Climate Change: Design Approaches for a Greenhouse Gas Reduction Program

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Summary

Three events provide impetus for revisiting the cost issue with respect to designing a greenhouse gas reduction program. The first is the election of a new President publicly committed to substantial reductions in greenhouse gases over the next several decades. The second was passage of H.R. 2454 by the House that would mandate a 83% reduction in the country's greenhouse gas emissions from 2005 by 2050. The reduction would be primarily achieved through a market-based, cap-and-trade program, beginning in 2012. The third is the Copenhagen Accord that may begin the process of incorporating developing countries in a global climate change framework by committing them to implement "mitigation actions," along with monitoring, reporting, and verification procedures "in accordance with guidelines adopted by the Conference of the Parties." 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 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 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 the 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. 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 has been a significant feature of the congressional debate on H.R. 2454. As passed by the House, the bill would mandate an 83% reduction in the country's greenhouse gas (GHG) emissions from 2005 by 2050. The reduction would be primarily achieved through a market-based, cap-and-trade program, beginning in 2012 that supporters believe will result in cost-effective reductions in greenhouse gas emissions and encourage other countries to initiate their own programs. 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.

With the congressional debate moving to the Senate, concern about costs and economic impacts has attention focused on options to address these issues and to move the debate forward. These options range from incremental mechanisms within a tradeable permit program, such as banking and borrowing of credits, which minimally affect overall emissions reduction targets, to more fundamental proposals, such as a carbon tax, which 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 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 approaches 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 the 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

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[1] For an analysis of federal policy and congressional debate since ratification of UNFCCC, see CRS Report RL30024, *U.S. Global Climate Change Policy: Evolving Views on Cost, Competitiveness, and Comprehensiveness*, by (name redacted) and (name redacted).

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

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, emissions reduction efforts focus on sources at which controls can be achieved at least cost.

However, if one feels uncertain of the environmental benefits of a specific level of reduction and anxious about the downside risk of substantial control costs to the economy, 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 reduction 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 emissions 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.[3] 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/or importation of the chemicals, or the importation of products that contain them or used them in their production processes. In

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[3] Finland, the Netherlands, Sweden, Denmark, and Norway. France has proposed a carbon tax, but its implementation is currently being litigated.

addition, inventories of certain ODCs held on January 1 of each year are subjected to a "floor stocks tax."[4]

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 criteria. Finally, variables involved with techniques include promotion and availability of new technology, the degree of flexibility permitted in complying with 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. 2007 U.S. Greenhouse Gas Emissions

Economic Sector	Million Metric Tons of CO_2 equivalent	Percentage of Total
Electric power industry	2,445	34.5%
Transportation	1,995	28.1%
Industry	1,386	19.5%
Agriculture	503	7.1%
Commercial	408	5.8%
Residential	355	5.0%

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[4] For CFC-11 and 12, the current (2009) tax is $11.65 per pound. The floor stocks tax is $0.45 per pound (2009). For more specifics on the current tax level, see IRS Form 6627, *Environmental Taxes*.

Economic Sector	Million Metric Tons of CO_2 equivalent	Percentage of Total
Total	7,092	100.0%

Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007*, (April 15, 2009), p. ES-16.

Note: The total does not include 58 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.[5] Developing such a price signal involves variables such as the magnitude and nature 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.[6] 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.”[7]

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.[8]

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

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

[6] 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).

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

[8] 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, January 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).

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[9]:

- 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 generally 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 reduction requirements and cost.

