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Issues in Designing U.S. Climate Change Policy

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RESOURCES FOR THE FUTURE

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Abstract

Over the coming decades, the cost of U.S. climate change policy likely will be comparable to the total cost of all existing environmental regulation—perhaps 1–2 percent of national income. In order to avoid higher costs, policy efforts should create incentives for firms and individuals to pursue the cheapest climate change mitigation options over time, among all sectors, across national borders, and in the face of significant uncertainty. Well-designed national greenhouse gas mitigation policies can serve as the foundation for global efforts and as an example for emerging and developing countries. We present six key policy design issues that will determine the costs, cost-effectiveness, and distributional impacts of domestic climate policy: program scope, cost containment, offsets, revenues and allowance allocation, competitiveness, and R&D policy. We synthesize the literature on these design features, review the implications for the ongoing policy debate, and identify outstanding research questions that can inform policy development.

Key Words: cap-and-trade, carbon tax, cost containment, competitiveness

JEL Classification Numbers: Q48, Q54, Q58

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Joseph E. Aldy and William A. Pizer*

Introduction

Around the world, interest is growing in designing and implementing mandatory, domestic, market-based climate change policies. The European Union launched the Emission Trading Scheme (ETS) in 2005 covering roughly half of all carbon dioxide (CO_2) emissions in the EU and announced its intent to continue the ETS beyond the Kyoto Protocol's 2008-2012 commitment period (European Commission 2008). The EU has linked and is pursuing linking its trading regime with other domestic cap-and-trade programs, including those in Iceland, Norway, and New Zealand. With the election of a new government in late 2007, Australia is moving forward with plans for a domestic cap-and-trade program. In the United States, with twelve proposals for mandatory climate regulation in the 109th Congress and nearly that many again in the first session of the 110th, momentum continues to build for federal action (Table 1). Trends at the state and regional level, including California, New England and the mid-Atlantic states, reinforce this effort through their own calls for mandatory policies.[1] Several governments have pursued carbon taxes, including in Costa Rica and British Columbia.

The design of domestic climate change policy has important environmental, energy, economic, and fiscal implications. Mitigating greenhouse gas (GHG) emissions is a critical element in addressing what is widely believed to be the most pressing environmental problem of the 21st century. Over the long term, climate change policy may radically alter how fossil fuels power industrialized economies. Climate change policy will affect more firms and households and impose greater costs and greater benefits than any environmental policy to date. The costs of domestic GHG mitigation policy—perhaps 1-2 percent of national income—may be roughly comparable to all other environmental policies combined.[2] Finally, market-based approaches to

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[1] See Arimura et al. (2007) for a recent description of U.S. policy developments.

[2] For example, several Congressional proposals call for emission targets through 2050 that fall between two illustrative policy scenarios evaluated by Paltsev et al. (2007) with the MIT EPPA model, which yield economic losses of 1.45 and 1.79 percent of GDP in 2050. More stringent emission goals or cost-ineffective policy implementation could substantially increase costs.

climate change provide the opportunity to generate government revenues of the magnitude comparable to other large streams of revenues, such as the corporate income tax.[3]

With the potential for such far-reaching effects, it is important to consider several key questions to frame the evaluation of various domestic cap-and-trade or emissions tax proposals. Will these proposals promote efficiency by addressing climate change in a manner sensitive to costs and benefits? Will these proposals employ cost-effective implementation so that they achieve their stated emission reduction goals as inexpensively as possible? How will these proposals affect the distribution of benefits and costs across the U.S. economy?

The first question—will these proposals promote efficiency by balancing costs and benefits—is the most difficult for economic analysis. The significant uncertainty and long time horizons associated with mitigation benefits challenge underlying assumptions in conventional economic analysis. For example, a standard and sensible condition is that consequences further and further into the future, and/or with smaller and smaller probabilities, should not dominate our analysis. Otherwise, we find ourselves trying to model and forecast events sufficiently rare and/or distant that conventional tools are rendered useless (Weitzman 2007).

Even keeping the standard assumptions, putting the pieces together for a benefit-cost analysis is daunting. Nordhaus (2007) finds that an optimal global emissions pathway would result in a doubling of CO_2 concentrations. Supporting this conclusion are assumptions about various climate impacts, their valuation in multiple regions around the world, and the choice of discount rate to convert these estimates into present value terms. Yet, having employed benefit-cost analysis for the management of a global public good, we are still left with several more challenges in evaluating *national* policies. First, a global benefit-cost analysis does not provide guideposts on how to divide costs among countries; for example, will developing countries pay according to the same rules as industrialized countries? Second, national policies may involve a more provincial attitude to benefits, where those benefits accruing to other countries are not counted the same; this requires additional information than the global analysis. Finally, regardless of how any single country chooses to answer the first two challenges in developing a national policy, they must confront the fact that every other country will be doing the same

[3] Corporate income taxes generate around $350 billion in revenue each year.

thing—creating the potential for strategic behavior by some countries to free-ride on others' actions.[4]

Given the difficulties of applying economic analysis to the first question of balancing benefits and costs, we focus our attention primarily on the latter questions of cost effectiveness and distribution. We have identified the following six design issues to inform the consideration of these questions: (1) program coverage and scope; (2) cost containment; (3) use of offsets; (4) revenues and allowance allocation; (5) mechanisms to address competitiveness concerns; and (6) complementary R&D and technology policies. This paper synthesizes the literature on each of these design issues and highlights the implications for building a robust, efficient climate policy that can appropriately address distributional issues identified by policymakers. We draw on the suite of proposals in the 110th session of the U.S. Congress to emphasize the practical nature and range of these choices (summarized briefly in Figure 2 and Table 1). Where relevant, we assess the need for additional analysis and research to better inform policy-making. We conclude by emphasizing the key messages that emerge from the synthesis in light of these design issues.

Program Coverage and Scope

Greenhouse gas emissions occur as a by-product of virtually every form of economic activity. More than 80 percent of U.S. emissions arise from fossil fuel combustion (coal, oil, and natural gas) from an extremely wide range of sources: large power plants and industrial facilities; homes, businesses, and commercial buildings; agriculture and other small businesses; and automobiles and other modes of transportation. The remaining sources include fugitive emissions of nitrous oxide and methane from agriculture, and industrial releases of fluorinated gases and nitrous oxide (US EPA 2008). Given this remarkable breadth of the cause of climate change, a cost-effective and efficacious emission mitigation policy should exploit emission abatement opportunities among as many of these sources as possible.

The economic literature has generally supported as broad a single-price policy as possible. This follows from application of Samuelson's (1954) basic result that a public good—or bad, such as GHG emissions—should be priced at its marginal social benefit. Numerous

[4] Contrast the Stern Review (Stern 2007), which did not incorporate strategic behavior in its assessment of climate damages and costs of mitigating much of the forecast climate change, with Carraro and Siniscalco (1993) and Barrett (1994) and other game-theoretic papers building on this work (Carraro and Galeotti 2002 provide a review of this literature).

studies have empirically considered how non-price policies lead to much higher costs (Tietenberg 1985). A ton of CO_2 makes the same contribution to climate change regardless of the location of emissions in the world. For emissions of other GHGs, they will generally have different radiative forcings and different atmospheric lifetimes; however, their global warming potential (GWP) can be converted to "equivalent" CO_2 units (IPCC 2001).

The issue of non-CO_2 gases is not without controversy, however, as the GWPs are sensitive to assumptions about damages, discounting, and time horizon (Schmalensee 1993). For example, methane has an extremely high GWP according to the IPCC—23 times CO_2 by weight—but also has a very short half life. This raises the question: Are we comfortable trading off one ton of methane against 23 tons of CO_2, given the methane would have been scavenged from the atmosphere and have no discernible climatic effect several decades from now, presumably when we are really beginning to care about impacts? Meanwhile, the 23 tons of CO_2 would have decayed very little. Despite this question, most discussions of climate change economics and the design of policy ignore this issue and take the GWPs as an adequate measure of marginal benefit trade-offs—perhaps as an undesirable but necessary simplification. A notable exception is the report issued as part of the US Climate Change Science Program where the relative price of gases changes in response to compliance with a target for radiative forcing (Clarke et al. 2007). Not surprisingly, methane comes up with a very low price in early years.

Returning to the issue of the 80 percent of emissions comprised of fossil fuel related CO_2, the debate quickly turns to one of *where* to regulate. Traditional market-based regulation—the U.S. sulfur dioxide (SO_2) and nitrogen oxides programs, the EU ETS, and most recently RGGI and the Alberta emission reduction regime—have focused on large point sources.[5] Such sources have reasonably low monitoring costs and—from a political perspective—are often easier to target for regulation. For traditional pollutants, the focus on smoke-stack emitters reflects the technological opportunities to pursue mitigation efforts through end-of-pipe treatment.

Carbon dioxide is unlike most pollutants because there are no end-of-pipe control technologies – it is the primary product of breaking down hydrocarbon chains. When a fossil fuel is mined, extracted, or imported, we can be relatively confident of the eventual CO_2 emissions—excepting efforts to sequester the fuel into products (plastics), exportation of fuels before

[5] The one notable exception is the US phasedown of lead in gasoline, where lead emissions from cars were limited by regulating gasoline refiners (Kerr and Newell 2003).

combustion, or the potential for large emissions sources to capture and store CO_2 underground.[6] With the dispersed nature of mobile source and residential emissions, the idea of regulating CO_2 at or near the point of fossil fuel production has received substantial attention (Keeler 2002). Such regulation would have modest monitoring costs and would have to cover only about 2,000 to 3,000 facilities in order to control all fossil fuel CO_2 emissions (Stavins 2007; Hall 2007). More recently, many climate change proposals in the Senate have moved in this direction (see Table 1, where all economy-wide bills are at least partially upstream).

Despite the potential practicality of broad coverage through upstream regulation at or near the point of production, there have been a number of primarily anecdotal concerns (Pizer 2007). First, some have advanced the concern that producers cannot pass on the cost of allowances or taxes to consumers. In some cases, this reflects existing institutional constraints. For example, natural gas pipelines tariffs may be regulated in ways that make it difficult for pipeline companies to pass on costs. Market power by the railroads may make it difficult for coal mines to pass through costs to coal users. Despite these concerns, however, most seem surmountable. Second, some have voiced the concern that firms only change their behavior in response to direct regulation, and will not adjust in response to changes in the prices of carbon-intensive inputs such as fossil fuels.[7] While there may be some “awareness effect” of forcing end users to think about their fossil fuel use in not just cost but also pollution consequences, the magnitude of this effect would seem to have some practical limits. More importantly, a substantial empirical literature has characterized induced technological change in the U.S. economy, showing that higher input prices induce firms to invest in factor-conserving technology. For example, industrial firms invested in energy-conserving technologies in response to the energy prices shocks of the 1970s and early 1980s. Finally, there is often pressure from some sectors that believe their situation warrants special consideration—competition from abroad, vulnerability to price volatility, or security.

