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Climate Change: Design Approaches for a Greenhouse Gas Reduction Program

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Summary

With the passage of the 2005 Sense of the Senate climate change resolution calling on the Congress to enact a mandatory, market-based program to slow, stop, and reverse the growth of greenhouse gases, the issue of related costs has taken on increased importance. Indeed, the resolution itself states that the program should be enacted at a rate and in a manner that "will not significantly harm the United States economy" and "will encourage comparable action" by other nations. Facets of the cost issue that have raised concern include absolute costs to the economy, distribution of costs across industries, competitive impact domestically and internationally, incentives for new technology, and uncertainty about possible costs.

In general, market-based mechanisms to reduce greenhouse gas emissions, the most important being carbon dioxide (CO_2), focus on specifying either the acceptable emissions level (quantity) or compliance costs (price), and allowing the marketplace to determine the economically efficient solution for the other variable. For example, a tradeable permit program sets the amount of emissions allowable under the program (i.e., the number of permits available limits or caps allowable emissions), while allowing the marketplace to determine what each permit will be worth. Likewise, a carbon tax sets the maximum unit cost (per ton of CO_2 equivalent) that one should pay for reducing emissions, while the marketplace determines how much actually gets reduced. In one sense, preference for a carbon tax or a tradeable permit system depends on how one views the uncertainty of costs involved and benefits to be received.

Market-based mechanisms attempt to address the cost issue by introducing flexibility into the implementation process. The cornerstone of that flexibility is permitting sources to decide for themselves their appropriate implementation strategy within the parameters of market signals and other incentives. That signal can be as simple as a carbon tax or comprehensive credit auction that tells the emitter the value of any reduction in greenhouse gases, to a credit marketplace that is constrained by a ceiling price (safety valve) and includes incentives for new technology. As illustrated here, the combinations of market mechanisms are numerous, allowing decision makers to tailor the program to address specific concerns.

In a sense, the options discussed here represent a continuum between alternatives focused on the price side of the equation (e.g., carbon taxes) through hybrid schemes (e.g., safety valves) to alternatives focused on the quantity side (e.g., banking and borrowing). They are tools to assist in the assessment of potential greenhouse gas reduction approaches, leaving any policy decision on balancing the price-quantity issue to the ultimate decision makers.

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Climate change has been a continuing policy issue since the United States ratified the 1992 United Nations Framework Convention on Climate Change (UNFCCC). An integral part, and sometimes driving part, of the ensuing debate has been the issue of cost — in several manifestations.[1] For the George W. Bush Administration, the Kyoto Protocol was "fatally flawed in fundamental ways," including requiring compliance with mandates that "would have a negative economic impact with layoffs of workers and price increases for consumers."[2] This concern about cost can also be seen in the Senate's most recent resolution on climate change in 2005 (S.Amdt. 866). Echoing the language of its 1997 resolution (S.Res. 98) on the same subject, the 2005 Sense of the Senate resolution on climate change declared that a mandatory, market-based program to slow, stop, and reverse the growth of greenhouse gases[3] should be enacted at a rate and in a manner that "will not significantly harm the United States economy" and "will encourage comparable action" by other nations.[4] Facets of the cost issue that have raised concern include absolute costs to the economy, distribution of costs across industries, competitive impact domestically and internationally, incentives for new technology, and uncertainty about possible costs.

Because a stalemate has persisted on strategies to control greenhouse gas (GHG) emissions, particularly because of cost uncertainties, attention has increasingly focused on options to address these concerns and to move the debate forward. These options range from incremental mechanisms within a tradeable permit program, such as banking and borrowing of credits, that have a minimal effect on overall emission reduction targets goals to more fundamental proposals, such as a carbon tax, that would take climate change policy in a new and somewhat uncharted direction.

This paper explores these options to address the cost issue in four parts. First, the basic economic tradeoff between controlling the quantity of GHG emissions and the program's compliance costs is introduced and explained. Second, the five

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[1] For an analysis of federal policy and congressional debate since ratification of UNFCCC, see CRS Report RL30024, *Global Climate Change Policy: Cost, Competitiveness and Comprehensiveness,* by Larry Parker and John E. Blodgett.

[2] President George W. Bush, *President Bush's Speech on Global Climate Change* (June 11, 2001).

[3] The six gases recognized under the Kyoto Protocol are carbon dioxide (CO_2), methane (CH_4), nitrous oixde (N_20), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFC), and perfluorocarbons (PFC)

[4] S.Amdt. 866, passed by voice vote after a motion to table, failed 43-54, June 22, 2005.

dimensions of the cost issue that have arisen so far in the climate change debate are identified and discussed. Third, a representative sample of proposed aproaches to address cost concerns is compared and analyzed according to the five cost dimensions identified previously. Finally, the proposed options are summarized and opportunities to combine or merge different approaches are analyzed. The paper does not provide a detailed discussion of allocation and implementation issues that creating a market-based mechanism (particularly a cap-and-trade program) would entail.

Introduction: The Price Versus Quantity Debate

In general, market-based mechanisms to reduce GHG emissions, the most important being carbon dioxide (CO_2), focus on specifying either the acceptable emissions level (quantity) or compliance costs (price) and allowing the marketplace to determine the economically efficient solution for the other variable. For example, a tradeable permit program sets the amount of emissions allowable under the program (i.e., the number of permits available limits or caps allowable emissions), while permitting the marketplace to determine what each permit will be worth. Likewise, a carbon tax sets the maximum unit cost (per ton of CO_2 equivalent) that one should pay for reducing emissions, while the marketplace determines how much actually gets reduced. In one sense, preference for a carbon tax or a tradeable permit system depends on how one views the uncertainty of costs involved and benefits to be received.

For those confident that achieving a specific level of CO_2 reduction will yield significant benefits — enough so that even the potentially very high end of the marginal cost curve does not bother them — a tradeable permit program may be most appropriate. CO_2 emissions would be reduced to a specific level, and in the case of a tradeable permit program, the cost involved would be handled efficiently, though not controlled at a specific cost level. This efficiency occurs because through the trading of permits, emission reduction efforts focus on sources at which controls can be achieved at least cost.

However, if one feels more certain of the potential downside risk of substantial control costs to the economy than of the benefits of a specific level of reduction, then a carbon tax may be most appropriate. In this approach, the level of the tax effectively caps the marginal cost of control that affected activities would pay under the reductions scheme, but the precise level of CO_2 reduction achieved is less certain. Emitters of CO_2 would spend money controlling CO_2 emissions up to the level of the tax. However, because the marginal cost of control among millions of emitters is not well known, the overall emissions reductions for a given tax level on CO_2 emissions is subject to some uncertainty.

Hence, a major policy question is whether one is more concerned about the possible economic cost of the program and therefore willing to accept some uncertainty about the amount of reduction received (i.e., carbon taxes); or one is more concerned about achieving a specific emission reduction level with costs handled efficiently, but not capped (i.e., tradeable permits).

A model for a tradeable permit approach is the sulfur dioxide (SO_2) allowance program contained in title IV of the 1990 Clean Air Act Amendments (42 U.S.C. 7651). Also called the Acid Rain Program, the tradeable permit system is based on two premises. First, a set amount of SO_2 emitted by human activities can be assimilated by the ecological system without undue harm. Thus the goal of the program is to put a ceiling, or cap, on the total emissions of SO_2 rather than limit ambient concentrations. Second, a market in pollution licenses between polluters is the most cost-effective means of achieving a given reduction. This market in pollution licenses (or allowances, each of which is equal to 1 ton of SO_2) is designed so that owners of allowances can trade those allowances with other emitters who need them or retain (bank) them for future use or sale. Initially, most allowances were allocated free by the federal government to utilities according to statutory formulas related to a given facility's historic fuel use and emissions; other allowances have been reserved by the government for periodic auctions to ensure market liquidity.

