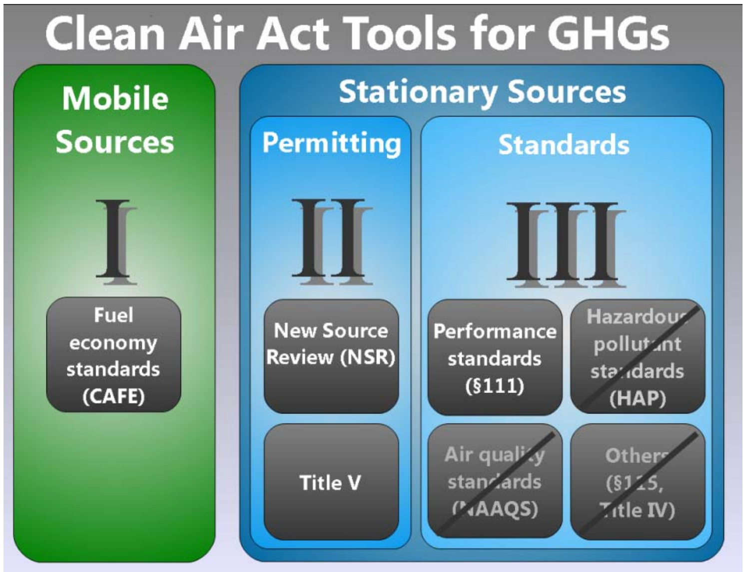
this process unfolds, other EPA regulations ostensibly unrelated to climate also will be implemented; many will have their own indirect but perhaps equally important effect on GHG emissions.

Those EPA actions have put the act at center stage, where it will remain in the absence of new legislation. This may come as a surprise to some, as the economics literature has been focused for the past couple of decades almost exclusively on the design of incentive-based approaches such as cap-and-trade or emissions taxes that would be implemented under comprehensive legislation. To paraphrase John Lennon, it appears that history is what happens while one is busy making other plans.

2. Three Tools under the Clean Air Act

EPA has three sets of tools that can be brought to bear on GHGs under the Clean Air Act, as illustrated in Figure 1. First, the agency has extensive powers to regulate in the transportation sector by setting rules for new vehicles. The agency began this process in March 2010 by setting GHG emissions standards for new cars and trucks. These standards effectively tighten previous CAFE standards and allow limited trading across vehicle types both within and among firms. The new regulations took effect January 2, 2011, affecting vehicles introduced in the 2012 model year and covering the 2012 to 2016 period. The standards impose annual improvements in fuel efficiency of 5 percent a year or more, raising the fleet average fuel efficiency for light trucks and SUVs to 30 miles per gallon (mpg) by 2016, and to 39 mpg for cars, resulting in a combined fleet average of 35.5 mpg. They are expected to reduce light vehicle emissions by 21 percent by 2030, making the standards among the most stringent in the world. Even stricter standards are in development and could take effect between 2017 and 2023; they could require fuel efficiency improvement of another 40 percent.

Figure 1. Tools of the Clean Air Act



As soon as emissions of a pollutant are restricted under any CAA authority, stationary sources that emit that pollutant are subject to construction and operating permit requirements and performance standards—a second tool under the Act. Stationary-source permits are required for new construction and major modifications to existing sources, a procedure known as new source review (NSR).

Permitting under NSR requires both site-specific, technology-based review of the control technology proposed by the source and a demonstration that the plant will not create or exacerbate violations of air quality standards in the surrounding area. A facility requesting a construction permit must show that its design uses best available control technology (BACT). This review procedure explicitly takes costs into account and can depend on geographic considerations. NSR permitting is usually done at the state level, though the technological inquiry is national in scope and subject to EPA oversight. Most large emitters are already subject to NSR review for new construction and modifications because they also emit other pollutants regulated under the CAA; starting in January 2011 that process will now involve review for GHGs.

One of the most controversial aspects of permitting is the number of sources that might be affected. The act identifies specific threshold emission quantities (tons per year), but greenhouse gas pollutants typically are emitted in greater quantities than “traditional” pollutants already regulated under the Act, so a much larger class of emitters would appear to be included. Tens of thousands of large office and apartment buildings, hospitals, commercial facilities, and other emitters could exceed this threshold every year, raising costs for sources and creating an administrative dilemma for regulators. EPA addressed this looming problem in its “Tailoring Rule” by restricting permit requirements, at least initially, to the largest emitters of GHGs. EPA suggests that this rule, if it survives legal challenge, will limit to 900 the number of projects annually reviewed solely because of GHG emissions.

The third tool of CAA authority primarily covers existing stationary sources. Ultimately, EPA decisions in this area will have the greatest effect on GHG emissions in the United States; however, relatively little is known about the agency’s plans. Hence, we examine EPA’s options carefully.

3. Standards for Stationary Sources

3.1 EPA's Options

How the agency chooses to establish general emissions standards for stationary sources has been until recently the largest unanswered question about implementation under the Act. EPA has four distinct approaches available.[3]

One is to treat GHGs as a hazardous pollutant under CAA §112, as the agency does for mercury, for example. This approach is unlikely to be useful for the regulation of most GHGs because it is designed for highly toxic substances emitted in relatively low quantities, whereas most GHGs are not toxic and are emitted in large quantities.

A second approach would be to regulate GHGs with national ambient air quality standards (NAAQS) under CAA §108–110. This is the best-known program under the act and the source of much of its regulatory impact for other pollutants. As the name implies, a single air quality standard for each regulated pollutant is set for the entire country. States are then responsible for on-the-ground regulation of emitters to comply with the standards.[4] Unfortunately, implementing a NAAQS for GHGs may pose significant conceptual and practical difficulties. There is also little support for a NAAQS approach; it is opposed by many in industry, most major environmental groups, and EPA itself. Although some believe NAAQS to be a viable approach, the mainstream view is that it is a poor fit.

A third approach could be aimed directly at emissions with international effects. Under CAA §115, EPA may regulate US emissions based on their international impact. Superficially, this seems ideal for the GHG problem because the nature of harm from GHG emissions has global consequences (Chang, 2010; Martella and Paulson, 2009). However, this section is skeletal and has never been used. Courts usually take a dim view of attempts by agencies to use short, vague statutory language to justify sweeping regulatory changes.

The fourth approach involves performance standards for new and existing sources under §111*;* we call it the "knowable path" because the agency has committed to implementing

[3] Richardson et al. (2011) provide a thorough review of these options. See also Mullins et al. (2010).

[4] Six pollutants are currently regulated under NAAQS: sulfur dioxide (SO_2), tropospheric ozone, nitrous oxides (NO_x), particulate matter (PM; two particles sizes are regulated separately), lead, and carbon monoxide.

performance standards for some sources and because this is likely to be the most effective and practical approach.