The renewed interest in broader, upstream regulation partly reflects concerns about the inefficiency of narrow policy coverage and the difficulty reaching more aggressive targets. First,

[6] Capture and storage is impractical for all but large power plants, and currently non-commercial; see Anderson and Newell (2004) for a recent review.

[7] The run-up in energy prices in recent years illustrates both pass-through and consumer response to price changes. Higher crude oil prices have translated into higher gasoline prices, and consumption has slowed in response. After annual consumption growth of 1.5 percent for all petroleum products over 1995-2005, U.S. consumption has declined since 2005 (U.S. EIA 2008).

excluding some sources from regulation reduces the set of low-cost abatement opportunities to be exploited. Second, incomplete coverage of the economy's sources may spur emission leakage. The regulation of large sources may drive economic activity towards smaller sources, e.g., home use of natural gas and heating oil, instead of electricity. It may also cause unregulated sources to generate power on-site instead of purchasing power from regulated firms. Third, US EPA (2007) shows that under one proposal uncovered sources constitute 20-25 percent of reference case emissions, but they eventually comprise almost half of emissions after imposing regulations on covered sources. Yet, the idea that there would be an eventual broadening of coverage—starting with a few sectors with the aim of expanding to cover other sectors over time—may produce strong, concentrated special interests opposed to such expansion, making it increasingly difficult to further reduce emissions if such sources are not included from the start.

Exactly what is the economic cost of narrow versus broad coverage? There has been considerable numerical analysis focused on this question. Until recently, the vast majority of studies examined the cost savings from broad coverage among *countries* rather than within countries. In perhaps the most influential study of the former sort, Weyant and Hill (1999) summarized the results of Energy Modeling Forum 16, where modeling teams compared the cost of implementing the Kyoto Protocol targets unilaterally, with Annex I trading, and with developing country participation. They found that costs were cut by more than half going from autarky to Annex I trading, and at least half again when including developing country participation. Considering a more relevant dimension for the domestic regulatory discussion, EMF-21 considered the effect of including non-CO_2 gases in mitigation policies, and again found costs were roughly cut in half with such broader scope of coverage (Weyant et al. 2006).[8] This suggests that even though these gases are often a relatively small part of emissions, they are a disproportionably important part of low-cost emission *abatement.* The same result has been observed in studies of U.S. mitigation costs (EIA 2005).

Only recently has attention shifted to quantifying the effect of partial coverage of CO_2 emissions within a given country. Pizer et al. (2006) consider both the question of coverage and inefficient policies, examining the consequences of excluding different sources from a cap-and-trade program as well as using policies such as fuel economy standards and renewable portfolio

[8] The 2007 Lieberman-Warner bill (S. 2191) voted out of the Environment and Public Works committee would establish a separate refrigerants trading program. Since these comprise a significant share of near-term, low-cost abatement efforts, the parallel markets could reduce cost-effectiveness of the program.

standards. They found that limiting the policy to the power and transport sectors—excluding the industrial sector—doubled costs. Using inefficient policies, however, raised costs by a factor of ten.[9] Excluding relatively small sectors—direct emissions from residential and commercial buildings—had a negligible effect. This is consistent with EIA (2007) which similarly found a very small effect of excluding the commercial building sector in a domestic policy. The contrast could be quite stark between legislative proposals for effectively economy-wide caps (e.g., Lieberman-Warner) and proposals for utility-sector-only caps (e.g., Alexander-Lieberman, Table 1). Additional analysis could inform the scope of coverage of a domestic climate change policy.

Cost Containment

Any discussion of cost containment should start with the proposition that market-based policies already offer substantial cost reductions over traditional command and control regulation. A rich theoretical and empirical literature supports this proposition (e.g., Stavins 1998, Carlson et al. 2000). The discussion then turns to the choice between a quantity instrument (i.e., cap-and-trade program) and a price instrument (i.e., an emissions tax). While this choice may not matter much from an efficiency perspective when abatement costs are well known, that is not likely to be the case with the regulation of GHGs over the next decade as firms and government agencies have little current information on abatement costs.

It is this concern about uncertainty in the costs of implementing a quantity-based climate change program that has spurred consideration of mechanisms to contain climate policy costs. Weitzman (1974) provided the fundamental intuition that when uncertainty exists about costs in a regulated market, the relative slopes of marginal costs and marginal benefits will determine preferences for price versus quantity mechanisms. More specifically, relatively flat marginal benefits favors prices; relatively steep marginal benefits favor quantities.[10]

Since climate consequences depend on the atmospheric accumulation of GHGs over many decades, the marginal benefits of emission mitigation are relatively flat (Nordhaus 1994; Kolstad 1996). With annual contributions of about 1/100th of the accumulated volume (above pre-industrialization levels), these annual contributions cannot cause a dramatic increase in

[9] For example, refer to several analyses comparing the costs of fuel economy standards with the costs of gasoline and carbon taxes in attaining a given emission target (Austin and Dinan 2005; Crandall 1992; Jacobsen 2008).

[10] Stavins (1996) provides an extension when benefits and costs are correlated that modifies the relative slopes rule.

marginal damages. Thus, most economic analyses of policy choice under uncertainty favor prices on efficiency grounds (Pizer 2002; Newell and Pizer 2003). Using parameters from the broader literature, these studies find price policies, like an emissions tax, deliver five times the expected net benefits of quantity policies, like a simple cap-and-trade program.

The design of climate policy can draw from these insights and even more recent developments by considering modifications to an otherwise simple quantity mechanism. First, allowing the trade of quantities (emission allowances) over time through banking and borrowing can deliver greater near-term price stability, like an emissions tax.[11] Given the stock nature of climate change, relaxing the quantity constraint for any one year while maintaining an aggregate, long-term quantity constraint can address concerns that cap-and-trade may yield highly volatile allowance prices without a loss of environmental benefit. Ellerman and Sue Wing (2003) were the first to suggest that banking could change the price versus quantity results for climate change, but there has been little subsequent analysis. In terms of moderating price fluctuations, mechanisms like banking and borrowing inherently depend on individual and firm behavior. If individuals do not bank and borrow as the models predict, they will not stabilize prices—unlike an actual price control that does not leave the outcome in individual hands.[12]

Second, the fixed quantity under cap-and-trade could be relaxed by indexing quantitative caps to economic output. Argentina proposed a national commitment indexed to output in 1999 (Barros and Conte Grand 2002), and the United States proposed an intensity (emissions-to-GDP) goal in 2002 (EOP 2002). Several studies have shown that indexing improves on traditional fixed quantity caps in instances where the index is highly correlated with emissions and not too "noisy" (Quirion 2005; Sue Wing et al., in press; Newell and Pizer, in press). The form of the index—a simple intensity ratio or a more sophisticated function of output—should perform well both under expected economic growth and shocks to output (Aldy 2004). Nonetheless, price instruments still tend to dominate indexed caps on conventional expected welfare grounds.

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[11] While banking is frequently allowed under traditional cap-and-trade programs, borrowing is not. Recent Senate bills have proposed various forms of borrowing, including quantitative limits, interest rates, and systemwide versus firm-level provisions.

[12] The short-term price smoothing under banking and borrowing is also evident in smoothing prices over longer time horizons, such as promoting dynamic cost-effective attainment of global long-term atmospheric concentration stabilization goals (Wigley, Richels, and Edmonds 1996).

Third, implementation approaches could include elements of both quantity and price instruments. Roberts and Spence (1976), Weitzman (1978), and Yohe (1978) all consider generalizations to hybrid price-quantity mechanisms as well as step-wise schedules of allowance supply by the government. Interest in such hybrid policies has increased in recent years. For example, roughly half of the U.S. states have renewable energy standards for their electric power sectors, requiring utilities to generate or buy renewable energy credits in order to meet a statewide standard. In lieu of holding sufficient credits to satisfy the standard, many states allow their utilities to comply with their regulatory obligation by making alternative compliance payments, set at various dollar-per-megawatt-hour levels that effectively cap the cost of renewable energy credits (Union of Concerned Scientists 2008). This combination of trading with a price cap—or safety valve—is in several Congressional proposals, such as the Bingaman-Specter Bill, S. 1766 in the 110th Congress.[13]

Other proposals have emerged that are more complex than the specification of a particular annual permit supply schedules. Some have advocated for cost containment through a "circuit breaker" that would stop a ramp-down in annual emission caps over time if the allowance price exceeds a specified trigger (Bluestein 2003). Such a policy effectively sets future permit supply based on past prices, and requires the government to define "allowance price".[14] The proposal for a "Carbon Market Efficiency Board" in the Lieberman-Warner Bill, S. 2191 in the 110th Congress, illustrates an alternative to specifying the price-quantity trade off in legislation; that is, to delegate authority for managing price and emission uncertainty to an independent board (see S. 2191 in Table 1).

Fourth, the basic price-quantity comparison does not fully capture the complexity of adjustment and evolution of the policy over time. As we learn more about climate science, technology costs, policy efficacy, and global participation, we will unquestionably revisit our price/quantity goals. In a world with no transaction costs, government could adjust policy continually to such new information. In reality, it seems likely that the government will make

[13] S. 3036, the substitute amendment to S. 2191, includes a price-quantity-price-quantity mechanism that sets a minimum price, a cap (if the minimum price is exceeded), a second price at which additional allowances enter the system (technically borrowed from the future), and then a maximum limit on those additional allowances. See Murray et al. (2008).

[14] The previous policies simply require the government to stand by ready to sell allowances at a fixed price or through a minimum price auction in each period. The circuit breaker requires the government to define a market condition in one period (the average price) and then take a distinct action in the next period (change the target).

policy adjustments less frequently. A policy that sets the profile of prices (tax rates) over time may not provide as much flexibility for firms and individuals to adjust their behavior as a quantity policy with banking and borrowing. The price profile under tax policy does not change until the government changes it, even as expectations about the “correct” price may change. A flexible quantity policy with banking and borrowing, however, could respond as expectations about future targets change. For example, SO_2 allowance prices in 2004 increased in response to anticipated new regulations (US EPA 2005). These regulations do not affect the emission cap until 2010, and were not even finalized until 2005. Since firms may bank allowances for future use, a change in expectation about 2010 scarcity and prices propagates back to a change in expectation about the correct price in 2004. This in part motivates the discussion in Murray et al (2008) of a quantity-price-quantity mechanism over a simpler quantity-price safety valve.