There are no existing U.S. models of an emissions tax, although five European countries have carbon-based taxes.[5] The closest U.S. example is the tax on ozone-depleting chemicals (ODCs). To facilitate the phaseout of ODCs under the Montreal Protocol and subsequent amendments, the United States imposed a tax on specific ODCs in 1990. This tax was designed to supplement the allowance trading program that the EPA had designed to implement the international agreements. Several activities trigger the tax, including the production and import of the chemicals, along with the importation of products that contained them or used them in their production processes. In addition, inventories of certain ODCs held on January 1 of each year are subjected to a "floor stocks tax."[6]

Five Dimensions of the Cost Issue

Five dimensions of costs associated with reducing GHG emissions are discussed in this section: (1) absolute costs, (2) distribution of costs, (3) long-term costs, (4) price signal and stability, and (5) uncertainty of costs.

The *absolute costs* of a GHG reduction program are a function of the interplay among the tonnage reduction required, the timetable imposed on that reduction, and the techniques available and used to achieve that reduction (the "three Ts"). Variables involved with the tonnage requirement include the magnitude and firmness of the reduction requirement and the number of gases and sectors involved in the program. Variables involved with the timetable include its length and number of phases, along with the number and extent of any deadline extensions allowed and on what basis. Finally, variables involved with techniques include promotion and availability of new technology, the degree of flexibility permitted in complying with

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[5] Finland, the Netherlands, Sweden, Denmark, and Norway.

[6] For CFC-11 and 12, the current (2006) tax is $10.30 per pound. The floor stocks tax is $0.45 per pound (2006). For more specifics on the current tax level, see IRS Form 6627, *Environmental Taxes.*

the program, and any ceiling on compliance costs. All these program design parameters influence the absolute cost of the program and the timing and extent of any benefits received.

A second concern with costs is their *distribution* across the various sectors of the economy. As indicated by **Table 1**, GHG emissions are spread throughout the economy, with about 81% emitted by the electric power, transportation, and industry sectors. Restricting participation by any group could increase the absolute cost of the program and would certainly increase the costs to the remaining participants. However, numerous rationales have been put forward to justify excluding one group or sector from a reduction requirement, or to provide some other special consideration. Rationales offered include a sector or industry's concern about (1) international competitiveness, (2) lack of cost-effective control options, (3) inability to make necessary capital investments, (4) economic disruption, (5) credit for previous efforts that reduced emissions, and (6) the "minor" contribution that industry or sector makes to the overall problem. It is the multitude of such variables that make constructing an acceptable reduction allocation scheme very difficult.

Table 1. 2004 U.S. Greenhouse Gas Emissions

Economic Sector	Million Metric Tons of CO_2 equivalent	Percentage of Total
Electric power industry	2,338	33.3%
Transportation	1,955	27.9%
Industry	1,377	19.6%
Agriculture	491	7.0%
Commercial	460	6.6%
Residential	391	5.6%
Total	7,012	100.0%

Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004*, EPA 430-R-06-002 (Washington, DC), p. ES-13.

Note: The total does not include 62 million metric tons from U.S. territories.

A third concern is the *long-term cost* considerations of a GHG reduction program. Climate change policy has to be thought of in decades, not years. Ultimately, a successful climate change program would involve a long-term transition to a less carbon-emitting economy. Generally, studies that indicate the availability and cost-effectiveness of emerging new technologies to achieve this transition include an economic mechanism to provide the necessary long-term price signal to direct research, development, demonstration, and deployment efforts.[7] Developing such a price signal involves variables such as the magnitude and nature

[7] For example, see Interlaboratory Working Group, *Scenarios for a Clean Energy Future*, ORNL/CON-476 (November 2000).

of the market signal, and the timing, direction, and duration of it. In addition, studies indicate combining a sustained price signal with public support for research and development efforts is the most effective long-term strategy for encouraging development of new technology.[8] As stated by Morgenstern: "The key to a long term research and development strategy is both a rising carbon price, and some form of government supported research program to compensate for market imperfections."[9]

A fourth consideration is the stability of the *price signal* in whatever form it takes (e.g., allowance prices, carbon taxes, auction prices). A stable and reliable signal is necessary to minimize economic disruption and to encourage new technology. Experience with existing emissions markets suggests that short-term price spikes and troughs occur that have at least short-term economic effects, either disrupting the market (in the case of high prices) or discouraging new technology (in the case of low prices). Causes of this volatility can include (1) lack of trading volume, (2) illiquidity in the market, (3) external events, and (4) regulatory uncertainty. History with previous emissions trading programs suggests that if a greenhouse gas program is based on a market-based implementation strategy, the inclusion of flexibility mechanisms to ensure reasonable market stability is desirable.[10]

A final cost consideration is the *cost uncertainty* presented by the wide range of projected costs of GHG reduction. To the extent one understands the variables that create the range presented by different forecasting models, one can design a program to address those variables. Projected costs of a proposed greenhouse gas reduction program will differ among models, based on the various economic and technological assumptions either embedded in the particular model's processes (endogenous variables) or assumed externally and inserted into the model. Weyant has identified five assumptions that explain many of the differences in greenhouse gas reduction program cost estimates:[11]

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[8] For example, see *CERA Advisory Service, Design Issues for Market-based Greenhouse Gas Reduction Strategies; Special Report* (February 2006), p. 59; Congressional Budget Office, *Evaluating the Role of Prices and R&D in Reducing Carbon Dioxide Emissions* (September 2006).

[9] Richard D. Morgenstern, *Climate Policy Instruments: The Case for the Safety Valve* (Council on Foreign Relations, Sept. 20-21, 2004), p. 9.

[10] For example, see Dallas Burtraw, David A. Evans, Alan Krupnick, Karen Palmer, and Russell Toth, *Economics of Pollution Trading for* SO_2 *and NOx* (Resources for the Future, March 2005); David Harrison, Jr., *Ex Post Evaluation of the RECLAIM Emissions Trading Program for the Los Angeles Air Basin* (Organization for Economic Co-operation and Development, Jan. 21-22, 2003); and Andrew Aulisi, Alexander E. Farrell, Jonathan Pershing, and Stacy VanDeveer, *Greenhouse Gas Emissions Trading in U.S. States: Observations and Lessons from the OTC NOx Budget Program* (World Resources Institute, 2005).

[11] John P. Weyant, *An Introduction to the Economics of Climate Change Policy* (Pew Center on Global Climate Change, July 2000).

- Basecase projections of future GHG emissions and climate damages.
- The specifics of the reduction program examined (particularly the amount of flexibility permitted in complying with its mandates).
- How dynamic the model is, representing substitution possibilities by producers and consumers, including the turnover of capital equipment.
- How the rate and processes of technological change are modeled.
- How benefits are modeled.

Figure 1, below, illustrates how these and other variables (such as type of model used) can influence the estimated costs of climate change legislation. Measured by impact on GDP, the figure indicates impacts ranging from a positive 2% increase in GDP to a 4% decrease. Interestingly, the variables used in projecting cost and benefits are sufficiently robust to obscure a strong correlation between cost and reduction requirements.

The range indicated also reflects the perspectives and parameters assumed by the forecast authors. In a previous report, CRS noted that cost analyses are influenced by the perspective (or lens) through which one views the problem.[12] Analysts viewing climate change policy through a technological perspective see it as an impetus for improved efficiency through technology improvements in the economy, consistent with concepts such as life-cycle costs. Analysts viewing policy through an economic lens work through the boundaries of market economics and cost-benefit considerations. Finally, analysts viewing the issue through an ecological lens look to the benefits of controlling greenhouse gases and are suspicious of "baseline" scenarios that suggest that "business as usual" is an acceptable yardstick from which to measure policy changes. Each of these lenses implies fundamentally different ways of assessing policy actions and modeling potential costs and benefits. The quantitative result are cost estimates that range from actual savings to the economy (from GHG reductions) to substantial costs.