3.2 Performance Standards: The "Knowable Path"

Many authors have suggested regulating stationary sources with performance standards under CAA §111, and this is the path EPA has now identified for major types of GHG emitters. Standards under §111(b) apply to new sources (these are termed New Source Performance Standards, or NSPS), and those under §111(d) to existing sources.

For NSPS for new or modified sources, EPA usually identifies control technologies that can be applied to the source category or subcategory. After consideration of a variety of factors (including the cost and effectiveness of control), EPA typically establishes a performance standard (e.g., pounds of pollution per million British thermal units [Btu] of energy input) that the selected control technology can meet. To accommodate technological change, EPA is required to regularly update NSPS for listed source categories, and as these revisions proceed, EPA is likely to include performance standards for GHGs. . EPA has already committed to including GHGs in its 2011-2012 revisions of performance standards for fossil-fired steam power plants and refineries.

EPA also has authority to set guidelines for state regulation of existing sources under §111(d). These standards are often referred to as a type of NSPS—a bit of a misnomer because they apply only to certain existing-source emissions, specifically those not regulated elsewhere under the Act. EPA has pledged to issue such standards for fossil-fired steam power plants and refineries by 2012, contemporaneously with its release of NSPS for the same sources described above.

This approach to regulation of existing sources has several advantages. First, it would build on an established program. Experience and precedent reduce the risk of litigation, and the program is familiar to emitters, environmental groups, and other stakeholders. Second, the regulatory process may be relatively fast. Third, unlike the NAAQS program, it allows for the consideration of cost in standard setting and provides a flexible approach to implementation. Performance standards have traditionally applied to individual sectors, and EPA has flexibility to define and redefine source categories for regulation. Moreover, §111(d) allows EPA to recognize that different, less stringent requirements may be appropriate for existing sources.

Finally, performance standards would likely permit some degree of emissions trading. EPA has interpreted §111 as allowing the adoption of a trading program for NO_x emissions from municipal waste combustors and for mercury emissions from coal-fired electric utility units (although the mercury emissions trading program was overturned on other grounds). The CAA requires all §111 standards to be tied to the "best system of emission reduction." Though "system" has traditionally been understood in technological terms, it is plausible to interpret it more generally, such that an emissions trading program could be considered a system. EPA embraced this interpretation in its earlier efforts to implement emissions trading under §111(d).

Hence, there is some precedent for implementing a trading program for existing sources based on performance standards, and EPA has suggested that the program could include new sources. Such an approach provides an incentive for sources to identify and make low-cost emissions reductions beyond those required to meet a strict technology-based standard. It would allow the agency to consider larger reductions in GHG emissions than it would otherwise be able to support, and it would allow the agency to adopt a phased approach with emissions limits tightening over time.

There are disadvantages to performance standards as well. Since NAAQS regulations supersede §111(d) standards, one risk is that courts might require EPA to issue a GHG NAAQS and therefore scrap existing-source performance standards (Richardson 2009). EPA might understandably be concerned about wasting its limited resources on creating a program that could be killed by an indirect legal challenge. Second, performance standards typically are technical and data-intensive, based on a demonstrated control technology. In addition, because these standards are established for source categories that have traditionally been defined for a specific technology and fuel, it may be difficult to expand the regulatory scope to encourage fuel switching. Third, regulation of individual source categories or sectors one at a time will likely result in costlier emissions reductions than could be achieved through an economy-wide trading program. If, for example, EPA were able to reconfigure source categories for GHG to combine industrial boilers and all electricity-generating units within one group, it might be able to allow trading across these sources. But economy-wide emissions trading probably could not be enacted with performance standards. Another disadvantage is that the sectoral approach enables rent seeking because it allows Congress and the regulated entities within the sector to push for leniency.

In general, however, the policy advantages of NSPS for existing sources probably outweigh the drawbacks, so it is not surprising that this program is apparently the agency's choice. But although the agency has begun to develop standards for the first group of GHG source categories by 2012, recent revisions to GHG reporting rules that delay reporting requirements for many sources until 2014 imply that the agency does not plan to implement comprehensive rules for existing sources before that date.

4. Emissions Reduction Opportunities Under CAA

Two critical questions are what emissions reductions would ultimately result from a regulatory approach and how this would compare with legislation.

4.1 Mitigation Options

EPA has identified efficiency improvements as the most attractive short-term mitigation opportunity at existing facilities in most sectors. In a series of technical documents and white papers, EPA (2008a, 2008b, 2010a-e) identifies emissions reduction opportunities that could be used for the determination of BACT, the technology criterion that will be applied for permitting and would likely influence standards for existing sources. Based on these papers and other reports, we estimate the total potential emissions reductions and cost associated with short-term measures. Table 1 summarizes the current GHG emissions as a share of total U.S. inventory for nine sectors that constitute roughly 75 percent of domestic emissions.[5] Reduction potential and cost estimates are available for six of the sectors, which constitute about 62 percent of domestic emissions. In these sectors estimates indicate opportunities to reduce total U.S. emissions by 2.3 to 6.2 percent—up to 10 percent of the emissions from these sectors. This estimate includes some degree of double counting for boilers that operate in the iron and steel and pulp and paper sectors, potentially accounting for up to 0.6 percent of total U.S. emissions. Note that some studies cited rely on old data. Some sectors may have implemented specific measures identified by the underlying studies as available options; however, new measures may be available since the studies were completed.

To determine average gross abatement cost, we compute the average capital and variable cost of a measure in a sector. The average gross costs across the schedule of possible measures for the sector reported in the table are weighted by the measure's abatement potential. These measures are identified by authors or EPA as "cost-effective," meaning that they are zero-cost options for the firm after accounting for the cost of energy saved. These calculations are typically based on engineering costs; the broader set of economic costs such as opportunity cost of

[5] Transportation is excluded. Attribution of percentage of emissions among sectors is based on EPA estimates and incorporate some double counting for boilers.

scheduling investments and alternative use of space and resources are not included. Nonetheless, evidence suggests this range of mitigation options is available at moderate costs to firms.

Those estimates focus only on short-term measures, including energy and process efficiency improvements, beneficial use of process gases, and limited material and product changes throughout the economy. With the exception of biomass cofiring of coal-fired power plants, the estimates include no fuel switching or major process changes; they include new investment only through replacement of outdated and inefficient equipment at existing facilities. Inclusion of technically feasible but not yet cost-effective measures would expand abatement potential substantially. For example, implementing all technically available measures in just the iron and steel, pulp and paper, and cement sectors, which account for just 6 percent of domestic emissions, could reduce total U.S. emissions by more than 1 percent (82 MtCO2e). General technological advance and the development of new regulations including incentives for fuel switching, or increases in energy costs, would further expand the set of cost-effective mitigation options.