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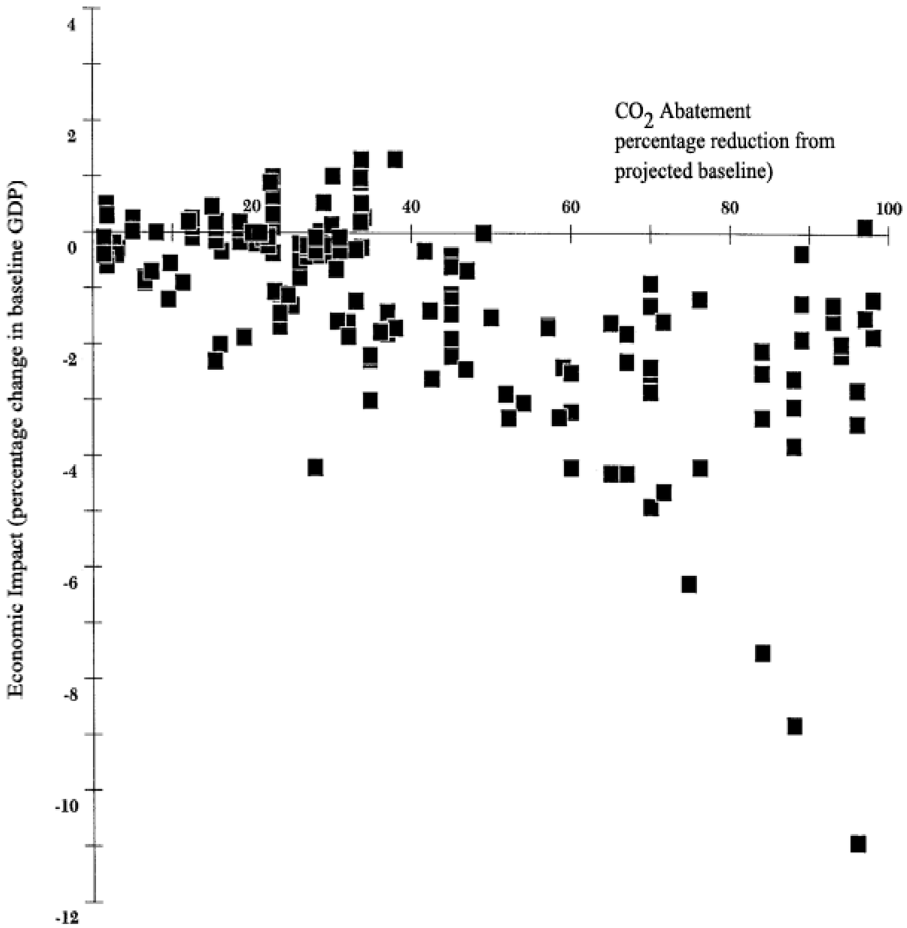
[9] John P. Weyant, *An Introduction to the Economics of Climate Change Policy* (Pew Center on Global Climate Change, July 2000).

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.

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.[10] 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 results are cost estimates that range from actual savings to the economy (from GHG reductions) to substantial costs.

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[10] See CRS Report 98-738, *Global Climate Change: Three Policy Perspectives*, by (name redacted) and (name redacted).

An illustration of this can be seen in the contrast between two cost analyses of H.R. 2454. The results presented below were obtained by the American Council for Capital Formation/National Association of Manufacturers (ACCF/NAM) high cost case and the "high technology" sensitivity case conducted by EIA using the same model: EIA's NEMS model. **Table 2** summarizes the general approach of the two analyses according to the three perspectives identified above. In its sensitivity case, EIA mimics H.R. 2454's various technology and efficiency provisions by employing its High Technology baseline that has more aggressive technology development assumptions than its reference case, and also includes banking, and phased-in offsets. In contrast, ACCF/NAM is not confident that new technology, new energy sources, and market mechanisms (e.g., carbon offsets, banking) will be sufficiently available to achieve H.R. 2454's emission targets. Accordingly, ACCF/NAM's High Cost case assumptions differ substantially from EIA's High Technology sensitivity analysis by discouraging banking, restricting the availability of offsets to half that allowed in H.R. 2454, and significantly restricting availability of various low- and non-carbon technologies beyond what is embedded in the NEMS base case.