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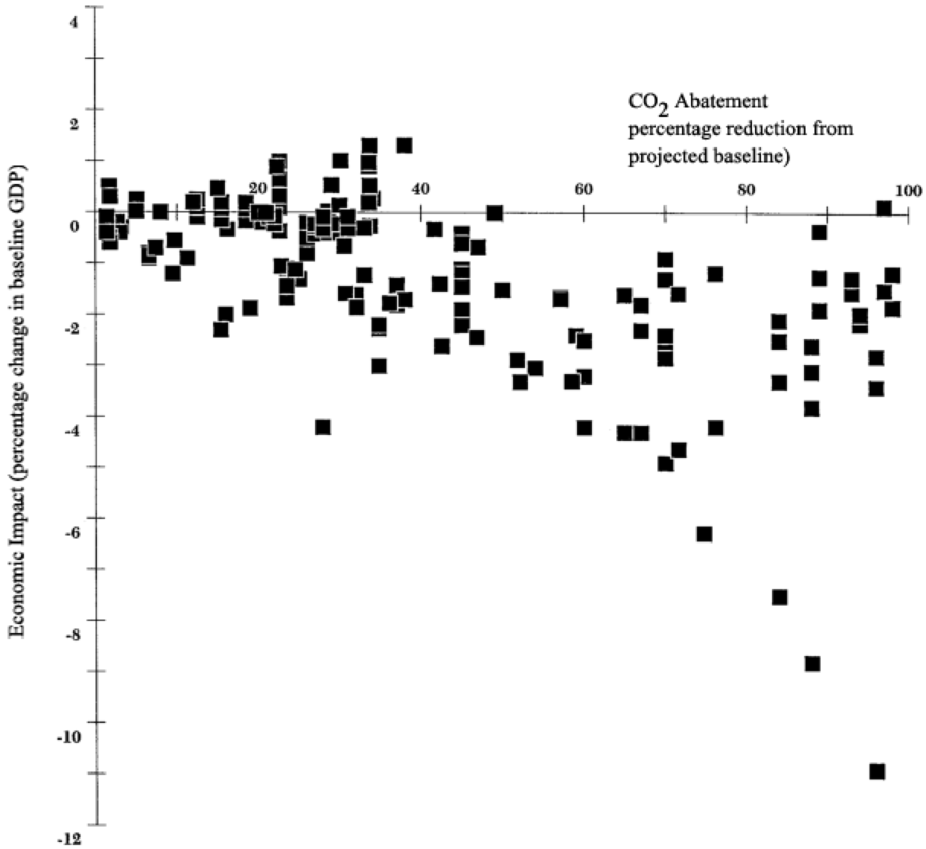
[12] See CRS Report 98-738, *Global Climate Change: Three Policy Perspectives*, by Larry Parker and John Blodgett.

Figure 1. The Predicted Impacts of Carbon Abatement on the U.S. Economy (162 Estimates from 16 Models)



Source: Robert Repetto and Duncan Austin, *The Costs of Climate Protection: A Guide for the Perplexed* (World Resources Institute, 1997), p. 12.

Approaches for Addressing Cost Concerns

The following analysis of options to address the cost concerns identified above is loosely arranged by the focus of the specific option: (1) the tonnage requirement, (2) the time frame, and (3) the techniques allowed for compliance. It should be noted that several options examined affect more than one of the "Ts." Also, the options are not mutually exclusive — many can be combined to create more refined options.

Tonnage Options

Much of the discussion on GHG reductions has focused on a historic baseline as the starting point for reductions. Assuming that the emissions inventory for a specific year is adequate to support a regulatory program (whether market-based or not), such a baseline is reasonable. Most existing emissions trading programs are based on a historic baseline with modifications. However, there are options to calculate a baseline that responds to economic events over time without necessarily compromising the tonnage cap. Also, the historic baseline can be eliminated in favor of different methods of achieving specific reductions.

Carbon Tax. The most radical approach to controlling costs and addressing the concerns identified above is to impose a carbon tax in lieu of proposed allowance trading programs. As discussed in the "Introduction," under a carbon tax, the costs are fixed by the legislation and the quantity of emissions reduced becomes the variable. Carbon taxes are generally conceived as a levy on natural gas, petroleum, and coal, according to their carbon content, in the approximate ratio of 0.6 to 0.8 to 1.0, respectively. However, the levy would not have to be imposed on the fuels themselves — proposals have been made to impose the tax downstream at the point where the fuel is converted into heat and CO_2. In addition, there is no reason why the tax could not be expanded to include all greenhouse gases in appropriate carbon equivalents.

A carefully designed carbon tax could potentially address all five of the concerns identified above. A carbon tax puts a limit on absolute cost by capping the marginal costs that participants should pay to reduce GHG emissions. Participants would receive a firm price signal with respect to the upper value of GHG emissions, and respond in the most cost-effective manner — that is, reduce emissions up to the cost of the carbon tax and pay the tax on any remaining emissions that are more expensive to eliminate.

A carbon tax can be tailored to address distributional concern in two ways. The first would be to exempt, either partly or completely, whatever sectors or industries were felt to be threatened, either competitively or otherwise, by imposing the tax. The current tax code provides numerous exemptions from various taxes for a variety of reasons. However, such an approach would create economic distortions and complicate the tax structure. The second approach would be to use some of the revenue generated by the tax to provide appropriate relief to targeted sectors or industries. This could involve increasing funding for existing programs for such sectors or industries, or creating new ones. In some ways, this approach might be more transparent than an approach that involves a potentially complicated tax structure. These approaches are not mutually exclusive; they could be combined if considered appropriate.

Likewise, a carbon tax can be employed to address long-term concerns in two ways. First, the carbon tax would create a long-term price signal to stimulate innovation and development of new technology. This price signal could be strengthened if the carbon tax were escalated over the long run — either by a statutorily determined percentage or by an index (such as the producer price index). Second, some of the revenue generated by the tax could be used to fund research, development, demonstration, and deployment of new technology to encourage the long-term transition to a less-carbon-intensive economy.

A carbon tax's basic approach to controlling GHG emissions is to supply the marketplace with a stable, consistent price signal — the fourth cost concern. Designed appropriately, there would be little danger of the price spikes or market volatility that can occur in the early stages of a tradeable permit program.

Finally, a carbon tax basically places an upper boundary on projected economic cost uncertainty. However, it increases uncertainty with respect to environmental benefits by making emission reductions a dependent variable. This is the basic tradeoff that a price-based control system presents. One way that might mitigate the problem to some extent would be to combine the carbon tax with some form of quantity controls. As noted earlier, the CFC program attached a tax to its trading program with beneficial results. However, it is the trading program, not the CFC tax, that is the primary regime for control. In this manner, a carbon tax would be more of a revenue raiser than a control regime. A second hybrid would be a "safety valve" that capped allowance prices such as proposed by the National Commission on Energy Policy.[13] That approach is discussed later in this report. The degree to which the problem is mitigated (and others created) depends on the interplay between the quantity control and the carbon tax.

Dynamic Tonnage Target. Another approach to address some of the concerns identified above is to calculate the tonnage target based on economic or other indexes or measures rather than strictly on a historic or other static baseline. For example, the National Commission on Energy Policy recommended that the tonnage requirements for a GHG reduction program begin with year 2000 emissions, with the future trajectory of emissions based on the product of a progressively declining limit on the country's GHG intensity times projected economic growth. Over time, the progressively more stringent carbon intensity index would produce progressively more stringent emission tonnage caps, despite projected increases in economic growth. The actual steepness of that path would depend on the rate of decline in carbon intensity mandated by the program and actual economic growth. Of course, the dynamic tonnage target could be indexed to just about any relative variable (e.g., energy prices).