In summary, measures are expected to yield emissions reductions up to 10 percent in sectors that have been studied. Only measures found to be cost-effective from an engineering cost perspective are included; additional reductions might be achieved at modest additional costs. However, these estimates do not include the transportation sector, where new efficiency standards largely offset an expected increase in vehicle miles traveled so that emissions levels do not change substantially. Finally, note that these measures do not account for any switching of fuels in electricity generation. A balanced view of these findings indicates plausible GHG emissions reductions under the CAA of up to 10 percent relative to 2005 levels.

The only independent assessment that has looked at potential emissions reductions across the entire economy concludes that reductions of 6 to 14 percent below 2005 levels could be achieved by 2020 (WRI 2010). That study examined a range of implementation scenarios ranging from “lackluster” efforts to “go-getter.” To understand how these estimates can be so uncertain, and the kinds of choices EPA face in implementing the Act, we look in detail at the electricity sector.

Table 1. Emissions Reduction Options and Costs of Identified "Cost-Effective" Measures

Source category	*CO_2e emissions (percentage of U.S. total)*	*CO_2e emissions ($MtCO_2e$)*	*CO_2e reduction (percentage of sector)*	*CO_2e reduction (percentage of U.S. total)*	*CO_2e reduction ($MtCO_2e$)*	*Average gross cost (2008$/$tCO_2e$)***
Iron and steel	1[i]	71	19[ii]	0.19	13	1.54–2.58[iii]
Pulp and paper	1.4–3[iv]	99–212	14[v]	0.2–0.4	14–28	41.06[vi]
Cement plants	2[vii]	141	1–10[viii]	0.02–0.2	1.4–14	—[ix]
Boilers (industrial, commercial, institutional)	20[x]	1411*	1–10[xi]	0.2 – 2*	14–141	0.40–15.37[xii]
Petroleum refineries	3[xiii]	212	1–10[xiv]	0.03–0.3	2.1–21.2	Few cost figures; paybacks 0.5–5 years[xv]
Boilers (electric power)	34[xvi]	2398	5–9[xvii]	1.7–3.1	120–219	—
Coal-fired: efficiency gains	28[xviii]	1975	2–5[xix]	0.56–1.4	39–99	10.74–63.91[xx]
Coal-fired: biomass cofiring			2–5[xxi]	0.56–1.4	39–99	—
Landfills	1.8–2.6[xxii]	127–183				
Petroleum and gas systems	3[xxiii]	212				
Agriculture	8[xxiv]	564				
Totals	74–77%	5233–5402*	N/A	2.34–6.19%*	165–437	N/A

Note: References are listed at the end of the document. Specific measures identified may have already been implemented.

*Boilers double count emissions and reductions, potentially overstating total reductions by up to 0.6% (see text).

**Average cost does not include the cost savings from reduced energy use that make the listed measure cost effective from an engineering cost perspective (see text). Ranges indicate costs in different processes used in the sector.

4.2 The Electricity Sector Example

Coal-fired electricity generation deserves special attention because it represents 50 percent of electricity generation, 80 percent of GHG emissions from electricity, and 33 percent of emissions nationally (EIA 2009). Existing sources in the electricity sector are likely to constitute the majority of emissions in the sector for decades.

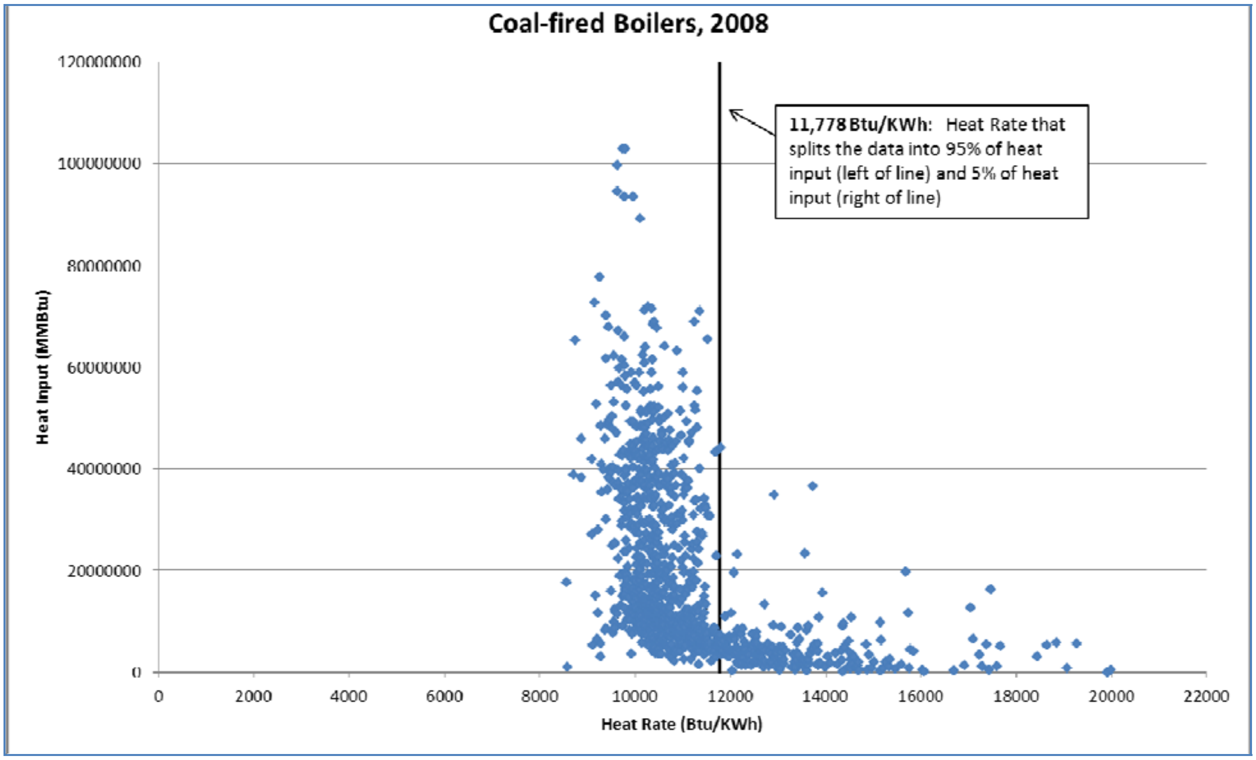
Large emissions reductions from the electricity sector would require fuel switching from coal to natural gas or nonemitting generation sources, or the introduction of postcombustion controls to capture carbon. However, CAA regulation is likely to start with opportunities for efficiency improvements at existing facilities.