Table 2. General Perspective of ACCF/NAM-High Cost and EIA-High Technology Assumptions

	EIA High Technology	ACCF/NAM-High
Technology	Assumes no constraints on technology availability beyond those embedded in the NEMS model	Assumes significant constraints on further low- and non-carbon technology availability beyond that embedded in NEMS
Economic	Assumes aggressive technology development, efficient decision-making via banking, and phasing in of offsets to the levels allowed in H.R. 2454 (2 billion metric tons)	Assumes short-term decision-making with a 10% discount rate; total offsets allowed limited to 1 billion metric tons annually (50 million from international sources)
Ecological	Assumes decisions made in favor of technology and efficiency because of H.R. 2454's incentives, regulations, and price signal	Assumes none—total GHG emissions are not presented

Source: Energy Information Administration (EIA),Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009 (August 4, 2009); Science Applications International Corporation, *Analysis of the Waxman-Markey Bill "The American Clean Energy and Security Act of 2009" (H.R. 2454) Using the National Energy Modeling System* (NEMS/ACCF-NAM 2), a report by the American Council for Capital Formation and the National Association of Manufacturers (2009).

As indicated by **Table 3**, the widely different cost assumptions provided the expected results, although both analyses remained in the 0-4% GDP range common for greenhouse gas reduction analysis. Allowance price estimates diverge significantly by 2030, but this cost measure tends to exaggerate differences between results and should not be confused with average costs or program costs. This is particularly true for analyses of H.R. 2454, as ACCF/NAM did not publish its environmental results in terms of greenhouse gases reduced; thus, one can not compare the allowance price with what is being reduced over time. Unfortunately, the analyses do not present sufficient sensitivity analysis and other information to determine whether it is the economic assumptions (e.g., discount rates and offset availability), the behavioral assumptions (e.g., impact of efficiency programs), the technology assumptions (e.g., availability), or what combination of these assumptions that explains the differences in results.

Table 3. Selected Results from EIA's "High Technology" and ACCF-NAM's "High Cost" Cases

	Year	EIA High Technology	ACCF-NAM High Cost
GDP per capita Reduction From Reference Case	2020	0.06%	0.4%
	2030	0.31%	2.4%
Allowance Price (2005$)	2020	$26	$58
	2030	$54	$150
Total GHG Emissions	2020	6.8 (5.8 net of offsets)	not presented
	2030	6.1 (4.0 net of offsets)	not presented

Source: Energy Information Administration (EIA), Energy Market and Economic Impacts of *H.R. 2454*, the American Clean Energy and Security Act of 2009 (August 4, 2009); Science Applications International Corporation, *Analysis of The Waxman-Markey Bill "The American Clean Energy and Security Act of 2009" (H.R. 2454) Using the National Energy Modeling System* (NEMS/ACCF-NAM 2), a report by the American Council for Capital Formation and the National Association of Manufacturers (2009). All estimates converted to 2005 dollars using the GDP implicit price deflator.

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.[11] 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.

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[11] Recognizing that, on a global basis, choosing a specific year has substantively different effects on countries, because of their differing situations regarding economic development and resource endowments. See CRS Report RL32721, *Greenhouse Gas Emissions: Perspectives on the Top 20 Emitters and Developed Versus Developing Nations*, by (name redacted) and (name redacted).

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 emissions 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 economic conditions, 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, such as the 2008-2009 recession, would reduce the available emissions 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).[12]

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 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 emissions 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 were 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

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[12] 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.

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.[13] Also, some proposed programs have included international trading of emissions credits and biological sequestration offsets among the permissible means of complying with reduction requirements.[14] Some of these options, particularly international trading and sequestration, have included limits on their applicability. For example, the Regional Greenhouse Gas Initiative[15] 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.[16] 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.[17]

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

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[13] Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFC), and perfluorocarbons (PFC).

[14] For more on sequestration approaches, see CRS Report RL33801, *Carbon Capture and Sequestration (CCS)*, by (name redacted).

[15] The Regional Greenhouse Gas Initiative (RGGI) is an initiative of currently ten 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.