Depending on the specifics of the methodology and measures used in creating it, the dynamic target could be more responsive to some unforeseen events, such as substantial economic growth, than a static baseline. At least in the short term, this could reduce costs and economic disruption if a sharp spike in economic growth were to occur. In contrast, slower-than-anticipated growth would reduce the available emission credits and thereby reduce the potential for "hot air" credits (i.e., credits "created" by a slowdown in the economy rather than by control efforts).[14]

By potentially mitigating some effects of a static, historic emissions baseline, a dynamic tonnage methodology allows flexibility in distributing reductions and the resulting costs among different sectors of the economy. Growth, GHG intensity, production, and other variables could be tailored for sectors, states, or regions based on specific concerns, such as competitiveness. For example, an industry growth index could be used to calculate reduction requirements rather

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[13] The National Commission on Energy Policy, *Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges* (December 2005), p. 21.

[14] Vicki Arroyo and Neil Strachan, *Addressing the Costs of Climate Change Mitigation*, presented at the Aspen Workshop: A Climate Policy Framework: Balancing Policy and Politics.

than an aggregated index such as GDP. Like most schemes, a dynamic target scheme could completely exclude some industries, with the obvious result of a shift in cost to the ones remaining in the program.

The effect of a dynamic target on long-term costs would depend on the slope of reductions mandated by the program. For example, the recommendation of the National Commission on Energy Policy called for an annual 2.4% reduction in allowable GHG intensity increasing to 2.8% annually after 10 years. This declining curve would be multiplied by a projection of presumably increasing economic growth. A steeper slope in GHG intensity mandates and/or an overly pessimistic projection of economic growth would strengthen the need for less carbon-intensive technology, but at the risk of increasing cost if those technologies did not arrive in a timely manner. A weak GHG intensity mandate and/or an overly optimistic projection of economic growth could reduce necessary emission reductions and provide a weak incentive for new technology.

A dynamic target would not necessarily prevent short-term fluctuations in the price signal, depending on the frequency of adjustments. If a target was based on macro-economic trends, such as GDP, it would not respond much to short-term or localized events, such as the 2000-2001 electricity shortage in California. Also, the mixture of indices with different vectors (e.g., GHG intensity reducing targets while economic growth is increasing targets) may create some uncertainty in markets regarding the appropriate price of credits.

Finally, a dynamic target would not increase the certainty of cost estimates. Uncertainty about the future trajectory of economic growth would be reflected in cost estimates (just as they are now, with emissions capped at historically determined levels). Likewise, benefit certainty would not improve for the same reason.

Expand Supply Options. The breadth of options permitted under a reduction program can have a significant effect on absolute costs. Legislation introduced in recent Congresses has ranged from programs based on one economic sector (e.g., electric utilities) and one greenhouse gas (e.g., carbon dioxide) to several sectors (including opt-in provisions) and all six greenhouse gases covered by the Kyoto Protocol.[15] Also, some proposed programs have included international trading of emission credits and biological sequestration offsets among the permissible means of complying with reduction requirements.[16] Some of these options, particularly international trading and sequestration, have included limits on their applicability. For example, the Regional Greenhouse Gas

[15] Carbon dioxide (CO_2), methane (CH_4), nitrous oixde (N_20), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFC), and perfluorocarbons (PFC).

[16] For more on sequestration approaches, see CRS Report RL33801, *Direct Carbon Sequestering: Capturing and Storing CO_2*, by Peter Folger.

Initiative[17] has put control cost triggers (characterized as "safety valves") on the availability of some supply options, such as sequestration.

Numerous analyses were done on the impact of global trading after the signing of the 1997 Kyoto Protocol. For the United States, the cost of complying with the Kyoto Protocol was estimated at $23-$50 per ton of carbon if global trading were included, versus $61-$119 if only trading among developed (Annex 1) countries were permitted. Cost estimates of "No trading" scenarios ranged from $193-$295 per ton.[18] Studies have suggested that, beyond international trading, including non-carbon dioxide greenhouse gases and sequestration in the supply mix can play an important and cost-effective role in any climate change program.[19]

Expanding supply sources could help industries that do not have readily accessible means of reducing greenhouse gases on their own by providing them with additional options and making the credit market more liquid. To the extent the expanded supply sources help create an integrated market with a true market price for credits, industries could avoid very high compliance costs and lessen the impact of those costs on their profitability. However, if competitors in other countries do not have to reduce emissions at all (as is currently the case with the Kyoto Protocol), competitive disadvantage would remain in some cases.

The degree to which expanded supply options would contribute to a long-term and stable price signal would depend on how integrated these sources are in the overall permit market. For example, with the European Trading System (ETS), there are separate markets for credits created within the 15 members of the European Union (EU) covered by the EU bubble, credits created by Joint Implementation with eastern European countries, and credits created via the Clean

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[17] The Regional Greenhouse Gas Initiative (RGGI) is an initiative of currently seven northeastern states to reduce GHG emissions. A signed 2005 memorandum of agreement (MOU) requires the parties to stabilize and then reduce CO_2 emissions from powerplants, implemented through an allowance-based cap-and-trade program. If the allowance price rises above $7, offsets from outside the region may be used for compliance purposes at a 1:1 ratio, with the generator able to cover up to 5% of its emissions. (If below $7, such offsets are discounted 50% and the compliance limit is 3.3% of a generator's emissions. If the allowance price exceeds $10, offsets from international projects could be used to cover up to 20% of a generator's emissions.) For more information, see [http://www.rggi.org].

[18] For a review of these estimates, see CRS Report RL30285, *Global Climate Change: Lowering Cost Estimates through Emissions Trading — Some Dynamics and Pitfalls*, by Larry Parker (available from the author).

[19] For example, see John Reilly, Marcus Sarofim, Sergey Paltsey, and Ronald G. Prinn, *The Role of Non-CO2 Greenhouse Gases in Climate Policy: Analysis Using the MIT IGSM*, MIT Joint Program on the Science and Policy of Global Change, Report No. 114 (August 2004); MIT Joint Program on the Science and Policy of Global Change, *Multi-gas Strategies and the Cost of Kyoto*, Climate Policy Note 3 (April 2000); Vincent Gitz, Jean-Charles Hourcade, and Philippe Ciais, "The Timing of Biological Carbon Sequestration and Carbon Abatement in the Energy Sector Under Optimal Strategies Against Climate Risks," 27 *The Energy Journal* 3 (2006), pp. 113-133.

Development Mechanism (CDM) with Third World countries.[20] One type of credit can not be traded for another. The result is a range of credit prices, reflecting the relative risk and availability of the various credit types. Thus, the long-term signal being delivered is currently unclear, and may take time to develop. Likewise, substantial fluctuations in the EU credit market have not been stabilized by the existence of the other two credit types.

In some ways, expanding supply options may increase the uncertainty of cost estimates, not only because of disparity in assumed reduction costs, but also in assumed availability and penetration of the options themselves. For example, emission reductions via the Clean Development Mechanism could be substantial and very cost-effective. However, the mechanism itself creates uncertainty with respect to availability, as does the willingness of foreign governments to participate. It is difficult to quantify the effect such an option could have on costs without some track record, as is slowly being built by the ETS.