4.2.1 Efficiency Improvements at Coal-Fired Power Plants

Based on analysis of the U.S. coal fleet, Figure 2 indicates that opportunities for efficiency improvements appear to be available. The figure displays the heat rate (i.e., operating efficiency) of existing coal-fired plants along the horizontal axis.[6] The vertical axis is heat input (i.e., fuel use) at each facility. As one might expect, the most heavily used plants are among the most efficient, with heat rates less than 10,000 Btu per kilowatt-hour (kWh) of electricity generation. However, the figure displays a substantial right-hand tail, with many facilities that appear to be efficiency outliers.

[6] This analysis uses data on existing coal-fired electricity-generating units in the lower 48 states during 2008 from the Energy Information Administration's form 923 (previously form 767). This government-mandated survey collects boiler- and generator-level information from steam electric power plants with nameplate capacity greater than 10 megawatts (MW). The EIA-923 provides reported annual and monthly fuel quantity, fuel heat content, and generation for each unit. Heat input is obtained by multiplying the quantity of fuel used at a unit by the fuel's heat content. Heat rates are heat input divided by generation. All units that generated electricity from coal during 2008 were included in the data set; however, this includes some generation from other fuels. Observations with heat rates less than 8,500 Btu/kWh or greater than 20,000 Btu/kWh were dropped from the analysis because these are likely due to errors in the data. The dropped values represent less than 1 percent of total heat input.

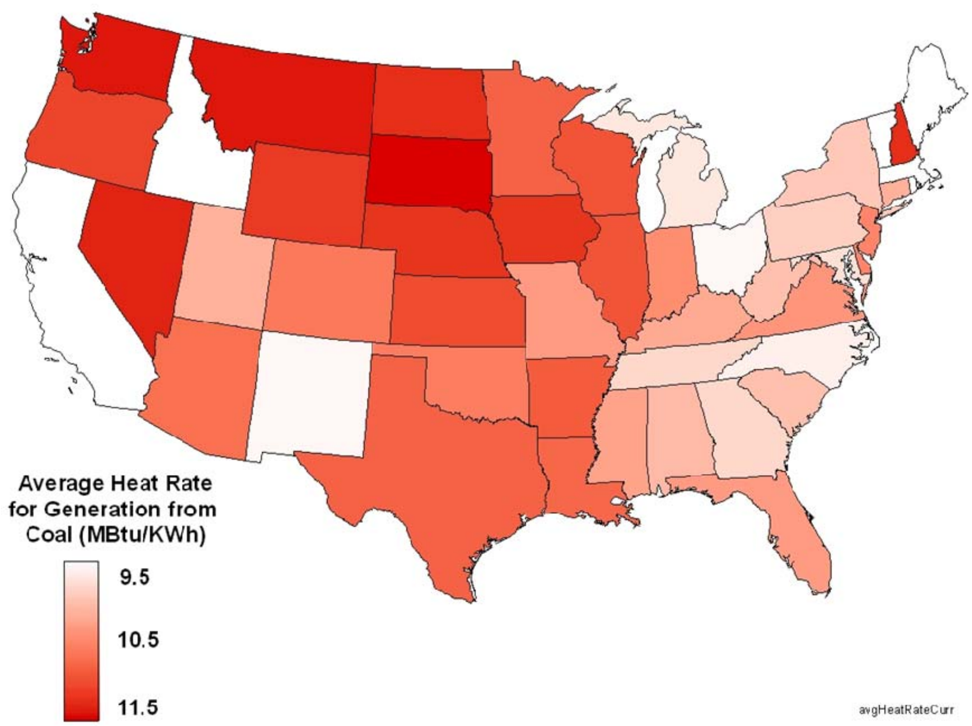
Figure 2. Coal Steam Units—Heat-Input Weighted Heat Rates



Plant operators already face an incentive to reduce operating costs through reduced fuel use; hence, one might expect that the distribution of heat rates would have an obvious technical explanation. For instance, heat rates might be expected to vary across technology, vintage, or fuel type. However, qualitative and preliminary statistical analysis described in Richardson et al. (2011) indicates that these factors do not strongly predict the distribution in heat rates across plants. The four most important types of boilers—tangentially fired, wall-fired, cyclone, and fluidized bed—share similar distributions of heat rates and have similar right-hand tails. Although the least efficient units are somewhat older than the fleet as a whole, the distribution by vintage overlaps for the most part. An important fraction of relatively high-emitting lignite and waste coal is used at these least efficient units, but these types of coal account for only a small portion of heat input at those units. Other coal types are used much more extensively and in rough proportion to the national average.

If technology, vintage, and fuel type do not explain most of the heterogeneity in operating performance at coal plants, one might consider other factors. One institutional factor is the prospect that modifications to improve efficiency might trigger NSR permitting for other pollutants that could be time consuming and costly. Consequently, facilities might delay such modifications. However, the regional variation suggests that this is not the primary cause of heterogeneity. NSR is based on national standards (though it is implemented by states), but Figure 3 indicates the least efficient units are not distributed evenly.7 The darker-shaded states have higher average heat rates, meaning that more coal is used—and more CO2 emissions result—per unit of electricity generated. Note that regions of the country often associated with heavy coal use—the Midwest, the Southeast, and Appalachia—are not those with the greatest average heat rate. A priori it is not evident why anticipation of NSR enforcement would have a greater effect in parts of the country with relatively less coal use.

Figure 3. State-Level Average Heat Rate Map



[7] This map uses data on existing electricity-generating units in the lower 48 states during 2007 based on units included in the Energy Information Administration's *Annual Energy Outlook 2009*. For each of these units, additional information on efficiency is drawn from EPA's Continuous Emissions Monitoring Database and the National Electric Energy Data System (NEEDS).

Two other factors appear statistically more important in preliminary analysis. One is the delivered cost of coal. The region of the country with less efficient facilities appears to be the region with relatively lower coal cost, and this holds up in ordinary least squares analysis. If this is a robust result, it indicates that a cap-and-trade program that introduced a price on CO_2 emissions would likely be effective in achieving improvements at the least efficient plants. In this case, a regulatory approach under the Clean Air Act might be less cost-effective.

The other factor that appears significant is the ownership structure of the firm. Independently owned (merchant) plants tend to be the most efficient, and investor-owned utilities tend to be slightly less so. However, both types of plants appear to be substantially more efficient than publicly owned plants, which are predominantly found in regions with the least efficient plants. Another institutional factor is fuel cost adjustment clauses that allow for the automatic pass-through of fuel cost into rates (NETL 2010). Such provisions eliminate risk of price fluctuations; unfortunately, they may also remove incentives to harvest low-cost efficiency improvements.

If ownership structure and the state-level regulatory environment are the main explanation for the heterogeneity in operating efficiency among plants, then a regulatory approach under the act might actually be more effective (relative to legislative cap-and-trade) at achieving improvements in energy efficiency. This is in part because performance standards can elevate the visibility of efficiency within the firm and to utility regulators.