Finally, changes in our understanding of the marginal damages under climate change, especially because of the potential for abrupt and catastrophic consequences, may overturn the standard prices versus quantities result for GHGs. Weitzman (2007) argues for more serious consideration of catastrophic consequences in policy evaluation, and the prospect of catastrophic impacts could yield much steeper marginal benefits functions for emission mitigation. Weitzman notes, however, that the potential for climate-related catastrophes is highly uncertain, in terms of timing, location, and magnitude. This uncertainty about when and where catastrophe might lie tends to undo the potential case for quantity controls; instead it might just argue for much more aggressive *price* mechanisms. In the long-term, if global climate policy strives for zero net GHG emissions, the welfare differences between quantity and price approaches decline.

Continued research can inform further the ongoing policy debate on cost containment mechanisms. For example, what impact does integrating a safety valve with banking and borrowing have? What are the tradeoffs between allowing firms discretion to borrow against future caps versus a government entity, akin to the Federal Reserve, holding that authority? Could other policy mechanisms dampen short-term price volatility while allowing the market to respond to long-term, fundamental drivers such as climate science, technological progress, and policy development in other countries?

Use of Offsets

While economic theory recommends making a cap-and-trade program as broad as possible in order to seek out the cheapest abatement opportunities, there are many sources that are unlikely to be covered. These include fugitive emissions that are difficult to monitor, particularly from agricultural and forestry activities, and emissions in developing countries. The latter, according to most estimates, offers an enormous mitigation opportunity that could halve the cost of emission targets among industrialized countries (Weyant and Hill 1999). Yet, both political and institutional capacity make full-fledged emission trading an unlikely possibility.[15]

Project-based offsets potentially offer a means to circumvent the problems of political and institutional capacity by focusing on individual mitigation activities. The theory is simple: projects that reduce emissions (relative to an agreed-upon baseline) are granted credits equal to the volume of reductions, and these credits may be sold into a cap-and-trade program. Firms regulated by the cap-and-trade program buy these credits and use them to offset some of their emissions. For example, 100 tons of emission reductions under an offset project sold into a cap-and-trade program effectively increases the emission cap by 100 tons. As long as the project's emission reductions are real, global emissions remain unchanged.

In practice, offset projects are much more complex. The challenge in designing an effective offset program lies in securing real, as opposed to paper, emission reductions. The assessment of real reductions reflects two problems: measuring actual emission levels and identifying an appropriate baseline. With the exception of agriculture and forestry projects, measurement is straightforward—the difficulty is identifying an appropriate baseline.[16]

Fundamentally, there is a trade-off. Spending more time and resources on estimating baselines and establishing the degree of real reductions provides greater environmental integrity. It also raises transaction costs and diminishes the volume of and opportunity for offsets to enter the market. Some have suggested moving away from "ton-for-ton" accounting and instead using offsets to provide incentives for projects with clear climate change and other benefits. Such an approach is particularly appealing when the price is regulated and offsets are limited in their effect on other mitigation efforts. Considerable effort has gone into designing procedures and approaches to strike a balance—for example, two-step registration processes, positive lists of approved project types, and tiered systems with different crediting levels (Hall 2007).

[15] Note that the problem is not only a question of industrialized countries paying for reductions in developing countries—this could be accomplished with a sufficiently generous allocation to developing countries. The problem is that developing countries are unwilling to accept *any* quantitative limit on their emissions, likely based on concerns about where such a process will lead. Even having such a commitment, it seems unlikely that many developing countries could monitor and enforce a broad domestic cap-and-trade program.

[16] See Myers (2007) for a recent discussion of ideas surrounding measurement and baselines for tropical forest activity.

The U.S. experience with project-based trading shows that high transaction costs can eliminate most of the potential cost-savings of trading. Under the 1977 Clean Air Act Amendments, regulated power plants could use offsets from other facilities for compliance with air quality rules. Transaction costs of up to 30 percent and EPA rejection of 40 percent of proposed trades resulted in cost savings of perhaps 1 percent (Hahn and Hester 1989; Hahn 1989). The limited trade activity and high transaction costs spurred the development of the much more efficient SO_2 cap-and-trade program under the 1990 Clean Air Act Amendments.

The Kyoto Protocol's Clean Development Mechanism has generated a substantial volume of certified emission reductions (CERs). If all projects in the pipeline as of July 2007 are completed, the CDM will introduce more than 2 billion CERs into the Kyoto trading system (UNEP 2007). With an aggregate Annex B target of 58 billion tons over the 2008-2012 period, offsets could play a more meaningful role in Kyoto compliance than they have in past domestic environmental programs. While facilitating compliance with Kyoto targets on paper, the CDM does risk undermining the environmental objective of the Kyoto agreement if such projects do not represent truly additional effort to mitigate emissions (Wara 2006; Victor 2007).

The CDM experience points to second important point: the effect of offsets as a subsidy to production. Baumol and Oates (1988) established the principle that while subsidies and taxes create equivalent incentives in a static framework, subsidies lead to dynamic inefficiencies over time by lowering output prices and encouraging excess entry into a market (in order to collect the subsidy). The extent of this dynamic inefficiency reflects the size of the subsidy compared to other production costs. In one very notable case—the destruction of HFC-23, a byproduct of the production of HCFC-22—the subsidy dwarfs the value of the product. Not surprisingly, HFC-23 destruction has constituted 40% of registered and 23% of pipelined projects under the CDM (Wara, 2006). This, in itself, is not necessarily cause for concern as eligible facilities had to be engaged in production prior to the start of the program. The test, however, will come in the second commitment period: if there is a surge in HCFC-22 production, and opportunities for HFC-23 destruction, will the CDM respond by permitting newer facilities to collect the credit?

What does this suggest? Some project types, particularly those where the subsidy effect is quite large, may need to be dealt with through other mechanisms. This might be a side agreement that is not market-based, or a mechanism that does not credit HFC-23 destruction at its full market value. This need not create an inefficiency: in this case, the market is creating a corner solution where the mitigation is virtually 100 percent. Reducing the offset credit by an appropriate amount will not change that, and will reduce the incentive to expand production.[17]

Revenues and Allowance Allocation

Depending on the scope and stringency of a domestic climate change policy, imposing a price on GHG emissions through an emissions tax or cap-and-trade program with an auction could generate $100-300+ billion revenues annually (Paltsev et al. 2007, Congressional Budget Office 2007, EIA 2007). This volume of revenue—almost as much as the $350 billion collected by the corporate income tax—makes the question of what to do with this revenue (or the equivalent volume of allowances) one of the most formidable questions facing federal policymakers. Traditionally for a cap-and-trade approach, the question has been framed as either giving the allowances to regulated emitters at no cost versus auctioning the allowances for general revenue purposes. The policy debate has evolved beyond this simply dichotomy. Proposals now provide free allocation to a wider range of affected firms (versus only direct emitters), to states, and to funds or quasi-governmental corporations that, in turn, auction allowances to support climate-related activities. At the same time, auction revenues are also being earmarked for a wide range of climate-related activities ranging from adaptation, to technology support, to support for populations adversely affected by the regulation. This blurring of the traditional distinction between free allocation and auctions requires us to re-think how we describe the allocation choices facing policymakers.

This section surveys the impacts such choices can have on the costs borne by various parts of the economy—by industry, electricity generators, low-income households, and by region—as well as on the total costs of a climate change policy. First, we describe how such policies generate so much wealth and when various forms of tax and cap-and-trade policies are equivalent in their distributional impacts. Second, we illustrate the distributional implications of climate change policy and means for addressing distributional objectives. We conclude with a discussion of how using climate policy revenues can lower the total costs and regressivity of climate policy or, alternatively, finance other climate-related policy objectives.

[17] A variant of this idea would be to finance these subsidies through an international fund, perhaps itself supported by a credit auction. See, for example, CFR (2008).

A cap-and-trade program effectively rations the right to emit GHG emissions from covered sources in the economy. This rationing, as for any scarce asset, results in a positive price for emission allowances. This price reflects the value for the right to emit a specified unit of GHGs. Summed over the quantity of allowances, this provides an estimate of both the potential revenue to the government as well as the scale of redistribution between those who will end up paying more for fossil energy and those who initially hold the allowances—either the government or someone else. This potential revenue is quite substantial. Paltsev et al. (2007) evaluated three scenarios matched to various bills under consideration in the U.S. Senate and estimated that 100% auctioning would yield annual revenues of $130 to $370 billion by 2015. Similar results can be found in the EIA (2007) analysis of the Lieberman-Warner bill, S. 2191. Emissions taxes with tax profiles over time matching the estimated allowance prices in these scenarios would deliver the same revenues, and have equivalent distributional impacts.

If a cap-and-trade program freely allocates all of the emission allowances (or gives away the revenue from an auction), then the government has decided to redistribute hundreds of billions of dollars. A hybrid approach—partial free allocation, partial allowance auction—would result in some redistribution and some government revenues. Under an emissions tax regime, an analogous approach would be to rebate revenues to various groups of businesses or individuals affected by the policy, where this rebate would be roughly equivalent to the free allocation under cap-and-trade. An alternative but similar approach would simply exempt sources from paying taxes on emissions that equal a percentage of their historical emissions.

Regardless of the allocation mechanism (or tax implementation), downstream consumers will generally bear the same energy cost increases under a cap with 100% auction, a cap with 100% free allocation, or a tax set at the expected price of the cap-and-trade approach.[18] In all three cases, the price of the allowance or the tax represents the opportunity cost of emitting another unit of GHG emissions. Even if a business or individual with a compliance obligation receives allowances for free, that business or individual will still consider the price of those allowances in their decision to use fossil fuels and/or price their products. The opportunity to sell unused allowances that are not necessary for firm's compliance, not the initial implicit price of zero the firm faced when acquiring the allowances, will drive firm behavior and pricing

[18] A significant exception to this equivalence holds if allowances are granted for free to firms operating as regulated monopolies, such as utilities in cost-of-service jurisdictions (Burtraw and Palmer 2007), which holds for more than half the U.S. electricity market.

decisions. This effect has been evident in electricity markets in the U.S. under the Acid Rain Program's SO_2 allowance trading regime and in the EU under the CO_2 emission trading scheme (CBO 2007). Given the relatively inelastic demand for energy, most of the carbon price would be passed on to consumers. Lasky's (2003) survey of various energy-economic models shows that up consumers bear up to 96 percent of the price increases. Figure 1, for example, shows how the price paid and received for coal varies under various carbon price scenarios in a recent EIA (2008) analysis, with almost all of the burden falling on consumers. Here, supply is almost perfectly elastic while demand falls by 45% in the face of a 300% increase in price. Electricity and many energy-intensive product markets look similar, if not quite as extreme.