Timetable Options

Similar to the country's three-plus decades effort to reduce smog, climate change promises to be an effort measured in decades, not years. Unlike conventional pollution control efforts, the environmental benefit of mitigating climate change would come from a reduction in the stock of greenhouse gases that have built up in the atmosphere for decades, whereas the economic costs of control are related to the current flow of additional gases into the atmosphere. Thus, in a situation similar to protecting the stratospheric ozone layer, there would be a substantial delay between control costs and environmental benefits. Indeed, if short-term reductions in the stock of greenhouse gases were the focus of climate change policy, control efforts would be focused on controlling methane, which has a 20-year lifetime, compared with CO_2, which has a 200-year lifetime. Likewise, temporary measures, such as biologic sequestration, would be accelerated with the assumption that new technology would be available in the future to capture the biologically sequestered carbon dioxide when it is released decades from now.

This situation leads to disputes over how time should be managed under a GHG reduction program. One argument is that modest cuts (or slowing of the increase) early, followed by steeper cuts later, is the most cost-effective. Generally, three cost-related arguments are made in favor of this approach. First, over the long-term, sustained GHG reductions involve a turnover in existing durable capital stock — a costly process. If the time frame of the reduction is long enough to permit that capital stock to be replaced as it wears out, the transitional costs are reduced. Second, increased time to comply would permit the development and deployment of new, less carbon-intensive technologies that are more cost-effective than existing technology. Third, assuming a positive rate of

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[20] For more on the ETS, see CRS Report RL33581, *Climate Change: The European Union's Emissions Trading System (EU-ETS)*, by Larry Parker.

return on current investment, less money needs to be set aside today to meet those future compliance costs.[21]

A counter argument to the above focuses on the risks of delay, both in terms of scientific uncertainty and technology development. In terms of scientific uncertainty, there is no consensus on what concentration of greenhouse gases should not be exceeded in order to avoid undesirable climate change. If the stabilization level needed is relatively low, any delay in beginning reductions could be costly, both economically and environmentally.[22] Secondly, given the sometimes long lead times for technology development, both a long-term price signal and research and development funding may have to be initiated quickly to encourage technology development and deployment in time to hold GHG concentrations to a level that avoids unacceptable damages. In the same vein, an early signal with respect to climate change policy is necessary to discourage investment in durable long-lived (50-60 years) carbon-intensive technologies.[23] As stated by Jaccard and Montgomery:

> The window of opportunity for reducing cost implies a need for immediate and continuing action to develop new low-carbon technologies and to begin shifting long-lived investment decisions toward alternatives that lower carbon emissions. Absent these actions, the rapid future emissions reductions included in the delayed emissions scenario may be more costly than more evenly paced, and earlier reductions.[24]

Economic-Based Circuit Breaker. Delaying or suspending compliance with environmental mandates because of energy and economic reasons is not a novel idea. The Clean Air Act contains provisions permitting the President, in response to a petition by an affected state's governor, to temporarily suspend any part of a state implementation plan or enforcement of the SO_2 trading program, to address a severe national or regional energy emergency.[25] For example, during the 2000-2001 California energy crisis, President Clinton directed all federal agencies to do their part to assist the state in meeting its electricity demand. For its part, the EPA revised its guidance on emergency generators to allow backup generators to be used to avert a power blackout.[26] Previously, backup generators could be

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[21] Robert Repetto and Duncan Austin, *The Costs of Climate Protection: A Guide for the Perplexed* (World Resources Institute, 1997), p. 21.

[22] CERA Advisory Service, *Design Issues for Market-based Greenhouse Gas Reduction Strategies: Special Report* (February 2006), pp. 54-55.

[23] CERA Advisory Service, *Design Issues for Market-based Greenhouse Gas Reduction Strategies: Special Report* (February 2006), pp. 54-55; Robert Repetto and Duncan Austin, *The Costs of Climate Protection: A Guide for the Perplexed* (World Resources Institute, 1997) p. 22.

[24] M. Jaccard and W.D. Montgomery, "Costs of Reducing Greenhouse Gas Emissions in the USA and Canada," 24 *Energy Policy* 10/11 (1996), pp. 889-898.

[25] The Clean Air Act (42 U.S.C. 7401-7626), Section 110(c)(5)(C).

[26] U.S. Environmental Protection Agency, Letter to California Independent System Operator

(continued...)

used only when the power was actually interrupted. The increased flexibility permitted by the EPA during the emergency meant more power at the expense of more pollution (particularly of carbon monoxide and nitrogen oxides).

Likewise, market-based systems are not immune to being suspended if economic or energy conditions turn severe. A contributing factor in the California power crisis was the Regional Clean Air Incentives Market (RECLAIM), a credit trading system for reducing nitrogen oxide (NOx) emissions. RECLAIM was established in 1994 to provide flexibility for companies in the South Coast (Los Angeles) area as controls on NOx, a major contributor to smog formation, were tightened. Because of record electricity demand in 2000, electric generators in the South Coast area generated more power than they did in the base period, resulting in utilities buying RECLAIM trading credits in unprecedented quantities. As a result, the price of credits rose from less than $1 per pound of NOx in January 2000 to more than $60 per pound of NOx by March, 2001.[27] To solve this problem, in March 2001, the South Coast Air Quality Management District amended RECLAIM to remove large power plants from the trading system and required owners of such facilities to reduce emissions under a mandated command-and-control regime. Such facilities are scheduled to return to the trading system in 2007.[28]

Proposals have been made to formalize a "circuit breaker" into any GHG reduction program. In general, proposals envision a declining emission cap system where the rate of decline over time is determined by the market price of permits. If permit prices remain under set threshold prices, the next reduction in the emissions cap is implemented. If not, the cap is held at the current level until prices decline.[29] Such a cap could be implemented on an economy-wide basis or by sector or other relevant grouping.

Because the conditional reduction approach attempts to turn both the price and the quantity of reductions into variables solved by the trading market, its effect on cost depends on a host of variables — most obviously the profiles of the emission reduction targets and the price triggers. For example, the price trigger could be based on the spot-market price, the long-term market price, or some hybrid price mechanism. Also, the reliance on the market to either directly or indirectly determine price and quantity puts pressure on regulators to oversee operations and prevent any market manipulation designed to slow emission reductions.

A conditional tonnage target could address distributional issues if its tonnage targets and timetable triggers are tailored for specific sectors or industries. This

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[26] (...continued)
Corporation (August 12, 2000).

[27] "RECLAIM Poised for Major Changes," *Executive Brief* (New York: Evolution Markets), pp. 1-2.

[28] South Coast Air Quality Management District, Governing Board Meeting (Jan. 7, 2005).

[29] See Clean Power Group website, [http://www.eea-inc.com/cleanpower/index.html].

would substantially increase the complexity of the scheme and potentially risk bifurcation of the permit market. As with other permit schemes discussed here, another approach to addressing distributional concerns under a conditional tonnage target would be to simply exempt certain sectors from its mandates.

When the control regime responds to relatively short-term events, it may not provide the long-term price signal necessary to promote long-term solutions. The elastic time frame also gives ambiguous signals for planning the appropriate pace and scope of research and development efforts. In contrast, the regime's focus on short-term economic disruption may help in damping short-term volatility in the allowance market. As noted, the responsiveness of the price and timetable triggers would determine how effective the program would be in avoiding such disruption.

In reducing the uncertainty for cost estimates, the scheme introduces about the same number of new uncertainties as it does in reducing others. The circuit breaker prevents ever increasing costs, although with some undetermined lag time. However, it is difficult to estimate absolute costs because one does not know how often it will be used.

The scheme also increases uncertainty about the future trend in benefits by making the quantity of emissions reduced a variable. A short-term break might not make much of a difference, particularly if participants were required to make up the emissions later. However, it introduces uncertainty into the system that would be difficult to quantify.