Whatever the cause for the heterogeneity in operating efficiency of existing units, a performance standard would achieve some emissions reductions at modest cost. However, a tradable performance standard that limits the average emissions rate across all regulated entities should do even better. Under a tradable standard, each source would be allowed emissions up a certain level of CO_2 per kWh of electricity production (or million Btu of fuel use). A source could comply with this restriction either through improvement at its own facility or through the purchase of emissions reductions from other regulated sources. This type of flexibility would allow the regulated sector to take important steps toward a cost-effective distribution of emissions reductions.

4.2.2 Biomass Cofiring

Biomass can be mixed with coal and fired in a conventional boiler. The amount of biomass varies with the boiler type but can be roughly 10 percent of the heat input at a plant. If one considers biomass to be roughly CO_2 neutral, the substitution of biomass for coal leads directly to net emissions reductions. EPA (2008a) has reported that cofiring with biomass might replace 2 to 5 percent of the coal used by the industry. However, because biomass availability varies by region, a flexible trading approach (with credit for biomass) would be required to take advantage of the GHG emission reductions from cofiring.

4.2.3 Plausible Total Emissions Cuts from Coal

To summarize the evidence, EPA has identified a potential 2 to 5 percent reduction from heat rate (efficiency) improvements and an additional emissions reduction of 2 to 5 percent for the cofiring of biomass at coal-fired power plants. We believe a flexible performance standard under §111(d) could therefore capture a potential reduction of 5 to 10 percent in GHG emissions from coal—as much as about 3 percent of total U.S. emissions—without changing the level of electricity generation. There is reason to believe that such modest regulation would have modest costs compared, for example, with the marginal costs that would have been incurred under the proposed Waxman-Markey legislation (Sargent & Lundy, L.L.C. 2008; EIA 2008). Because efficiency improvements and biomass cofiring would very likely be among the first moves made by coal plants under any CO_2 price, it is unlikely that requiring these moves through regulation would result in comparatively higher costs than would a legislatively mandated cap-and-trade program, at least over the first few years.

4.2.4 Ancillary GHG Reductions from Other CAA Regulations

At the same time that regulations for GHG are emerging, EPA is moving forward with an ambitious agenda of rulemaking to address criteria pollutants (e.g., ozone and particulate matter, PM), air toxics (e.g., mercury), and other environmental concerns that could require substantial additional capital investment at coal-fired power plants. These ancillary regulations are likely to affect many inefficient coal-fired plants that will also be a target of regulations to reduce GHG emissions. The substantial investments required to comply with these rules, coupled with EPA efforts to regulate carbon emissions, leave the industry with a difficult choice: risk “stranding” of investments by future carbon regulations, or retire a substantial amount of coal-fired capacity. These other regulations could therefore achieve substantial collateral reductions in GHG emissions from stationary sources even without specific EPA GHG rulemaking under the CAA.

5. Comparing CAA Regulation with Alternatives

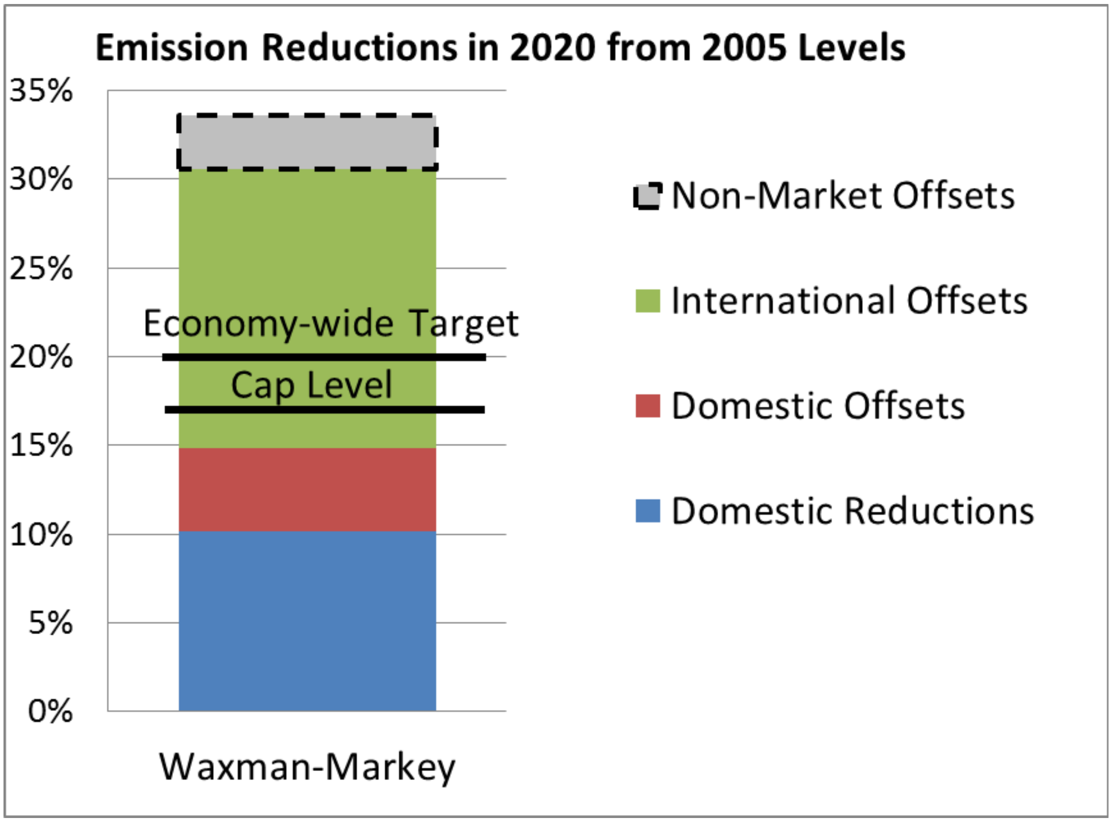
At the Copenhagen climate meetings in December 2009, President Obama pledged the United States to emissions reductions “in the range of” 17 percent below 2005 levels by 2020. At the time, the President rested hopes for meeting this goal on comprehensive cap-and-trade legislation. The Waxman-Markey legislation that passed the House in June 2009 set a domestic target of 17 percent reductions by 2020, with an additional 3 percent anticipated from international forestry projects. The legislation proposed by Kerry-Boxer in the Senate set a domestic target of 20 percent reductions. Most observers question whether the CAA is capable of achieving emissions reductions of this magnitude without any legislative changes. But before comparing what might be possible under CAA with what was expected to occur under those bills, it is useful to understand the nature of reductions that would have been achieved through legislation.

5.1 The Legislative Baseline

We use the Waxman-Markey bill as the legislative baseline because it is the most studied example of (nearly) politically acceptable climate legislation. Figure 3 illustrates the Energy Information Administration (2009) estimate that, if one accounts for offsets and contributions to the allowance bank, the expected emissions reductions under the bill approach 33 percent from 2005 levels by 2020. But reductions from regulated domestic sources were expected to account for only 10 percent from 2005 levels. Another 5 percent was expected from domestic offsets. Over 15 percent more was expected from international offsets—a policy tool unavailable under the act (Richardson, 2010).