The combination of the allocation decision and the incidence of emission pricing primarily on final consumers drive the distribution of climate change policy. A free allowance allocation to businesses in the energy-supply chain—fossil energy extraction, processing, power generation, and energy-intensive businesses—and the transmission of most of the allowance price to final consumers would likely make these businesses *better off*—as a group—under climate policy than the status quo.[19] This can lead to increasingly regressive household impacts.

Parry (2004) finds that the wealthiest quintile of Americans, who own a disproportionate share of capital, enjoy higher disposable income under climate policy, while the poorest 80 percent of the country experience lower disposable income. Metcalf (2007) shows that the lowest decile has 1.8 percent lower disposable income, while the top two deciles have higher disposable income under 100% free allocation. The free allocation benefits wealthy shareholders of businesses receiving those allocations, but the costs of the climate policy are distributed among all consumers of energy-intensive goods, which magnifies the regressivity of the policy since low-income households consume more energy as a share of their income.

An entirely free allowance scheme could also exacerbate geographical inequalities resulting from relative differences in the carbon intensity of household consumption across the country. Aldy (2007) shows that state-level CO_2 emissions per capita vary by a factor of ten. Pizer and Sanchirico (2007) estimate that a \$10 per ton price (or tax) on CO_2 would increase household spending by \$97 per year in York County, New York, but a much higher \$235 per

[19] It becomes much more complicated to understand how different businesses within an industry will fare. See, for example, Burtraw and Palmer (2007).

household in Tensas Parish, Louisiana. The disparity across regions reflects important differences in energy use, carbon intensities of electric generation, and electricity regulation.

Goulder (2001) has estimated that no more than about 15 percent of emission allowances need to be freely allocated to avoid equity losses in the must vulnerable industries. Free allocations above this level would effectively create windfall profits for those industries, as some have claimed in the pilot phase of the EU ETS. Morgenstern et al. (2007) shows that about a 20 percent perpetual free allocation would keep all manufacturing industries whole. Stavins (2007) estimates that a 50 percent free allocation phased-down to zero over 25 years is equivalent to a 15 percent gratis allocation into perpetuity in present value terms (assuming a real discount rate of 3 percent). NCEP (2007) suggests a similar 50 percent free allocation, declining to zero over time. This suggests that a substantial majority of the emission allowances could be auctioned and used to address concerns about regressivity and efficiency.

The opportunity to generate hundreds of billions of dollars of revenue annually could allow government to lower existing taxes on income, labor, and capital. Reducing distortionary taxes on these goods can promote greater labor participation and capital accumulation. This effective tax swap—increasing the tax (or auctioned allowance price) on GHG emissions and decreasing taxes on labor and capital—could substantially lower the costs of climate change policy. Goulder (2002) shows that a policy reducing GHG emissions 23 percent coupled with a 100 percent auction and optimal revenue recycling could result in half the costs to the U.S. economy of a program with 100 percent free allocation. Policies with allowance prices (or emissions taxes) up to about \$15 per ton of CO2 with optimal revenue recycling could result in faster economic growth than no climate policy (Bento and Parry, 2000). Presumably, the same arguments for optimal recycling would be applicable to revenue used to avoid tax increases.

The government could also direct revenues to address the regressivity of the domestic climate change policy. Metcalf (2007) illustrates how various approaches to returning revenues to the economy can mitigate the regressive impacts of pricing GHG emissions. Specifically, he finds that an “environmental tax credit” applied equally to all workers’ payroll tax obligations can offset most of the regressivity of higher costs of energy goods under climate policy, and a modified version that also includes a tax credit to social security recipients can transform the policy to being slightly progressive. Dinan and Rogers (2002) show how the disposable income for the lowest-income quintile could increase some 3.5 to 7.3 percent moving from gratis allocation to an auction with a lump-sum recycling (all households receive the same check).

In the policy world, support has increased in recent years to use the revenues from a climate policy program to benefit various interests, through either earmarking of auction revenue or allocating allowances for particular purposes. For example, some of the allowance auction revenues by states participating in the Regional Greenhouse Gas Initiative have been earmarked for energy efficiency and related demand side management programs. Several bills pending in the U.S. Senate would set aside revenues to aid low-income households and workers adversely affected by climate change policy transition into new positions. Allowances or revenues could also support additional R&D on climate-friendly technologies, such as carbon capture and storage and more research in climate science and adaptation (as specified in both S. 1766 and S. 2191).[20] Little research has addressed how these earmarking approaches would compare on welfare or distributional grounds to recycling revenues through tax rate cuts or tax credits.

Additional analysis can inform the design of policies that can generate substantial revenues and important distributional consequences. First, rigorous analysis should assess the claims of windfall profits during the pilot phase of the EU ETS. This work would provide a valuable empirical basis for the results reported from various simulation models. Second, some in the private sector have questioned the claims that allowance prices or emissions taxes can be so easily passed onto consumers in a world with more international trade and heterogeneity in climate policies among major trade partners. Others have raised questions about price pass-through given current real-world energy market features including long-term contracts, infrastructure regulation, and monopoly / monopsony power in some markets (e.g., rail transport of western coal). A more detailed assessment of how the burden of the policy passes through the fossil energy supply chain would benefit the development of provisions on the point of regulation and allocation. Finally, continued evaluation of efficiency–equity trade-offs in program design, including revenue recycling, free allocations to redistribute burden, and revenue or allowance earmarking, could benefit decision-makers as they craft policy. While the simple distinction between auctions and free allocation has become blurred, the underlying idea that higher fossil energy prices create allowance value that can be used for distinct purposes—redistribution, general revenue support, and, most recently, earmarked expenditures—remains the same and raises the same questions.

[20] This concept of special interest group allocations is a variation of the idea that free allocations to affected industries will be necessary to buy support for climate change policy (e.g., McKibbin and Wilcoxen 2007).

Mechanisms to Address Competitiveness Concerns

The design of a domestic GHG emission mitigation policy could adversely affect the competitive position of some U.S. industries, especially those that intensively use fossil fuels and face substantial international competition. Business and labor leaders have expressed concern that increasing the domestic price of energy through climate change policy may create incentives for U.S. facilities to relocate to countries without such policy-related price increases (i.e., developing countries) or to shift production to facilities already operating in these countries. This competitiveness effect—lower industrial employment and production in the United States coupled with higher net imports than would occur with comparable action in all countries—can reflect concentrated costs on those firms participating in a competitive, international market. Understanding the magnitude of this effect is important to inform the design of climate change policy, especially with respect to issues of the scope of regulation, allocation, and obligations imposed on imports from countries without comparable climate policies.

Some recent research shows that only a few, very energy-intensive industries would likely face adverse competitiveness effects of a domestic climate change policy. Ederington et al. (2005) show that U.S. environmental regulatory costs only affect the manufacturing sector's trade with developing countries; the comparability of environmental regulations across the OECD negates any competitiveness effects for U.S. firms with respect to firms in the developed world. Firms in industries with higher transportation costs, larger fixed physical plant share of capital, and those benefiting from agglomeration economies with other firms face less competitiveness pressures as well. Analyses by Morgenstern et al. (2007), using both simulation models and econometric analyses of the effects of energy prices on competitiveness, illustrate that only the most energy-intensive industries, such as iron and steel, non-ferrous metals, and chemicals, face any kind of economically and statistically meaningful competitiveness threats.

Policymakers could pursue a variety of options to address concerns about competitiveness: coordinating policy efforts with other countries, using allowance allocations and/or exemptions as means to mitigate adverse impacts on industry, and regulations or taxes on imports. The most effective way to ensure that implementing a domestic climate change policy does not result in adverse competitiveness effects on industry and emission leakage is through coordination of policy efforts across countries. If a firm would face the same price for emitting a ton of GHG emissions regardless of its location, then climate change policy no longer creates an incentive to relocate. Pursuit of a broad, cost-effective climate change policy across countries can similarly remedy the competitiveness drawbacks of a domestic program.

Such coordination can be explicit through an international agreement, such as the Kyoto Protocol. For example, large industrial facilities across the EU face the same price for emitting a ton of CO_2 through the cap-and-trade program employed by the EU to implement its Kyoto targets. Such coordination could be implicit, such as through countries developing policies that effectively target the prices faced by their competitors. Pizer (2007) describes how a number of countries have pursued climate change policies independently but have begun to converge on a similar price per ton. Such coordination could reflect prodding by countries taking the lead on climate change policy. The EU has proposed that it will unilaterally go to 20 percent below 1990 levels by the year 2020, but if other major industrial countries follow their lead they will pursue a 30 percent below 1990 goal. The Udall-Petri draft bill in the House of Representatives, as well as the Bingaman-Specter bill in the Senate (S. 1766), calls for a review of developing country actions and policies. If these are not deemed sufficient, then the U.S. cap would not be made more stringent. Additional research on the incentives for countries to follow a credible leader in a multilateral climate change game could further inform these approaches.

The government could also address these concerns through the allocation of emission allowances. Granting free allowances based on historic criteria has the appeal of compensating firms through a wealth transfer without affecting the first-order efficiency associated with equating marginal abatement costs across sources. While gratis allocation does not address the effective price wedge between covered U.S. firms and competitors in countries with no climate policies—so employment and production will fall—it can maintain profits for these firms.

In contrast, granting free allowances based on output or similar measures *would* affect the price difference between foreign and domestic production, acting essentially as a production subsidy. Traditional analysis in a closed-economy model and/or with industries that do not trade shows that such subsidies are inefficient, as cheaper opportunities to conserve product are forgone in favor of higher cost reductions to reduce emissions per unit of output (Kopp 2007).[21]

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[21] Any approach to gratis allocations maintained over time could be problematic. Updating also could be preferred to historical grandfathering. If free allowances are updated over time based on output, allowances will not be allocated to firms that have shut down as might be the case with grandfathering (though auctioning of allowances would also achieve this). If free allowances are uniformly distributed, firms with relatively lower carbon intense inputs may receive windfall gains.