Technology-Based Timetable. Another approach to increase flexibility in the system and encourage long-term technology development would be to provide special compliance schedules for entities deploying innovative, less carbon-intensive technologies. An example of this possibility is Section 409 of Title IV of the 1990 Clean Air Act Amendments.[30] Under Section 409, utilities choosing to meet their sulfur dioxide reduction requirements by installing a qualifying clean coal technology receive a four-year extension on the program compliance deadline. During the extension, the affected emitter is allowed to operate under existing regulations and operating conditions. If the technology fails to operate as designed, the affected unit may be retrofitted with another qualifying technology or with an existing control technology. For a GHG reduction program, a qualifying technology could include geologic sequestration, emerging energy efficient technology, or advanced solar power.

A technology extension could reduce costs in two ways. First, the delay in compliance itself would reduce cost by allowing the affected company more time to gather resources and optimize a compliance plan. Second, to the extent the delay encourages more cost-effective approaches to GHG reductions, compliance cost and long-term cost would be reduced. Of course, the risk is that the delay will not result in successful technology development. Indeed, it is likely that at least some of the projects would fail — that is the nature of innovation. However,

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[30] P.L. 101-559, Title IV, Section 409 (1990).

because technology development is crucial to long-term reductions in greenhouse gases, some may feel the risk is worth it.

Assistance with distributional costs under this option would depend on the opportunities for new technology in given sectors of the economy. Although some industries may have potentially cost-effective technology-fixes, such as geologic sequestration, others may involve long-term structural changes.

Of course, the focus of a technology-based timetable is to provide a long-term signal to the market encouraging new technology. Such a signal could be strengthened significantly with increased government funding of projects.

Because this option is focused on new technology, it would seem likely to have little effect on short-term price volatility. However, there may be a risk that the temporary removal of significant emitters from the market-system in response to the incentive could increase short-term volatility and uncertainty by diminishing permit demand and trading volume.

It is difficult to determine the effects of this option on cost estimates. It would depend on how widespread the assumed participation rate is.

Technique Options

Most current GHG reduction proposals assume a market-based implementation strategy — generally a permit trading program. This is not surprising, as flexibility and new technologies are considered the keys to a cost-effective implementation strategy over the long run. Generally, technique options range from making a tradeable permit program more flexible through mechanisms like banking, to creating a hybrid program where the regime shifts from a quantity-based permit program to a carbon tax, depending on defined circumstances.

Banking and Borrowing. Most existing trading programs include provisions for banking credits for either future use or future sale. Indeed, the absence of effective banking in the RECLAIM program (discussed earlier) is credited with contributing to RECLAIM's suspension during the California energy crisis. As summarized by Resources for the Future (RFF):

> Allowance banking has been an essential component of the SO_2 program. Its absence is a costly feature of the NOx programs, eroding the opportunity for cost savings from interannual trading and contributing directly to the suspension of trading in RECLAIM.[31]

Banking and borrowing reduces the absolute cost of compliance by making annual emission caps flexible over time. The limited ability to shift the reduction

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[31] Dallas Burtraw, David A. Evans, Alan Krupnick, Karen Palmer, and Russelll Toth, *Economics Pollution Trading for SO2 and NOx,* RFF Discussion Paper 05-05 (March 2005), p. 45.

requirement across time allows affected entities to better accommodate corporate planning for capital turnover and technological progress, to control equipment construction schedules, and to respond to transient events such as weather and economic shocks. Generally, banking and borrowing would not have any direct impact on distributional concerns, which are more directly determined by initial allocation decisions. Banking and borrowing can help provide a long-term market signal by supporting credit prices when costs are lower than expected.[32]

The flexibility provided by banking and borrowing, as noted, can help damp short-term volatility. The degree that they help is disputed. As discussed later, some argue that banking and borrowing may provide sufficient flexibility in some cases to keep market disruptions to a minimum.[33] However, others argue that if a program involves more than modest reductions, a more robust "safety valve" is preferable.[34]

In estimating costs, banking and borrowing help smooth out the reduction requirement, as witnessed by the current acid rain program. This economically desirable effect does not necessarily reduce the uncertainty in cost estimates because estimators will make different assumptions about the extent to which banking and borrowing are used by emitters. The smoothing effect, however, has no effect on the reduction requirement (in contrast with several of the other alternatives discussed here). This is a major reason why this alternative is generally favored by those whose priority is to achieve specific reductions.

Auctioning Permits. Auctions can be used in market-based pollution control schemes in several different ways. For example, Title IV of the 1990 Clean Air Act Amendments uses an annual auction to ensure the liquidity of the credit trading program. For this purpose, a small percentage of the credits permitted under the program are auctioned annually, with the proceeds returned to the entities that would have otherwise received them. Private parties are also allowed to participate. A second possibility is to use an auction to raise revenues for a related (or unrelated) program. For example, the Regional Greenhouse Gas Initiative (RGGI) is exploring an auction to implement its public benefit program to assist consumers or pursue strategic energy purposes.[35] A third possibility is to use auctions as a means of allocating some, or all, of the credits mandated under a GHG control program. In examining a modified auction program, RFF found that an auction scheme is "dramatically more cost-effective" in allocating credits than

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[32] Henry D. Jacoby and A. Denny Ellerman, *The Safety Valve and Climate Policy*, MIT Joint Program on the Science and Policy of Global Change, Report No. 83 (July 2002), p. 9.

[33] Henry D. Jacoby and A Denny Ellerman, *The Safety Valve and Climate Policy*, MIT Joint Program on the Science and Policy of Global Change, Report No. 83 (July 2002), p. 1.

[34] Richard D. Morgenstern, *Climate Policy Instruments: The Case for the Safety Valve*, Council on Foreign Relations (Sept. 2004), p. 10. This option is discussed further below.

[35] See Dallas Burtraw and Karen Palmer, *Summary of the Workshop to Support Implementing the Minimum 25 Percent Public Benefit Allocation in the Regional Greenhouse Gas Initiative*, RFF Discussion Paper DP 06-45 (Sept. 2006).

either a grandfathered allocation method[36] or a generation performance standard[37] (GPS) approach.[38] Obviously, the impact that an auction would have on the cost dimensions identified earlier would depend on how extensively it was used in any GHG control program, and to what purpose the revenues were expended.

The cost-effectiveness of an auctioning system results from allowing the marketplace to allocate credits. However, unlike a carbon tax, the market-clearing price for credits is not limited (unless the system is combined with a safety valve, as discussed below). Hence, an auction for credits would be more expensive for specific industries than under a historically based grandfathered system, where they would receive their credits free. Likewise, the price consumers pay may be greater, depending on the companies' ability to pass on their additional costs to them. However, when the substantial revenues received by the auctions are considered, auctions are more cost-effective than grandfathered or GPS systems. As stated by RFF:

> The bottom line is that the AU [auction] approach weighs in at substantially less economic cost to society than either of the two gratis approaches to allocating allowances.... AU also provides policymakers with flexibility, through the collection of revenues that can be used to meet distributional goals or to enhance the efficiency of the AU even further by reducing pre-existing taxes. Because the AU approach is so cost-effective, a corresponding a [sic] carbon policy will have less effect on economic growth than under the other approaches. This attribute provides the most significant form of distributional benefit.[39]

As noted by RFF, the revenues from an auction can be used to address a host of distributional concerns. Indeed, as noted earlier, the auction could be tailored to raise only as much as necessary to address those concerns (as with RGGI funding of public benefits programs) or made more comprehensive to address credit allocation.

In terms of a long-term price signal, the type of auction employed would have some effect. Likewise, it would have an effect on the stability of that price signal.

An auction could provide substantial incentive for new technology if the auction is structured to encourage a long-term and stable price signal and if revenues received are at least partly directed toward research, development, and demonstration programs.