Banking of allowances also clouds assessment of emissions reductions under legislation. Banking reduces short-term emissions, though it has no effect on long-term emissions unless emitters keep a perpetual reserve or allowances are later devalued or confiscated by regulators. If one does not consider contributions of emissions allowances to the bank, the Waxman-Markey cap-and-trade program was projected to achieve permanent domestic emissions reductions equal to 6 percent below 2005 levels after adjusting for banking. In contrast, under the CAA even if regulation includes some form of trading it may not include banking provisions, for either policy or legal reasons.

Figure 3. Emissions Reductions under Waxman-Markey



It is largely a matter of perspective which benchmark one chooses: emissions reductions under Waxman-Markey of 33 percent, the President's stated target of 17 percent, or domestic reductions of 10 percent (6 percent if adjusted for the bank). These different benchmarks are important to keep in mind when evaluating the strictly domestic emissions reductions that might be achieved under CAA.

5.2 CAA Regulation Over the Short and Long Run

In summary, for the next decade or so it appears a regulatory approach could achieve emissions reductions through mitigation in the domestic economy of up to 10 percent, relative to 2005 levels. These reductions would be comparable to domestic reductions that would have been achieved under the legislative cap-and-trade proposal. Some cost-effective mitigation measures would be missed, but other measures that might not be captured through cap-and-trade could be captured by regulation. In general, one cannot expect a regulatory agency to do as well as incentive-based regulation at identifying low-cost opportunities for emissions reductions because the agency does not have the same information as do private decisionmakers.

However, EPA may be able to identify most of the low-hanging fruit that could yield emissions reductions in the near term and may propose regulations mandating these measures. It may not matter much if the regulator makes some mistakes by mandating measures that are out of order from a cost-effectiveness perspective if the program becomes more stringent over time, because all the measures that the regulator mandates would soon be adopted anyway. This was the experience, for example, with the three-phase emissions reductions required by the Northeast Ozone Transport Region program. A cost-effective ordering might have introduced certain controls at some heavily utilized plants even during the first phase of the program and postponed other measures at less utilized plants until later. Nonetheless, under the trading program, ultimately all facilities would have implemented low-NO_x burners as the emissions caps tightened. Consequently, the unnecessary cost of the restrictive program in the first phase of the program was probably not very significant.

Over time, as standards are tightened, more and more daylight is likely to appear between the choices a regulator would make and the investments that firms would make under an incentive-based program. After the low-hanging fruit has been picked, the regulator may not be able to see additional measures as clearly as firms can given private, idiosyncratic information about technological options. In the long run, choices made by the regulator are likely to be less cost-effective. Moreover, a regulatory approach is likely to lead to less innovation, and different innovation, than would occur under a flexible incentive-based program. These factors combine to suggest that the greatest efficiency cost under CAA comes not with the first several years of regulation, but rather in the long run.

One partial remedy to that shortcoming would be the introduction of incentive-based approaches under the Act, which as we note may be possible but would face legal challenges, depending on the strategy employed by EPA. The limited nature of incentive-based approaches that are plausible under the CAA means that they would extend the time period over which costs are comparable to a comprehensive carbon price, but they could not do so indefinitely. Without new tools, regulators can do only so much within the current legal constraints.

Conversely, it is implausible to assume that climate legislation would be perfect: because of political compromises, it will surely be more expensive and less effective than theory suggests. A regulatory approach has serious shortcomings that become increasingly apparent over time, but it should be compared with plausible alternatives, not idealized policy.

5.3 Getting the Prices Right

Economists advocate an incentive-based approach to environmental regulation in part because it can "get the prices right" by internalizing the full social costs of economic activity into product prices. By doing so, the incentive-based approach promises not only to identify cost-effective mitigation actions but also to promote efficiency in the allocation of resources throughout the economy. If price signals internalize full social costs, then consumers have information that will help them make investment decisions in—for example—new cars and air-conditioners that balance energy efficiency with other product characteristics.

In the near term, EPA is likely to pursue measures that impose resource costs associated with mitigation activities on firms through performance standards, but these standards will not reflect the social cost of remaining emissions via a price signal for consumers, as might cap-and-trade or an emissions fee (Fischer 2003). In this regard, therefore, EPA regulation may perform poorly relative to a legislative cap-and-trade approach.

Once again, however, it is essential to compare CAA regulation with its practical legislative alternative rather than with idealized policy. The possible outcomes are summarized in Table 2. Under the major legislative options considered by the last Congress, emitters would face a price for their emissions, but those price changes would not immediately be passed downstream to other producers and consumers. The proposed Waxman-Markey legislation that passed the House and the Kerry-Boxer proposal in the Senate would have delayed for nearly two decades the introduction of changes in most product prices associated with the value of emissions allowances for downstream consumers. For instance, 39 percent of emissions allowances would be distributed for free to electricity and natural gas local distribution companies (LDCs) through 2026, finally phasing out by 2030. Since LDCs are rate-regulated, they could be expected to use the allowance value to offset most of the changes in energy prices in the wholesale power market under cap-and-trade. Consequently (and by design), consumers would not see an increase in prices that reflected social costs; rather, they would see an increase equivalent only to the resource costs used to achieve emissions reductions, which was expected to be just 14 percent of the price change that would otherwise occur in the electricity sector (Burtraw et al. 2009).[8]

[8] Spulber (1985) illustrates why efficient investment and utilization of resources in the long run require consumers to see the full social cost of emissions trading programs.

Table 2. Economic Performance of Approaches

	Clean Air Act			Waxman-Markey
	Prescriptive regulations	Single source category tradable performance standards*	Inter source category tradable performance standards	Cap and trade
Short-term cost effectiveness	Maybe	Probably	Probably	Probably
Long-term dynamic efficiency and innovation	Unlikely	Maybe	Probably	Yes
Prices right for emitters	No	Maybe	Probably	Yes
Prices right for consumers	No	No	No	Unlikely until 2030

* This might include trading across source categories within the electricity sector.

Prices also would not rise substantially for products from the group of energy-intensive, trade-exposed industries that would receive 15 percent of total allowances under Waxman-Markey. This allocation was intended to guard against unfair competition from countries that were not regulating GHG emissions by providing an output subsidy, leading to expanded production in these sectors and offsetting much of the increase in variable cost that otherwise results from cap-and-trade (Fischer and Fox 2007).