In models with potential trade distortions arising from some countries adopting GHG regulations while other do not, these subsidies can counteract those effects (Fischer and Fox 2007).

Finally, exempting some firms from market-based regulation could obviously eliminate the competitiveness effects of climate change policy. Complete exemption from regulation risks increasing the costs of achieving a given emission goal, since exempted firms would then face zero price on their emissions while covered firms would face a positive price. The costs could also increase as the climate policy provides fewer revenues with which to offset existing taxes. As an alternative, exempted industries might be subject to alternative regulation—although this could worsen the outcome depending on the design. Finally, a less onerous market-based regulation could be applied—either an emissions tax or cap—designed with a reduced burden in mind. For example, the November 2007 revisions to S. 2191 placed refrigerants under a distinct cap designed to reduce the impact of the broader cap-and-trade regime on these products' prices.

The most aggressive policies to address competitiveness concerns would impose a border tax or a regulation based on the emission intensity of imports from countries without comparable climate change policies (Biermann and Brohm 2005). Imposing a border tax on the carbon content of imports requires very detailed information on the production processes used in manufacturing those imports. Proposals under consideration in several bills in the U.S. Senate would limit the border tax adjustment—a permit-holding requirement—to bulk commodities like cement, rolled steel, etc. for which it is presumably easier to assess carbon content (see Table 1 on the Lieberman-Warner and Bingaman-Specter bills). This proposal would enact the permit-holding requirement only after an evaluation of other countries' efforts—deemed to be inadequate in mitigating emissions—several years after the start of the U.S. program.

Designing such a mechanism effectively must confront several questions, some of which could benefit from additional research. First, how will the mechanism deal with the variety of products, product quality, and production techniques, even within the narrowly-defined industries given in the bills? Second, to what extent would the potential of a border tax inspire developing countries to take on new, domestic emission mitigation policies, versus raising the prospects of a trade war?[22] In this vein, for example, it seems unlikely that developing countries would implement costly mitigation policies on their entire domestic economies to protect the

[22] See, for example, concerns raised in CFR (2008).

small fraction of output destined for the U.S. market. Finally, this mechanism raises key questions regarding compliance with World Trade Organization rules (Pauwelyn 2007).

Complementary R&D and Technology Policies

An adequate response to the risks posed by climate change will require the development and deployment of new low-carbon and zero-carbon technologies. Policies that impose a price on GHG emissions—such as a carbon tax or cap-and-trade program—would induce technological change and help move these new technologies into the marketplace. The private incentives to invest in R&D, even in the presence of an emission mitigation policy, will still be weak because of the public good nature of information: creating knowledge through R&D generates benefits that the innovator cannot fully appropriate. A climate-oriented R&D policy should address this market failure to complement mitigation policy. To the extent that current prices, and particularly expectations of future prices, are below the socially desired level, this creates a further argument for climate-oriented R&D.[23]

Along the R&D chain from initial idea to commercial product, the incentives for private investment vary. Innovations in basic science tend to suffer from public information problems much more than products and processes at the commercial stage. Government support for basic science can yield quite substantial returns on the investment, especially after accounting for positive spillovers of knowledge creation (Chow and Newell 2004). Government investment in basic R&D typically does not crowd out private sector R&D. The public policy rationale for commercial and near-commercial technologies—such as through pilot and demonstration projects—is weaker. Private firms have substantial incentive to invest in demonstration projects, and the prospect of public funding for these kinds of projects may crowd out private investment. Similarly, the rationale for subsidies to encourage the more rapid deployment of already available technologies— for example, subsidies for wind or corn ethanol—is even weaker.

The government could employ an array of models for promoting climate-related R&D. First, the government has fairly good success in supporting competitive, extramural research through the National Science Foundation, the Department of Energy's Office of Science, and work undertaken through the country's system of National Laboratories. Second, the National

[23] It may be difficult for current governments to create adequate expectations of future prices for a variety of reasons; see Montgomery and Smith (2007).

Academy of Sciences recently advocated for an agency akin to the Defense Advanced Research Projects Agency that would focus on innovative energy research (Augustine et al. 2006). This so-called ARPA-E would finance extramural research on cross-cutting, transformational science and technology at universities, private sector start-ups, and other research institutions. While the ARPA-E was part of a bill signed into law in 2007, the Bush Administration has indicated no interest in funding the agency (Newell 2007).

Energy prizes or competitions, similar to the super-efficient refrigerator competition in the early 1990s or the X-Prize for space flight in 2004, could also spur private sector commercialization of basic research. The appeal of a competition is that the government only pays out for proven winners, or more specifically, for outputs, not inputs. The design of competitions can circumvent the problem of "government picking winners" by specifying the characteristics of a winning product without dictating the means of designing the product. Such an approach can engage many research teams as they compete to develop the winning product. The actual incentive can often be considerably larger than the cash prize, as competitors vie for non-pecuniary benefits such as media attention and prestige (Newell and Wilson 2005).

So far the discussion has focused on provisions to encourage new technology development; however, climate policies often call for various technology mandates or related performance standards to accelerate deployment of already existing technologies. For example, renewable portfolio standards, biofuel mandates, and efficiency standards would supplement economy-wide cap-and-trade policies in several bills (refer to Table 1). Such policy approaches have two important effects on technological deployment, as well as a consequential impact on near-term costs. First and most directly, these mandates accelerate the deployment of existing technologies to ensure compliance with technology and performance standards in targeted industries. At the same time, however, this will tend to lower the allowance price in the emissions market, as the new regulation takes some of the pressure off the cap-and-trade program to reduce emissions. This lower allowance price lowers the incentive for innovation and technological adoption in those industries that are *not* targeted by the performance standard.

Perhaps most importantly, this combination of performance standards and a cap-and-trade program will tend to increase costs over a cap-and-trade program standing alone with the same environmental outcome. Even as the market-price of allowances falls, this occurs on a base of more expensive reductions required by the technology regulation. In summary, performance standards may increase technological deployment, but in doing so they likely retard technological deployment and improvement in non-targeted industries, and increase the costs of complying with a quantitative cap. For such a policy to be worthwhile, therefore, we must believe that additional deployment in the targeted industries will be enough to offset both foregone innovation in untargeted industries and higher compliance costs in the near term.

While we focused so far on the role of technology policies to supplement emission pricing, the design of the emission pricing policy can also impact innovation and deployment. Ignoring uncertainty, there have been a number of articles on whether taxes or tradable permits provide more incentive to innovate without any clear-cut result (Milliman and Prince 1989; Fischer et al. 2003). With uncertainty, however, substantial research in a variety of markets shows that price volatility discourages investment (Dixit and Pindyck 1994). Thus, an emissions tax may deliver more innovation than a cap-and-trade with an expected allowance price equal to the tax. Modifications to the cap-and-trade policy may address this discrepancy, such as through banking and borrowing than can help smooth prices out over time, or cost containment mechanisms such as the safety valve that effectively transforms a cap-and-trade policy to a tax policy at high allowance prices (discussed in section 3). Additional research could explore the potential impacts on private R&D of climate policies that can deliver stable emission prices.

Conclusion

With the recent enthusiasm for domestic climate change policy in the U.S. Congress and in the presidential campaigns of both major political parties, the likelihood of a mandatory GHG mitigation program is increasing. The distribution of the winners and losers and the aggregate costs and benefits of such a policy could vary significantly depending on the policy design. Domestic GHG mitigation policy will have larger and broader impacts over firms and consumers than any existing environmental policy. It could impose costs comparable to all other environmental policies combined, but, in concert with other countries' actions, deliver even greater benefits. Given the scope of the policy problem, interest is high in an efficient, transparent climate policy program to mitigate climate change risks.

We have focused on six key policy elements that any efficacious climate change policy will have to address: program scope and coverage, cost containment, use of offsets, revenues and allowance allocation, mechanisms to address competitiveness, and complementary R&D and technology policies. While identifying the need for more research, a number of points emerge:

(1) Broader coverage and the inclusion of more emission sources under a single emission pricing policy lowers the cost of any policy goal. Adding sources

after a program commences could be increasingly difficult as concentrated special interests evolve to oppose such expansion.

(2) Providing cost certainty can increase the political acceptance of a climate policy, deliver better investment incentives, and facilitate more ambitious long-term emission reduction goals by serving as insurance against unexpectedly high costs. Since any policy will need to adapt to new information on science, technology, and global participation, a key policy feature should allow for temporal flexibility through cost containment measures.

(3) Offsets can be a valuable way to allow access to inexpensive emission reductions that are otherwise outside a mandatory policy; however, there are hurdles that limit their effectiveness and create perverse incentives. This suggests using other policies, in concert with offsets, to address these emissions.

(4) Mitigating GHG emissions will place much of the burden on end-use consumers and involve large revenues. Traditional free allocation to emitters has given way to discussions of more targeted allocations to vulnerable consumers and businesses, earmarked funding for climate-related activities, and general revenues to reduce taxes.

(5) A small set of industries may face serious competitiveness concerns, defined as adverse business impacts related to domestic GHG regulation *and* the absence of regulation on international competitors. Policy could address these concerns by spurring more coordinated international action, using allocation to compensate and/or to create incentives for domestic production, and creating special import regulations. Unilaterally enacting the latter approach could create problems within the international trade regime.

(6) Policies to promote increased research and development are necessary to complement a market-based climate policy, owing to both the standard R&D market failures as well as the particular difficulties creating long-term policy credibility. The case for such policies are strongest early in the R&D process and weakest for the last step of increasing deployment of existing technologies. Much of the difficulty in basic R&D involves management, while the challenge in later stages revolve around support for R&D inputs

(e.g., investment credits) versus R&D outputs (e.g., prizes or production credits).

While there is a tendency to put a premium on getting started as soon as possible, with as strong a policy as possible, these observations suggest some important considerations for getting started with *as good a design as possible*. Identifying these and/or other fundamental design features should be an important priority for research. New research building on the existing economic literature can inform the design of a robust foundation for long-term domestic climate change policy. Such work can deliver near-term payoffs in the design of a U.S. domestic program, but also facilitate improvements of other national climate policy programs (e.g., the EU ETS) and guide the design of climate change policies in emerging and developing countries.