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[36] Used in the SO_2 trading program, credits are allocated gratis to entities in rough proportion to their historic emissions.

[37] Also called an output-based allocation, credits are allocated gratis to entities in proportion to their relative share of total electricity generation in a recent year.

[38] Dallas Burtraw, Karen Palmer, Ranjit Bharvirkar, and Anthony Paul, *The Effect of Allowance Allocation on the Cost of Carbon Emission Trading*, RFF Discussion Paper 01-30 (August 2001).

[39] Burtraw et al., *Allowance Allocation*, p. 30.

An auction would probably not reduce the uncertainty with costs, because differing assumptions could be made about the actual operation of the auction, its efficiency, and the effectiveness of the recycled revenues. However, an auction would not have any effect on benefits received by the program, unless it was joined with a safety valve or other limit on auction prices.

Safety Valve. The purpose of a safety valve is to limit the costs of any climate change control program (price) at the potential expense of reductions achieved (quantity). Safety valves encompass a variety of carbon tax-tradeable permit hybrid schemes. Perhaps the most publicized version is that recommended by the National Commission on Energy Policy.[40] The Commission scheme would be implemented through a flexible, market-oriented permit trading program. The total number of permits each year would be based on a mandated decline in GHG intensity and projected GDP growth. However, the scheme includes a cost-limiting safety valve that allows covered entities to make a payment to the government in lieu of reducing emissions. The initial price of such payments would be $7 per ton in 2010. Thus, if a covered entity chooses, it may make payments to the government at a specific price rather than make any necessary emissions reductions.

Effectively, a safety valve places a ceiling on compliance costs — in that way, it acts like a carbon tax. To the extent an entity's control costs, or the permit market, remain below the safety valve, the scheme acts like a tradeable permit program. The degree to which a safety valve reduces costs would depend on the extent to which it is used by entities (e.g., who do not have a cost-effective alternative). However, the complex interactions involved in a scheme that includes both price and quantity controls should not be underestimated. As stated by Jacoby and Ellerman:

> The usefulness of the safety valve depends on the conditions under which it might be introduced. For a time, it might tame an overly stringent emissions target. It also can help control the price volatility during the introduction of gradually tightening one, although permit banking can ultimately serve the same function. It is unlikely to serve as a long-term feature of a cap-and-trade system, however, because of the complexity of coordinating price and quantity instruments and because it will interfere with the development of systems of international emissions trade.[41]

In contrast, Morgenstern argues that the complexity is worth it in preventing price spikes, particularly if a substantial reduction in emissions is envisioned: "If only modest reductions are undertaken, a system of banking and offsets is likely to be adequate in preventing price spikes. In order to achieve more ambitious targets, however, the safety valve is clearly preferred."[42]

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[40] The National Commission on Energy Policy, *Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges* (December 2005).

[41] Jacoby and Ellerman, *The Safety Valve and Climate Policy*, p. 1.

[42] Richard D. Morgenstern, *The Case for the Safety Valve*, p. 10.

To address distributional concerns, a safety value could be tailored for specific sectors to address concerns about cost-effective reduction options or competition. In addition, to the extent the safety valve created revenues, some of the funds raised could be recycled to affected parties.

The effect of a safety valve on new technologies reflects the complexity discussion above. If a low safety valve price was chosen (meaning it would keep compliance costs low), it could have a dampening effect on long-term development of new technology. By creating a ceiling on the value of GHG reductions, but providing no floor for those reductions, a weak market signal may be sent. This might be offset to some degree if funds collected by the safety valve were directed toward new technology, but marketing of any resulting technology might still be difficult if the market price is held low.

A safety valve would dampen the possibility of an upward spike in credit prices — indeed, it is a major reason for considering such an option. However, it would not affect any volatility occurring below the safety valve value and have no effect on a collapse in credit prices. By the same token, the safety valve would put an absolute limit on the projected costs of the program at the level of the safety valve. However, it would do this at the expense of certainty in terms of reductions achieved.

Illustrative Approaches

The selected options discussed above are summarized in **Appendix A**. As suggested, the various options identified have different strengths and weaknesses, depending on the facet of costs one wants to address. Fortunately, many of the options are not mutually exclusive, nor do they require complete adoption — parts of individual approaches can be combined with other parts to meet program specifications in terms of firmness of the goal (also called the "hardness" of the emissions cap) and time frame.

To illustrate, a program focused on achieving a specific tonnage reduction with some flexibility in implementation but not in a manner that threatens the integrity of the cap could incorporate several of these options. The most obvious mechanism to include in the quantity-based cap-and-trade would be banking and borrowing options that would increase flexibility of the program across time without any deterioration in the tonnage requirement. Flexibility and protection against price increases could be enhanced by expanding supply options to include all greenhouse gases, sequestration, and international trading. Depending on one's confidence in the individual supply options, use could be restricted to a maximum percentage of reduction achieved through the option (common in many proposals) or to a more flexible percentage restraint based on credit prices (as proposed by RGGI). Proper monitoring and enforcement could minimize any potential effect on the cap.

This illustration would not necessarily provide either the long-term price signal or funding necessary for new technology. One supplemental option that could help mitigate this problem would be credit auctions. Auctions would have no effect on the cap, but would provide the program with a revenue flow that could be at least partly directed toward research and development. The auction could be designed to raise revenues only by auctioning a small percentage of the credits (such as the current acid rain program), or be comprehensive and auction all credits, thus improving overall economics and providing a clear market signal (as is being proposed by New York to meet its RGGI requirements). In the latter case, coordinating the auction with any trigger price mechanism for expanded supply options would ensure harmonious implementation. Depending on the structure of the auction chosen, the comprehensive auction would also provide a clear market price for reductions and, with the addition of forward markets, some indication of the general direction of those prices.

Finally, the auction and its resulting revenues could also be used to address pressing distributional cost issues. While the mixture of options used in this illustration could potentially mitigate several of the cost issues identified here, it would not provide cost certainty. The quantity side of the equation is the controlling factor under this illustration — prices could be tempered by the market flexibility introduced by the options, but actual costs would not capped.

In contrast, a more price-oriented illustration could employ a safety valve to place an absolute limit on credit prices. In such a hybrid system, the focus of the program is the safety valve limit as much as any tonnage cap. The quantity-based limits of the emissions cap determine the probability that the safety valve would be triggered, assuming a well-functioning market. However, in addition to the supply-demand dynamic that the credit market will reflect, any market failure or disruption resulting from external events could trigger the safety valve for participants. Ultimately, quantity is subordinate to price.

One can potentially reduce the probability that the safety valve would be invoked by including several of the other options discussed here. Expanding supply options would enlarge the pool of available reductions and potentially improve the stability of the credit market if properly integrated. Employing a dynamic tonnage target or an economic-based circuit breaker could help address any economic growth spike that might trigger the safety valve. The question of using these options in a safety valve program is whether they would affect the cap more or less than invoking of the safety valve. In contrast, borrowing and banking would help stabilize markets without having any effect on the cap.

Like the illustration above, this approach would not necessarily promote new technology — indeed the safety valve could discourage such development, unless it generated revenue that was directed toward research and development. If revenues were deemed insufficient for new technology (and to address distributional concerns if desired), the safety valve program could be supplemented with an auction. However, in any case, this illustration is driven by price concerns — concerns that make coordinating new technology development and minimizing impacts on the emission cap difficult.

A final illustration could also be the simplest — imposition of a carbon tax. The clear focus of the program would be the level of the tax, the steepness of any future increases in the tax, and who has the pay the tax. As noted earlier, it could be crafted to address all the cost concerns identified in this report; however, it would represent a new direction in U.S. climate change and current international efforts.