Although it is important to get the prices right throughout the economy, most of the efficiency gains in the near term will come when emitters face the correct prices (Parry and Williams 1999). The proposed legislation would capture these gains because it would ensure that emitters faced a price of emissions; this would not occur under prescriptive regulation. However, incentive-based regulation, such as the tradable performance standard discussed above, would also create an emissions price. But even in this case, overall costs would likely be higher because separate programs would impose higher costs than necessary for some sectors and forgo opportunities for low-cost emissions reductions in other sectors.

EPA could, for example, develop tradable performance standards across existing source categories in the electricity sector, perhaps by defining a new source category for CO_2 that included all fossil-fired generation (or fossil-fired steam generation). Alternatively (and more boldly from a legal perspective), EPA could identify a cap-and-trade program as the "best system" of emissions reductions for the sector. This would be distinguished from a tradable performance standard because it would cap the total emissions from the sector, and it would require an allocation of emissions allowances to sources, which under the CAA would be the prerogative of states. Either approach would expand the set of emissions reduction opportunities for the sector, probably allowing substantially greater reduction options at low cost. But harmonization of marginal costs across the economy would only be possible if EPA utilized a broad-based tradable performance standard (or cap-and-trade program) that reached across many sectors, not all of which can plausibly be regulated under the CAA.

Even with incentive-based regulation, the CAA would limit the coverage of the program. For example, a CAA-based approach is limited to emissions activity inside the fence line at covered facilities; EPA regulations probably cannot give credit for measures taken outside the facility, such as transmission line upgrades, investments in renewable energy, or end-use efficiency programs.

Furthermore, for a variety of reasons, incentive-based mechanisms are widely thought to do a better job of promoting innovation in production processes than prescriptive regulation, with this advantage growing over time (Kneese and Schultz 1975; Milliman and Price 1989). But unlike legislative cap-and-trade, even tradable performance standards are not expected to provide adequate incentives for innovation and technology adoption for end-use efficiency improvements because downstream product prices change little under this type of regulation (Burtraw et al. 2006). The cost resulting from the failure to get the prices right for consumers would increase in the long run as they make decisions about the purchase of new household capital without accurate information about social costs.

6. Implementation

Beyond the theoretical advantages and disadvantages of a regulatory program, there are important implementation issues, including the role for states, enforcement, and legal viability.

6.1 The Role for States

Under legislative proposals, EPA would have primary responsibility for implementation and enforcement, with some responsibilities delegated to other agencies—for example, the Department of Agriculture would have regulated agricultural offsets. Under most CAA programs, and especially under the NAAQS or performance standards, states have the primary implementation and enforcement role for existing sources. But, the EPA has oversight responsibility and must implement the program where states decline to assume responsibility for implementation and enforcement.

Under the CAA, states also have had a role in determining whether incentive-based approaches, such as tradable performance standards or cap-and-trade, can be used to achieve emission reduction goals. If a CO_2 cap-and-trade program emerged under the CAA, the allocation decision would be the prerogative of the states. Allocation was a federal matter under most legislative proposals. It is noteworthy that the authority to assign value associated with environmental regulation traditionally has been the prerogative of the states, exercised through various permitting procedures (Burtraw and Shobe 2009). States also allocate emissions allowances under the NO_x budget program (which was initiated under NAAQS authority) and most other previous trading programs. The only exception to this rule is the Title IV sulfur dioxide (SO_2) program, where allocation was explicitly set by the 1990 CAA amendments. EPA's recently proposed Transport Rule also would reserve allocation decisions for the agency itself.

In the near term, one of the most important questions is how EPA will accommodate existing state cap-and-trade programs in the Northeast (the Regional Greenhouse Gas Initiative) and in California (slated to begin trading in 2010). States in the Western Climate Initiative and Midwestern Accord also have begun to implement cap-and-trade. These states have argued that their efforts should be treated as equivalent to actions under the CAA. If some states successfully petition to have their trading programs accepted as a sufficient substitute for EPA's program, it could leave the door open for expansion of trading programs by other states (Litz et al. 2011).

Moreover, companies in other states facing inflexible and potentially more costly regulatory measures under the CAA might advocate for flexible state programs. In this sense, suboptimal federal regulation might lead to more efficient state regulation. The result might be a mosaic of programs across the states that, while not optimally efficient, could capture most cost-saving opportunities.

6.2 Potential Challenges to CAA

The Waxman-Markey and Kerry-Boxer bills would have preempted or precluded major elements of EPA authority to regulate GHGs. Climate policy in general and the CAA specifically both have their share of opponents who may seek blocking legislation or pursue litigation against the agency. Given these challenges, what are the Act's chances of success?

The most immediate threat to CAA authority is likely to come from direct legislative challenge. This might be accomplished through overturning of regulations under the Congressional Review Act, through legislative preemption, or through defunding of EPA activities through riders to appropriation bills.

These challenges are serious but at this time seem unlikely to be successful. First, President Obama has stated he would veto legislation that undid EPA authority without putting something new in its place—though this does imply that compromise is possible, perhaps as a part of broader energy legislation. The CAA has withstood many challenges over its lifetime and remains broadly popular legislation that is credited with substantially improving the nation's air quality. Moreover, if the EPA activity were defunded, private lawsuits against the agency might create a legal entanglement. Rather than reducing uncertainty associated with new source permitting, this could increase it, with an adverse effect on investment.

There are other plausible threats to EPA's efforts to enforce the Act. For example, a court-ordered requirement for a NAAQS for GHGs is a long-term possibility (Richardson 2009). If that happens, EPA's efforts to develop a regulatory approach under NSPS for existing stationary sources would be undone, unless Congress stepped in to resolve the issue.

6.3 Is There an Opportunity for Emissions Trading under CAA?

EPA's ability to use market-based approaches is of special interest to economists. Vehicle fuel economy standards create some flexibility, but emissions from existing facilities offer the greatest opportunities for efficiency gains because of the heterogeneity in emissions and costs (Newell and Stavins 2003). The lead phase-out in the 1980s is an example of a tradable performance standard implemented under the mobile source provisions in Title II of the CAA. NAAQS regulation allows emissions trading, as illustrated by the regional NO_x budget program and various emissions reduction credit trading programs. There is also limited precedent for trading under §111. Although the statute appears to be sufficiently flexible to incorporate a market-oriented mechanism, EPA might be limited by both legal and policy considerations.

Two recent decisions have hampered agency rules that would have implemented trading programs for other pollutants. First, the Clean Air Mercury Rule, which would have introduced a trading program for mercury under NSPS §111(d), was overturned by the D.C. Circuit Court in *New Jersey v. EPA*.[9] However, that decision has little bearing on the use of this section to introduce trading because the court never reached the issue before overturning the rule on other grounds (though it was briefed).