References

Aldy, J.E. (2004). "Saving the Planet Cost-Effectively: The Role of Economic Analysis in Climate Change Mitigation Policy." In: R. Lutter and J.F. Shogren, eds., *Painting the White House Green: Rationalizing Environmental Policy Inside the Executive Office of the President.* Washington, DC: Resources for the Future Press, 89–118.

Aldy, J.E. (2007). "Divergence in State-Level Per Capita Carbon Dioxide Emissions." *Land Economics* 83(3): 353–369.

Anderson, S. and R. Newell. (2004). "Prospects for Carbon Capture and Storage Technologies." *Annual Review of the Environment and Resources* 29:109–42

Arimura, T., D. Burtraw, A.J. Krupnick, and K.L. Palmer. (2007). "U.S. Climate Policy Developments." RFF Discussion Paper 07-45. Washington, DC: RFF.

Austin, D. and T. Dinan (2005). "Clearing the Air: The Costs and Consequences of Higher CAFE Standards and Increased Gasoline Taxes." *Journal of Environmental Economics and Management* 50: 562-582.

Barros, V. and M. Conte Grand. (2002). "Implications of a Dynamic Target of Greenhouse Gas Emission Reduction: The Case of Argentina." *Environment and Development Economics* 7: 547–569.

Barrett, S. (1994). "Self-Enforcing International Environmental Agreements." *Oxford Economic Papers* 46: 878-894.

Barrett, S. (2008). "The Incredible Economics of Geoengineering." *Environmental and Resource Economics* 39: 45-54.

Baumol, W.J. and W.E. Oates, W.E. (1988). *The Theory of Environmental Policy*, 2nd Edition. Cambridge: Cambridge University Press.

Bento, A. and I. Parry. (2000). "Fiscal Interactions and the Case for Carbon Taxes," In: D. Helm, ed., *Climate Change Policy.* New York: Oxford University Press.

Biermann, F. and R. Brohm. (2005). "Implementing the Kyoto Protocol without the USA: The Strategic Role of Energy Tax Adjustments at the Border." *Climate Policy* 4: 289-302.

Bluestein, J. (2003). Testimony before Senate Environment and Public Works Committee, Subcommittee on Clean Air, Climate Change, and Nuclear Safety, Hearings on Powerplant Multipollutant Regulation. May 8, 2003.

Burtraw, D. and K. Palmer. (2007). Compensation Rules for Climate Policy in the Electricity Sector. *Journal of Public Policy Analysis and Management.*

Carlson, C., D. Burtraw, M. Cropper, and K.L. Palmer. (2000). “Sulfur Dioxide Control by Electric Utilities: What Are the Gains from Trade?” *Journal of Political Economy* 108(6): 1292-1326.

Carraro, C. and M. Galeotti. (2002). “The Future Evolution of the Kyoto Protocol: Costs, Benefits, Incentives to Ratification and New International Regimes.” In: C. Carraro and C. Egenhofer, eds., *Firms, Governments, and Climate Policy: Incentive-Based Policies for Long-Term Climate Change*. Cheltenham, UK: Edward Elgar.

Carraro, C. and D. Siniscalco. (1993). “Strategies for the International Protection of the Environment.” *Journal of Public Economics* 52(3): 309-328.

Chow, J. and R. Newell. (2004). “A Retrospective Review of the Performance of Energy R&D.” Washington, DC: RFF.

Clarke, L., J. Edmonds, H. Jacoby, H. Pitcher, J. Reilly, R. Richels. (2007). *Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations*. Sub-report 2.1A of Synthesis and Assessment Product 2.1 by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Department of Energy, Office of Biological & Environmental Research, Washington, DC., USA, 154 pp.

Congressional Budget Office (CBO). (2007). “Trade-offs in Allocating Allowances for CO_2 Emissions.” Economic and Budget Issue Brief, April 25. Washington, DC: CBO.

Council on Foreign Relations, Independent Task Force on Global Climate Change (2008). “Confronting Climate Change: A Strategy for U.S. Foreign Policy”. New York: Council on Foreign Relations.

Crandall, R. (1992). “Policy Watch: Corporate Average Fuel Economy Standards.” *Journal of Economic Perspectives* 6(2): 171–180.

Dinan, T. and D.L. Rogers. (2002). “Distributional Effects of Carbon Allowances Trading: How Government Decisions Determine Winners and Losers,” *National Tax Journal* 55(2): 199–222.

Dixit, A. and R. Pindyck. (1994). *Investment Under Uncertainty*. New York: Princeton University Press.

Ederington, J., J. Minier, and A. Levinson. (2005). "Footloose and Pollution-Free." *Review of Economics and Statistics* 87(1): 92-99.

Ellerman, D. and I. Sue Wing. (2003). "Absolute versus Intensity-Based Emission Caps." *Climate Policy* 3 (Supplement 2): S7-S20.

European Commission. (2008). 20 20 by 2020: Europe's Climate Change Opportunity. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions, COM(2008) 30. Brussels, EC.

Executive Office of the President (EOP). (2002). Climate Change Policy Book. Washington, DC: Executive Office of the President.

Fischer, C. and A.K. Fox. (2007). "Output-Based Allocation of Emissions Permits for Mitigating Tax and Trade Interactions". *Land Economics* 83(4): 575-599.

Fischer, C., I.W.H. Parry, and W.A. Pizer (2002). "Instrument choice for environmental policies when technological innovation is endogenous." *Journal of Environmental Economics and Management* 45(3).

Goulder, L. (2001). "Confronting the Adverse Industry Impacts of CO_2 Abatement Policies." In: M. Toman, (ed.), *Climate Change Economics and Policy: An RFF Anthology*. Washington, DC: RFF Press.

Goulder, L. (2002). "Mitigating the Adverse Impacts of CO2 Abatement Policies on Energy-Intensive Industries." RFF Discussion Paper 02-22. Washington, DC: RFF.

Hahn, R.W. (1989). "Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor's Orders." *Journal of Economic Perspectives* 3(2): 95-114.

Hahn, R.W. and Hester. (1989). "Where Did All the Markets Go? An Analysis of EPA's Emissions Trading Program." *Yale Journal of Regulation* 6: 109-154.

Hall, D. (2007). "Offsets: Incentivizing reductions while managing uncertainty and ensuring environmental integrity." In: R. Kopp and W. Pizer, (eds.), *Assessing U.S. Climate Policy Options*. Washington, DC: RFF.

Intergovernmental Panel on Climate Change. (2001). *Climate Change 2001: The Scientific Basis*. Cambridge: Cambridge University Press.

Jacobsen, M.R. (2008). "Evaluating U.S. Fuel Economy Standards in a Model with Producer and Consumer Heterogeneity." UC-San Diego Working Paper, April draft.

Keeler, A. (2002). "Designing a Carbon Dioxide Trading System: The Advantages of Upstream Regulation." Washington, DC: Climate Policy Center.

Kerr, S. and R.G. Newell. (2003). "Policy-Induced Technology Adoption: Evidence from the U.S. Lead Phasedown." *Journal of Industrial Economics* 51: 317–343.

Kolstad, C.D. (1996). "Learning and Stock Effects in Environmental Regulation: The Case of Greenhouse Gas Emissions." *Journal of Environmental Economics and Management 31*(1): 1–18.

Kopp, R. (2007). "Allowance Allocation." In: R. Kopp and W. Pizer, (eds.), *Assessing U.S. Climate Policy Options*. Washington, DC: Resources for the Future.

Lasky, M. (2003). "The Economic Costs of Reducing Emissions of Greenhouse Gases: A survey of Economic Models." CBO Technical Paper 2003-3. Washington, DC: Congressional Budget Office.

McKibbin, W.J. and P.J. Wilcoxen. (2007). "A Credible Foundation for Long-Term International Cooperation on Climate Change." In: J.E. Aldy and R.N. Stavins, eds., *Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World.* Cambridge: Cambridge University Press, 185-208.

Metcalf, G. (2007). "An Equitable Tax Reform to Address Global Climate Change." Hamilton Project Discussion Paper 2007-12. Washington, DC: Brookings Institution.

Milliman, S.R. and R. Prince (1989). "Firm Incentives to Promote Technological Change in Pollution Control." *Journal of Environmental Economics and Management* 17: 247-265.

Montgomery, D. and A. Smith (2007). "Price, quantity and technology strategies for climate change policy." In M. Schlesinger, H. Kheshgi, J. Smith, F. de la Chesnaye, J.M. Reilly, T. Wilson and C. Kolstad, eds. *Human-induced Climate Change: An Interdisciplinary Assessment.* Cambridge: Cambridge University Press

Morgenstern, R.D., J.E. Aldy, E.M. Herrnstadt, M. Ho, and W. Pizer. (2007). "Competitiveness Impacts of Carbon Dioxide Pricing Policies," In: R. Kopp and W. Pizer, (eds.), *Assessing U.S. Climate Policy Options*. Washington, DC: RFF.

Murray, B., R. Newell, and W. Pizer (2008). "Balancing Cost and Emissions Certainty: A Reserve-Based Approach to Cap-and-Trade". RFF Discussion Paper xx-xx. Washington: Resources for the Future.

Myers, E. (2007). "Policies to Reduce Emissions from Deforestation and Degradation (REDD) in Tropical Forests: An Examination of the Issues Facing the Incorporation of REDD into Market-Based Climate Policies." RFF Discussion Paper 07-50. Washington: RFF.

National Commision on Energy Policy (2007). "Allocating Allowances in a Greenhouse Gas Trading System". Staff paper. Washington, DC: NCEP.

Newell, R.G. (2007). "Climate Technology Research, Development, and Demonstration: Funding Sources, Institutions, and Instruments." In: R. Kopp and W. Pizer, (eds.), *Assessing U.S. Climate Policy Options*. Washington, DC: RFF.

Newell, R.G. and W.A. Pizer. (2003). "Regulating Stock Externalities Under Uncertainty." *Journal of Environmental Economics and Management* 45: 416–432.

Newell, R.G. and W.A. Pizer. (in press). Indexed regulation. *Journal of Environmental Economics and Management*.

Newell, R.G. and T. Wilson. (2005). "Technology Prizes for Climate Change Mitigation" RFF DP 05-33. Washington: RFF.

Nordhaus, W.D. (1994). *Managing the Global Commons*. Cambridge: MIT Press.