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

[17] For example, see John Reilly, Marcus Sarofim, Sergey Paltsey, and Ronald G. Prinn, *The Role of Non-CO_2 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.

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), or if reductions are essentially voluntary (as seems to be the outcome of the Copenhagen Accord), 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 Development Mechanism (CDM) with Third World countries.[18] One type of credit cannot 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, emissions 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.

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.[19] As discussed in the introduction to this report, 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.

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

[19] For more on carbon taxes, see CRS Report R40242, *Carbon Tax and Greenhouse Gas Control: Options and Considerations for Congress*, by (name redacted) and (name redacted).

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 emissions 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.[20] 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.

Timetable Options

Similar to the country's four 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

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

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 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, the "recognized" scientific view agreed to under the Copenhagen Accord is that the increase in global temperature should be below 2 degrees. If this objective reflects the long-term stabilization level necessary to combat climate change, 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

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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.

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 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.[28] Such facilities returned to the trading system in 2007.

Proposals have been made to formalize a “circuit breaker” into any GHG reduction program. In general, proposals envision a declining emissions 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 emissions 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 emissions reductions.

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

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[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 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 (January 7, 2005).

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

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 cannot 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, 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.

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

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 emissions caps flexible over time. The limited ability to shift the reduction 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 dampen 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

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

[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.

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, many states participating in the Regional Greenhouse Gas Initiative (RGGI) are using auctions to implement their public benefit programs 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, a Resources for the Future (RFF) analysis found that an auction scheme is "dramatically more cost-effective" in allocating credits than 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 and/or a reserve price, 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.

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[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 (September 2004), p. 10. This option is discussed further below.

[35] For more information, see CRS Report RL33812, *Climate Change: Action by States to Address Greenhouse Gas Emissions,* by (name redacted).

[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).

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. For example, the program could implement a price floor to facilitate investment in new technology via a reserve price in the allowance auction process. In addition, the stability of that price signal could be strengthened by choosing to auction allowances on a frequent basis, ensuring availability of allowances close to the time of expected demand and making any potential short-squeezing of the secondary market more difficult.[40]

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. However, this is not a given, because differing assumptions could be made about the actual operation of the auction, its efficiency, and the effectiveness of the recycled revenues.

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.[41] 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,

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

[40] Karsten Neuhoff, *Auctions for CO_2 Allowances—A Straw Man Proposal*, University of Cambridge Electricity Policy Research Group (May 2007), pp. 3-6.

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

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 a 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.[42]

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."[43]

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 were 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 the **Appendix**. 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.

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

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

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 in RGGI's cap-and-trade scheme). 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 many RGGI participants are doing). In the latter case, coordinating the auction with any trigger price mechanism for expanded supply options would promote 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. Although 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 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 emissions 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 to 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

Three events provide impetus for revisiting the cost issue with respect to designing a greenhouse gas reduction program. The first is the election of a new President publicly committed to substantial reductions in greenhouse gases over the next several decades. The second was passage of H.R. 2454 by the House that would mandate a 83% reduction in the country's greenhouse gas emissions from 2005 by 2050. The reduction would be primarily achieved through a market-based, cap-and-trade program, beginning in 2012. The third is the Copenhagen Accord that may begin the process of incorporating developing countries in a global climate change framework by committing them to implement "mitigation actions," along with monitoring, reporting, and verification procedures "in accordance with guidelines adopted by the Conference of the Parties." 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 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. By offering flexibility to program designers and participants, market-based mechanisms can assist in implementing a GHG reduction program at less cost than more traditional command-and-control methods.[44] 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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[44] 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 (name redacted).

Appendix. 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 emissions 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.
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).

Option	Absolute Costs	Distributional Costs	Long-Term Costs	Price Stability	Cost Uncertainty	Effect on Benefits
Economic-Based Circuit Breaker	Reduces costs by temporarily extending compliance deadlines and/or slowing emissions 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.
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.
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.

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