Addressing Costs Through Market Mechanisms: Resolving the Price-Quantity Issue

The fundamental policy assumption that has changed between the U.S. ratification of the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and the current Bush Administration's decision to abandon the Kyoto Protocol process concerns costs.[43] The ratification of the UNFCCC was based at least partially on the premise that significant reductions could be achieved at little or no cost. This assumption helped to reduce concern some had that the treaty could have deleterious effects on U.S. competitiveness — a significant consideration because developing countries are treated differently from developed countries under the UNFCCC. Further ameliorating this concern, compliance with the treaty was voluntary. While the United States could "aim" to reduce its emissions in line with the UNFCCC goal, if the effort indeed involved substantial costs, the United States could fail to reach the goal (as has happened) without incurring any penalty under the treaty. This flexibility would have been eliminated if the United States had ratified the Kyoto Protocol with its mandatory reduction requirements; the Bush Administration cited this lack of flexibility as a major reason for rejecting the Kyoto process.

With the passage of the 2005 Sense of the Senate climate change resolution calling on Congress to enact a mandatory, market-based program to slow, stop, and reverse the growth of greenhouse gases, the need to address the cost issue has arisen again. Indeed, the resolution itself states that the program should be enacted at a rate and in a manner that "will not significantly harm the United States economy" and "will encourage comparable action" by other nations.[44] Facets of the cost issue that have raised concern include absolute costs to the economy, distribution of costs across industries, competitive impact domestically and internationally, incentives for new technology, and uncertainty about possible costs.

Market-based mechanisms attempt to address the cost issue by introducing flexibility into the implementation process. The cornerstone of that flexibility is permitting sources to decide their appropriate implementation strategy within the parameters of market signals and other incentives. That signal can be as simple as a carbon tax or comprehensive credit auction that tells the emitter the value of any reduction in greenhouse gases, to a credit marketplace that is constrained by a ceiling price (safety valve) and includes incentives for new technology. As

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[43] For a review of U.S. climate change policy, see CRS Report RL30024, *Global Climate Change Policy: Cost Competitiveness, and Comprehensiveness*, by Larry Parker.

[44] S. Amdt. 866, passed by voice vote after a motion to table, failed 43-54, June 22, 2005.

illustrated here, the combinations of market mechanisms are numerous, allowing decision makers to tailor the program to address specific concerns.

In a sense, the options discussed here represent a continuum between alternatives focused on the price side of the equation (e.g., carbon taxes) through hybrid schemes (e.g., safety valves) to alternatives focused on the quantity side (e.g., banking and borrowing). They are tools to assist in the assessment of potential greenhouse gas reduction approaches, leaving any policy decision on balancing the price-quantity issue to the ultimate decision makers.

This balance will not be easy to achieve. There is little doubt that market-based mechanisms are available to assist in implementing a GHG reduction program at less cost than more traditional command-and-control methods.[45] Market-based mechanisms offer substantial flexibility to program designers and participants. However, the complexity of market mechanisms (particularly trading programs) increases substantially with the scope of emitting sources included (particularly if international trading is envisioned) and the specificity of any allocation scheme. Thus, perhaps the most difficult issue to be addressed in designing a market-based implementation strategy for reducing GHG emissions is determining who is included, and who is exempted.

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[45] For background on this point with respect to climate change, see CRS Report RL30285, *Global Climate Change: Lowering Cost Estimates through Emissions Trading — Some Dynamics and Pitfalls*, by Larry Parker.

Appendix A. Summary of Selected Options To Address Cost Uncertainty of Greenhouse Gas Reduction Programs

Option	Absolute Costs	Distributional Costs	Long-Term Costs	Price Stability	Cost Uncertainty	Effect on Benefits
Carbon Tax	Allows economics to determine ultimate emission reductions. Costs limited to tax levy. Actual costs would depend on the level of the tax, availability of reduction below that level, and the distribution of the revenues	Distributional concerns about costs can be addressed by either partly or completely exempting specific sectors or targeting sectors with funding from the received tax revenues	Long-term development of new technology would be stimulated by creating a long-term price floor on carbon and strengthened further by targeting R&D with funding from the received tax revenues	Would provide a stable consistent price signal	Would provide an upper limit on potential cost estimates. The lower limit would still be subject to uncertainty	Would make reductions dependent on the level of the tax. The quantity reduction becomes the variable while the price is fixed
Dynamic Tonnage Target	Depending on specifics, would probably offer some cost protection against unforeseen spikes upward in economic growth	Distributional concerns about costs could be addressed by variety of regional or sector-specific, metrics.	Incentive for new technology would depend on the slope of reductions mandated by the program	Would not necessarily avoid short-term fluctuations in market price. Different metrics for different sectors could also create market price uncertainty	Would only have modest effect on reducing uncertainty in cost estimates	Depending on the specifics of the target, benefits could be at least slightly dependent on economic conditions

Option	Absolute Costs	Distributional Costs	Long-Term Costs	Price Stability	Cost Uncertainty	Effect on Benefits
Expanded Supply Options	Can substantially reduce costs, depending on the additional options included.	Can help sectors that do not have cost-effective means of reducing emissions on their own	Depends on how well the additional sources are integrated into the overall market — a stratified market can muddle the long-term price signal	Depends on how well the additional sources are integrated into the overall market — a stratified market may result in independent pricing trends	Can increase uncertainty by adding new variables to the estimates, including availability, penetration and costs of the additional options	Should have no effect on reductions achieved, assuming proper safeguards are taken, but new risks are introduced with some options (like international trading)
Economic-Based Circuit Breaker	Reduces costs by temporarily extending compliance deadlines and/or slowing emission reduction targets. The degree of cost savings depends on the specifics of the program	Could address distributional concerns by tailoring its tonnage and timetables triggers to specific sectors	Its short-term focus could muddle the long-term price signal important for developing new technology	Depending on the responsiveness of the tonnage and timetable triggers, it would help mitigate short-term price volatility	Scheme introduces many new uncertainties while reducing others in estimating costs	Increases uncertainty of benefits by making the quantity of reductions achieved a variable

Option	Absolute Costs	Distributional Costs	Long-Term Costs	Price Stability	Cost Uncertainty	Effect on Benefits
Technology-Based Timetable	Potentially reduces costs by delaying compliance and encouraging more cost-effective approaches in the long-term	Would depend on opportunities for new technologies in given sectors	Arguably, the primary focus of this scheme is to encourage new technology deployment	May have little effect on price stability; indeed, it could increase short-term volatility and uncertainty by removing demand and volume from the market	Scheme introduces new uncertainty to cost estimates	Effect would depend on how widespread the assumed participation rate is.
Banking and Borrowing	Reduces costs by making the emissions cap more flexible over time	Little effect	Can help support a long-term price signal for new technology by supporting prices when costs are lower than expected	The added flexibility can help damp short-term volatility, but not eliminate it	No significant effect	No significant effect over the long-term
Auctioning Permits	Allows the marketplace to allocate permits. Actual costs would depend on percentage of permits auctioned and distribution of the revenues	Can be used to address concerns by tailoring auctions for specific sector and/or directing revenues toward affected sectors	Some revenues could be targeted for new technology. Also, auctions would help determine market price of reductions	Depending on the volume of the auction, could have some effect on short-term volatility, but not eliminate it	Scheme introduces new uncertainties to cost estimates	No significant effect

Option	Absolute Costs	Distributional Costs	Long-Term Costs	Price Stability	Cost Uncertainty	Effect on Benefits
Safety Valve	Effect on cost depends on level that the safety valve is set	Safety valve levels could be tailored for specific sectors	By setting a ceiling, but not a floor on prices, could have a damping effect on new technology depending on the level imposed	Would place an upper limit on price volatility	Would place an upper limit on cost estimates	Would make reductions a function of the safety valve level