Nordhaus, W.D. (2007). The Challenge of Global Warming: Economic Models and Environmental Policy in the DICE-2007 Model. Mimeo, Yale University.

Paltsev, S., J.M. Reilly, H.D. Jacoby, A.C. Gurgel, G.E. Metcalf, A.P. Sokolov, and J.F. Holak. (2007). "Assessment of U.S. Cap-and-Trade Proposals." MIT Joint Program on Science and Policy of Global Climate Change, Report no. 146. Cambridge, MA: MIT.

Pauwelyn, J. (2007). U.S. Federal Climate Policy and Competitiveness Concerns: The Limits and Options of International Trade Law. Nicholas Institute for Environmental Policy Solutions Working Paper 07-02. Durham, NC: Duke University.

Parry, I.W.H. (2004). "Are Emissions Permits Regressive?" *Journal of Environmental Economics and Management* 47: 364–87.

Parry, Ian W.H. (2003). "Fiscal Interactions and the Case for Carbon Taxes Over Grandfathered Carbon Permits." *Oxford Review of Economic Policy* 19: 385-399.

Pizer, W.A. (2002). "Combining Price and Quantity Controls to Mitigate Global Climate Change." *Journal of Public Economics* 85(3): 409–434.

Pizer, W.A. (2007). "Scope and Point of Regulation for Pricing Policies to Reduce Fossil Fuel CO_2 Emissions." In: R. Kopp and W. Pizer, (eds.), *Assessing U.S. Climate Policy Options*. Washington, DC: RFF.

Pizer, W.A. (2006). "Practical Climate Policy." In: J.E. Aldy and R.N. Stavins, eds., *Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World.* Cambridge: Cambridge University Press, 280-314.

Pizer, W.A., D. Burtraw, W. Harrington, R. Newell, and J. Sanchirico (2006). "Modeling Economy-Wide Versus Sectoral Climate Policies Using Combined Aggregate-Sectoral Models." *The Energy Journal* 27(3): 135–168.

Pizer, W. and J. Sanchirico. (2007). "Regional Patterns of U.S. Household Carbon Emissions," RFF Discussion Paper. Washington: RFF.

Quirion, P. (2005). "Does Uncertainty Justify Intensity Emission Caps?" *Resource and Energy Economics* 27: 343–353.

Roberts, M.J. and M. Spence. (1976). "Effluent Charges and Licenses Under Uncertainty." *Journal of Public Economics* 5 (3,4): 193–208.

Samuelson, P.A. (1954). "The Pure Theory of Public Expenditure." *Review of Economics and Statistics* 36(4): 387–389.

Schmalensee, R. (1993). "Comparing Greenhouse Gases for Policy Purposes." *The Energy Journal* 14(1): 245–255.

Stavins, R.N. (1996). "Correlated Uncertainty and Policy Instrument Choice." *Journal of Environmental Economics and Management* 30: 218–232.

Stavins, R.N. (1998). "What Can We Learn from the Grand Policy Experiment? Lessons from SO_2 Allowance Trading." *Journal of Economic Perspectives* 12(3): 69-88.

Stavins, R.N. (2007). "A U.S. Cap-and-Trade System to Address Global Climate Change." Hamilton Project Discussion Paper 2007-13. Washington, DC: Brookings Institution.

Stern, N. (2007). *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press.

Sue Wing, I., A.D. Ellerman, and J. Song. (In press). "Absolute vs. Intensity Limits for CO_2 Emission Control: Performance under Uncertainty." In: H. Tulkens, and R. Guesnerie, (eds.), *The Design of Climate Policy*. Cambridge, MA: MIT Press.

Tietenberg, T. H. (1985). *Emissions Trading: Principles and Practice*. Washington: RFF Press.

Union of Concerned Scientists (2008). Renewable Electricity Toolkit. www.ucsusa.org/res.

U.S. Energy Information Administration. (2005). *Impacts of Modeled Recommendations of the National Commission on Energy Policy*. Report SR/OIAF/2005-02. Washington, DC: Department of Energy.

U.S. Energy Information Administration (2007). *Energy Market and Economic Impacts of S.280, the Climate Stewardship and Innovation Act of 2007*. Report SR/OIAF/2007-04. Washington, DC: Department of Energy.

U.S. Energy Information Administration. (2008). *Short-Term Energy Outlook, May 2008*. Washington, DC: Department of Energy.

U.S. Energy Information Administration (2008). *Energy Market and Economic Impacts of S.2191, the Lieberman-Warner Climate Security Act of 2007*. Report SR-OIAF/2008-01. Washington, DC: Department of Energy.

UNEP Riseo. (2007). CDM/JI Pipeline Analysis and Database, July 2007. Internet: http://cdmpipeline.org/. Accessed August 2, 2007.

United States Environmental Protection Agency (U.S. EPA). (2005). Clean Air Interstate Rule. Online: http://www.epa.gov/cair/index.html. Accessed December 11, 2007.

United States Environmental Protection Agency (U.S. EPA). (2007). *EPA Analysis of The Climate Stewardship and Innovation Act of 2007*. July 16, 2007 Draft. Washington, DC: U.S. EPA Office of Atmospheric Programs.

United States Environmental Protection Agency (U.S. EPA). (2008). *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2006*. Report 430-R-08-005. Washington, DC: U.S. EPA Office of Atmospheric Programs.

Victor, D. (2007). "Fragmented Carbon Markets and Reluctant Nations: Implications for the Design of Effective Architectures." In: J.E. Aldy and R.N. Stavins, (eds.), *Architectures* *for Agreement: Addressing Global Climate Change in the Post-Kyoto World.* Cambridge: Cambridge University Press, 133-160.

Wara, M. (2006). “Measuring the Clean Development Mechanism’s Performance and Potential.” Program on Energy and Sustainable Development Working Paper #56. Palo Alto, CA: Stanford University

Weitzman, M. (1974). “Prices vs. Quantities.” *Review of Economic Studies* 41(4):477–491.

Weitzman, M. L. (1978). “Optimal Rewards for Economic Regulation.” *American Economic Review* 68(4): 683-691.

Weitzman, M. (2007). “On Modeling and Interpreting the Economics of Catastrophic Climate Change.” Harvard University Department of Economics Working Paper. Cambridge, MA: Harvard University.

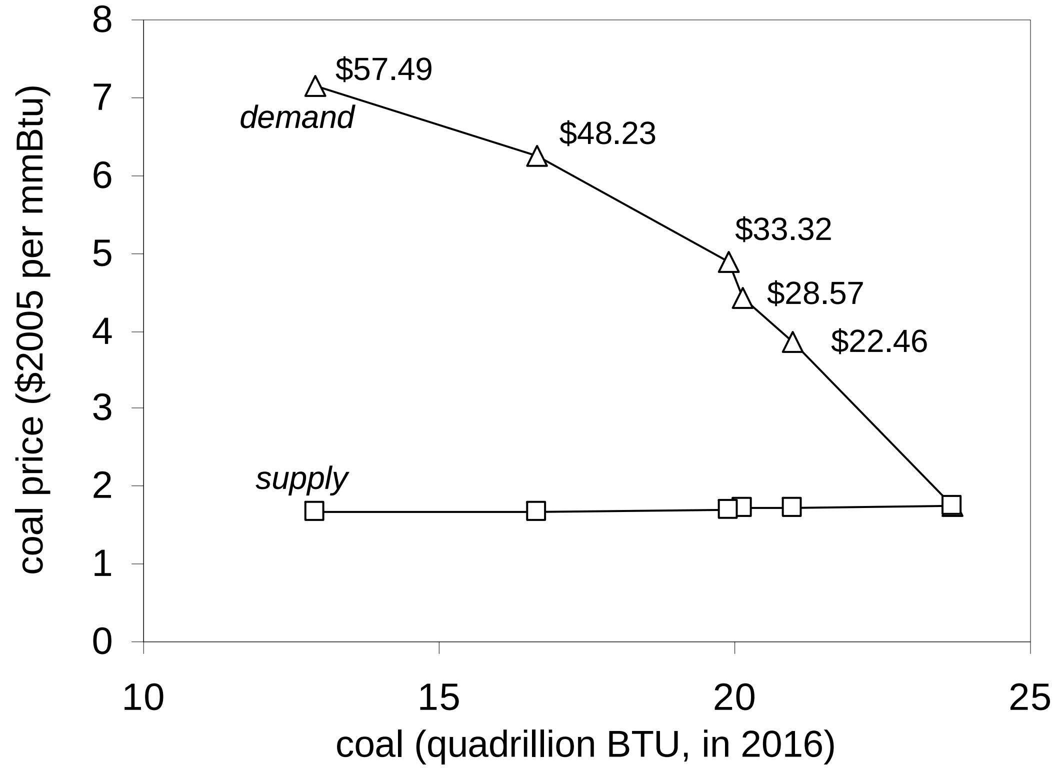
Weyant, J.P. and J. Hill. (1999). “The Costs of the Kyoto Protocol: A Multi-Model Evaluation, Introduction and Overview.” *The Energy Journal* Kyoto Special Issue: vii–xliv.

Weyant, J.P., F. de la Chesnaye, and G. Blanchard. (2006). “Overview of EMF-21: Multigas Mitigation and Climate Policy.” *The Energy Journal* Special Issue.

Wigley, T.M.L., R. Richels, and J.A. Edmonds. (1996). "Economic and Environmental Choices in the Stabilization of Atmospheric CO_2 Concentrations." *Nature* 379: 240–243.