Second, trading provisions in the agency's 2005 Clean Air Interstate Rule were challenged. The rule was issued under NAAQS authority and would have modified the SO_2 trading program and introduced a new program for NO_x trading. The D.C. Circuit Court remanded the rule to EPA, leaving the rule in place but directing the agency to revise it substantially.[10] This decision also has no bearing on the permissibility of trading under performance standards, however, since it hinged on interpretation of language elsewhere in the act (specifically, the NAAQS). The major problems identified by the court—the rule's inability to guarantee prevention of contributions to downwind pollution levels and its interference with the Title IV SO_2 program created by Congress—are not relevant in the GHG context.

At this juncture, the chief air officer for EPA has stated that its planned regulation will not involve federal cap-and-trade, but this leaves open two other options that involve some degree of trading. One is that the CAA could allow for tradable performance standards. The second is that EPA could sanction state and regional trading programs as adequate substitutes for federal CAA rules. These will be crucial decisions to watch for.

7. Research Agenda

The new direction for climate policy opens up questions that have been largely absent from the research agenda in economics for the past several years.

One task is to understand and explain the magnitude of heterogeneity in the operating efficiency of industrial facilities, power plants, and buildings in the United States. At first glance, heterogeneity among these facilities would appear to represent opportunities to achieve reductions in GHG emissions. To the extent these opportunities can be readily identified, they may be low-hanging fruit reachable via regulation, especially if improving operating efficiency

[9] 517 F.3d 574 (D.C. Circuit 2008).

[10] *North Carolina v. EPA*, 531 F.3d 896 (D.C. Circuit 2008).

brings such other benefits as reduction in conventional pollutants or lower variable production costs. To find the best remedy, one must understand why these improvements have not already occurred. If heterogeneity is driven by differences in relative prices, then incentive-based approaches would have a strong advantage because they leave discretion to the firm about whether and how to respond to the incentives. On the other hand, if heterogeneity is due to institutional factors, then regulation may have the advantage, in that it may slice across the institutional setting to force improvements.

We also need to understand the institutional and legal constraints that shape the way policies actually will be implemented. Instrument design for policies such as cap-and-trade has been well studied, but little effort has been given to comparing real-world, second-best policy implementation of such policies with regulatory alternatives. The choice of policies under the CAA is governed largely by considerations of legal risks. Little analysis exists about the economic benefits of different approaches under the CAA, and this information will be valuable to EPA policymakers and others who seek to balance risks with rewards within the regulatory framework.

8. Conclusion

We see substantial opportunities under the Clean Air Act for domestic emissions reductions that can be achieved at what will probably be moderate cost. However, enthusiasm about the act as a vehicle for carbon regulation should be tempered. First, this paper suggests that achieving meaningful emissions benefits at reasonable cost is possible, but it will require EPA to be bold. The agency must interpret sections of the act to enable use of flexible mechanisms, must be ambitious in setting emissions targets, and must shift its focus to a new regulatory program. In short, to do all of this well, the agency will need to innovate. For an agency scarred by defeats in recent court battles, there may be little appetite for such ambition.

Second, EPA action under the CAA is inferior to new legislation from Congress, especially over the long term. Although it is possible to identify some readily available opportunities for emissions reductions and push them via regulation (with market tools to keep costs down), it quickly becomes difficult to identify what steps should be taken next. A carbon price (either cap-and-trade or a carbon tax) created by legislation would allow the market to make these decisions. Comprehensive climate legislation could also establish a uniform carbon price across sectors, provide for international offsets, create greater opportunities for innovation, and include other cost-saving mechanisms that the Clean Air Act cannot provide. Congress can also make political trade-offs between various interest groups that stand to lose or gain from carbon regulation, can take measures to protect trade-exposed industries, and can be bold without inviting litigation. It will be difficult for EPA to do any of these things with its current tools.

With those reservations, however, the Clean Air Act—if used wisely by EPA—can be a useful vehicle for short-term greenhouse gas regulation. Given the inertia in Congress, that is good news. Not everyone agrees, of course; members of Congress from both parties have introduced measures to block EPA action on carbon under the Clean Air Act. But so far none of these proposals have succeeded. Until and unless this changes, the CAA is the law, and is therefore a tool EPA is required to use. Fortunately, it also appears to be an effective one, at least over the short term.

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Notes to Table 1

[i] EPA 2008a, p. 26.

[ii] These reductions are deemed cost-effective using cost of conserved energy (CCE) as the marginal cost cutoff. For integrated steel mills, the CCE used was 2.03 $/GJ; for secondary steel mills, 2.83 $/GJ (1994 dollars).

[iii] Lower bound is average cost of abatement for integrated steel production; upper bound is average cost of abatement for secondary steel production. The abatement cost was calculated using measures deemed cost-effective through cost of conserved energy (Worrell et al. 1999).

[iv] EPA 2010d, p. 7.

[v] These reductions are deemed cost-effective using cost of conserved energy (CCE) of 3 $/GJ (1994 dollars) as the marginal cost cut-off (Martin et al. 2000).

[vi] Average abatement cost was calculated using measures deemed cost-effective through cost of conserved energy (CCE). Estimated abatement cost of these cost-effective measures ranges from –16.81 to 106.50 $/tCO2 (1994 dollars) (Martin et al. 2000).

[vii] EPA 2008a, p. 22.

[viii] Regulating Greenhouse Gas Emissions under the Clean Air Act; Proposed Rule, 73 Federal Register 147 (July 30, 2008), p. 44354-44520.

[ix] Capital costs and operating costs ($/ton CO2e) are included in Table 3 of EPA 2010c.

[x] EPA 2008a, p. 13.

[xi] EPA 2008a, p. 13.

[xii] These cost projections were made using three control measures from Table 1 of the EPA white paper on industrial, commercial, and institutional boilers (EPA 2010a). Assumptions include a capital charge of 10 percent, emission factor of 93.98 kgCO_2/MMBtu for coal and 53.06 kgCO_2/MMBtu for natural gas (also from EPA 2010a), and capacity factors ranging from 0.35 to 0.75.

[xiii] EPA 2008a, p. 18.

[xiv] EPA 2008a, p. 19.

[xv] EPA 2010b.

[xvi] EPA 2008a, p. 15.

[xvii] EPA 2008a, p. 17.

[xviii] Calculated from EPA 2010e.

[xix] EPA 2008a, p. 16.

[xx] Calculated using figures from Sargent & Lundy, L.L.C. (2009) for measures (and associated heat rate reductions/costs). All calculations performed for a 500 MW coal plant with a 70% capacity factor, using a 10% capital charge. Delta heat rate and cost assumptions are taken from Sargent and Lundy (2009). When ranges were given, optimistic and pessimistic scenarios were developed: lower bound represents optimistic scenario; upper bound represents calculations from pessimistic scenario.

[xxi] EPA 2008a, p. 17.

[xxii] Calculated from EPA 2008a, p. 32, table.

[xxiii] EPA 2008a, p. 29.

[xxiv] EPA 2008a, p. 36.