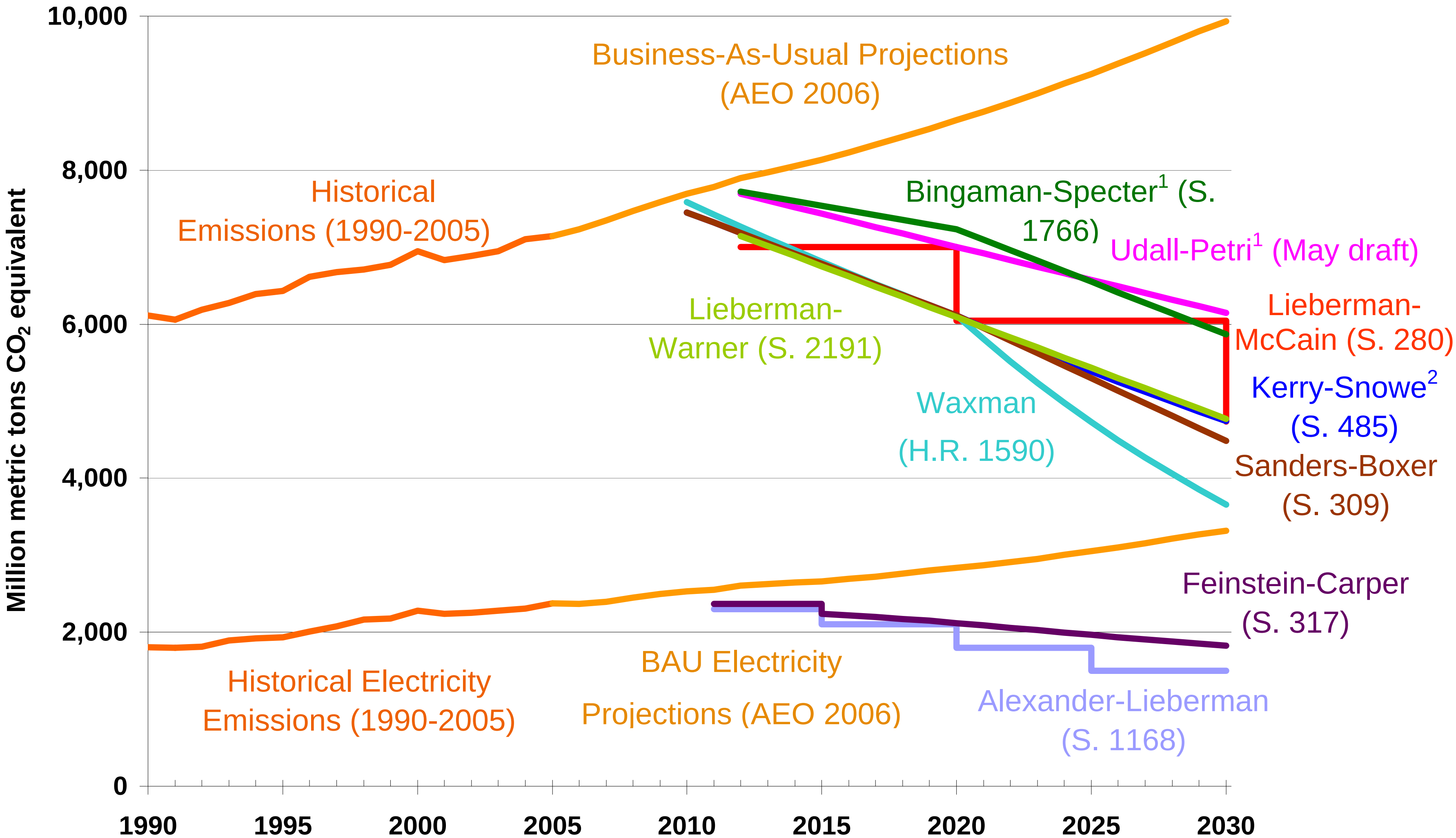
Yohe, G.W. (1978). “Towards a General Comparison of Price Controls and Quantity Controls Under Uncertainty.” *Review of Economic Studies* 45: 229–238.

Figure 1: Relationship between supply and demand in the coal market, as reflected in EIA (2008)



Note: Prices along demand schedule indicate CO_2 prices associated with different scenarios, in turn reflected by squares (supply) and triangles (demand) on each schedule. Supply and demand schedules reflect general equilibrium effects, with carbon prices on all fossil fuels

Figure 2. Comparison of Emission Reduction Goals in Legislative Proposals in the 110th Congress (as of 1/11/08)



<table>
<tr><th>Table 1.</th><th>Who's Regulated</th><th>Allowance Allocation</th><th>Cost Containment</th><th>Offsets</th><th>Technology</th><th>Competitiveness</th></tr>
<tr><td>Lieberman-Warner (S. 2191), as passed out of EPW</td><td>Economy-wide cap: coal and process emissions at emitters; oil refiners, NG processors, and oil/NG importers; and F-gas producers and importers. (Over 80% of US GHG emissions covered.) HFC producers and importers have a separate cap.</td><td>33% free to industry (including electric generators), with phase out; 11% to energy customers; 26.5% auctioned (gradually increased to 69.5%) to fund technology deployment, transition assistance, and adaptation; 9% set aside for CCS and sequestration; 10.5% to states; 5% for early action.</td><td>"Climate Fed" with discretion to increase use of borrowing and offsets and temporarily expand cap. Borrowing: up to 15% of allowances, for no more than 5 years.</td><td>Up to 15% of obligation can be met with domestic sequestration, and another 15% through international allowances and credits.</td><td>Technology deployment incentives for zero- and low-carbon generation, advanced coal, cellulosic biomass, and advanced vehicles (around 13% of allowance value). Plus 4% of allowances as bonus for CCS projects.</td><td>Bulk, energy-intensive imports from countries w/o comparable policy require "int'l reserve" allowances" (essentially a border tax) after 2020.</td></tr>
<tr><td>S. 3036, L-W substitute amendment</td><td>Adds coverage of NG produced in federal waters of Alaska Outer Continental Shelf. Otherwise identical.</td><td>32% free to industry w/ phase out; 13% to energy consumers; 28% used for federal programs, incl. technology, transition assistance, adaptation, and deficit reduction; 15% to states; 12% for CCS, sequestration, and early action.</td><td>Adds a reserve auction for 2012-2027 at $22-30 per metric ton. Establishes a floor price for regular auctions of $10/ton.</td><td>Domestic offsets for up to 15% of the annual cap; int'l offsets up to 5%; int'l forest carbon offsets up to 10%. Int'l allowances may be used if these limits not met, but total offsets limited to 30%.</td><td>Similar provisions but decreased funding (now around 10% of allowance value). 3% for CCS bonus allowances.</td><td>Allowances required starting in 2014. More imports covered, both primary products and manufactured goods.</td></tr>
<tr><td>Bingaman-Specter (S. 1766)</td><td>Economy-wide cap: coal and some industrial emissions at emitters; oil refiners, NG processors, and oil or NG importers; and F-gas producers and importers. (About 80% of emissions covered.)</td><td>53% free to industry (with phase out); 24% auctioned to support R&D, transition assistance, adaptation; 14% set aside for CCS and sequestration; 9% to states.</td><td>$12/metric ton CO_2 safety valve, rising at 5% per year above inflation.</td><td>Unlimited domestic offsets including methane and SF_6. Limits on international offsets (10% of cap) and domestic agricultural offsets (5% of cap).</td><td>Detailed technology development programs funded from allowance auction revenues (12-26% of auction revenues).</td><td>Bulk, energy-intensive imports from countries w/o comparable policy require permits after 8 years.</td></tr>
<tr><td>Udall-Petri (May draft and staff talks)</td><td>Economy-wide cap: upstream fossil-fuel sources (e.g., producers and importers), along with industrial emissions. (About 80% of emissions covered.)</td><td>20% free to industry. 80% auctioned to support RD&D; developing country engagement; adaptation, dislocation aid; sequestration; debt reduction.</td><td>$12/metric ton CO_2 safety valve, rising at 2-8% per year above inflation.</td><td>Unlimited geological sequestration offsets. 5% of allowances set aside to fund biological sequestration and 1% for CCS projects.</td><td>Establishes ARPA-E to fund technology advancement projects (24% of auction revenues).</td><td>Inaction by developing countries can justify delay in safety valve escalation.</td></tr>
<tr><td>Lieberman-McCain (S. 280)</td><td>Economy-wide cap: large downstream at emitter; transport emissions regulated at refinery. (Appr. 75% of emissions covered.)</td><td>Discretion of EPA, with guidance for some free allocation and an auction to fund R&D, transition assistance, adaptation measures.</td><td>Borrowing: up to 25% of allowances, for no more than 5 years.</td><td>Up to 30% of obligation can be met with domestic sequestration projects and international offsets.</td><td>Revenues from some auctioned allowances used for RD&D.</td><td rowspan="6">No provisions.</td></tr>
<tr><td>Kerry-Snowe (S. 485)</td><td rowspan="2">Economy-wide cap: point of regulation at discretion of EPA. (Coverage TBD by EPA.)</td><td rowspan="2">Discretion of the President with guidance from the EPA.</td><td rowspan="2">No provisions.</td><td>USDA sets rules for domestic biological sequestration.</td><td rowspan="3">Vehicle emission rules; efficiency & renewable standards for electric generation; additional bill-specific mandates.</td></tr>
<tr><td>Waxman (H.R. 1590)</td><td>No provisions.</td></tr>
<tr><td>Sanders-Boxer (S.309)</td><td colspan="4">Economy-wide cap: EPA has discretion to implement a market-based allowance program to achieve cap. (Coverage TBD by EPA.)</td></tr>
<tr><td>Feinstein-Carper (S. 317)</td><td rowspan="2">Electricity-sector cap: power plants. (The electricity sector is 34% of US GHG emissions.)
(S. 1168 also covers utility SO_2, NO_X, and mercury emissions.)</td><td>85% free to industry, based on generation (updated annually), and phased out by 2036.</td><td>Borrowing up to 10%, for no more than 5 years.</td><td>International offsets up to 25% of cap; extensive domestic biological offsets.</td><td>Distributes auction revenues to multitude of technology programs.</td></tr>
<tr><td>Alexander-Lieberman (S. 1168)</td><td>75% free to industry, based on heat input.</td><td>No provisions.</td><td>Domestic offsets in five categories, including methane, SF_6, efficiency, and forest sequestration.</td><td>NSPS for CO_2 emissions from new electric generation units.</td></tr>
<tr><td>Stark (H.R. 2069)</td><td rowspan="2">Economy-wide tax: fossil fuels taxed by CO_2 content at the point of production and import. (Almost 80% of US GHG emissions.)</td><td>100% revenues to US Treasury.</td><td>$3/metric ton CO_2, rising $3 annually.</td><td>Tax refunds for sequestered carbon: CCS, plastics.</td><td>No provisions.</td><td rowspan="2">Tax applied to fossil fuel imports; fossil fuel exports are exempt.</td></tr>
<tr><td>Larson (H.R. 3416)</td><td>1/6 of revenues to R&D, 1/12 to industry transition assistance (with phase out), remainder to payroll tax rebates.</td><td>$16.5/metric ton CO_2, rising 10% plus inflation annually.</td><td>Tax refunds for domestic sequestration and HFC destruction projects.</td><td>1/6 of tax revenues (up to $10B annually) for clean energy technology R&D.</td></tr>
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