

A MEANINGFUL U.S. CAP-AND-TRADE SYSTEM TO ADDRESS CLIMATE CHANGE

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ABSTRACT

There is growing impetus for a domestic climate policy that can provide meaningful reductions in emissions of CO₂ and other greenhouse gases. In this article, I propose and analyze a scientifically sound, economically rational, and politically feasible approach for the United States to reduce its contributions to the increase in atmospheric concentrations of greenhouse gases. The proposal features an upstream, economy-wide CO₂ cap-and-trade system that implements a gradual trajectory of emissions reductions over time and includes mechanisms to reduce cost uncertainty. I compare the proposed system with frequently discussed alternatives. In addition, I describe common objections to a cap-and-trade approach to the problem and provide responses to those objections.

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1. INTRODUCTION

It is increasingly clear that anthropogenic emissions of greenhouse gases (“GHGs”) are likely to change the earth’s climate in ways that many people will regret. Two trace constituents of the atmosphere, carbon dioxide (“CO₂”) and water vapor, create a thermal blanket for the planet much the way glass on a greenhouse traps the sun’s energy within. It is a good thing, too: without greenhouse warming, the planet would be far too cold to be

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livable. But the balance between too much and too little greenhouse effect is remarkably delicate. Massive quantities of CO₂ are produced from the combustion of fossil fuels — coal, petroleum, and natural gas — and deforestation. Meanwhile, the direct warming effects of CO₂ and other greenhouse gases — methane, nitrous oxide, and halocarbons — are indirectly amplified because the warming increases evaporation of water, in turn increasing atmospheric water vapor concentrations.¹

Global average surface temperatures have risen by about 1.25 degrees Fahrenheit over the past 100 years, and the rate of change has been almost twice that fast in the past fifty years.² The most important consequences of greenhouse gas concentrations, however, are likely to be changes in patterns of precipitation and runoff, the melting of glaciers and sea ice, increases in sea level, and changes in storm frequency and intensity.³ That is why it is important to view the problem as global climate change, rather than simply global warming.

Greenhouse gases mix uniformly in the atmosphere, so emissions in one country affect the climate in every other country. This fact underlies the fundamental logic of a global pact on emissions, such as the one hammered out in Kyoto, Japan, in December 1997.⁴ Many analysts — particularly economists — have been highly critical of the Kyoto Protocol, noting that, because of specific deficiencies, it will be ineffective and relatively costly for the little it accomplishes.⁵ Others have been more supportive by noting that Kyoto is essentially the “only game in town.”⁶ But both sides agree that whether that first step was good or bad, a second one is required. Indeed, as some nations prepare for the Kyoto Protocol’s first commitment period (2008-2012), the international policy community has begun to search for a better global policy architecture for the second commitment period.⁷

¹ Herve Le Treut et al., *Historical Overview of Climate Change*, in INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007 - THE PHYSICAL SCIENCE BASIS: Contribution of Working Group I to the Fourth Assessment Report of the IPCC 115-16 (2007) [hereinafter THE PHYSICAL SCIENCE BASIS].

² Kevin E. Trenberth, *Observations: Surface and Atmospheric Climate Change*, in THE PHYSICAL SCIENCE BASIS, *supra* note 1, at 237.

³ See generally Cynthia Rosenzweig et al., *Assessment of Observed Changes and Responses in Natural and Managed Systems*, in INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007 - IMPACTS, ADAPTATION AND VULNERABILITY: CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE IPCC (2007).

⁴ Agreement for the Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 11, 1997, 37 I.L.M. 32, available at <http://unfccc.int/resource/docs/convkp/kpeng.pdf> [hereinafter Kyoto Protocol].

⁵ See, e.g., Joseph E. Aldy, Scott Barrett & Robert N. Stavins, *Thirteen Plus One: A Comparison of Global Climate Policy Architectures*, 3 CLIMATE POL’Y 373 (2003).

⁶ See, e.g., *Viewpoint: Kyoto – the only game in town*, BBC NEWS, July 29, 2004, <http://news.bbc.co.uk/2/hi/science/nature/3932947.stm>.

⁷ ARCHITECTURES FOR AGREEMENT: ADDRESSING GLOBAL CLIMATE CHANGE IN THE POST-KYOTO WORLD 13 (Joseph E. Aldy & Robert N. Stavins eds., 2007) (hereinafter ARCHITECTURES FOR AGREEMENT).

In the meantime, the impetus for a meaningful U.S. climate policy is growing. Scientific evidence has increased,⁸ public concern has been magnified, and many people perceive what they believe to be evidence of climate change in progress. Such concern is reinforced by the aggressive positions of key advocacy groups receiving greatly heightened attention in the news media. The overall result is that a large and growing share of the U.S. population now believes that government action is warranted.⁹

In the absence of federal policy, regions, states, and even cities have moved forward with their own proposals to reduce emissions of CO₂ and other greenhouse gases.¹⁰ Partly in response to fears of a fractured set of regional policies, an increasing number of large corporations, acting individually or in coalitions, together with environmental advocacy groups, have announced their support for serious national action.¹¹ Building upon this groundswell is the April 2007 Supreme Court decision that the Environmental Protection Agency (“EPA”) has the legislative authority to regulate CO₂ emissions.¹² In addition, European allies and other nations continue to pressure the U.S. to reestablish its international credibility in this realm by enacting a meaningful domestic climate policy.

Thus, momentum clearly is building toward the enactment of a domestic climate change policy. But there should be no mistake about it — meaningful action to address global climate change will be costly. This is a key “inconvenient truth” that must be recognized when policymakers construct and evaluate proposals: a policy’s specific design will greatly affect its abil-

⁸ See generally THE PHYSICAL SCIENCE BASIS, *supra* note 1; Rosenzweig et al., *supra* note 3.

⁹ See *Concern Soars About Global Warming as World’s Top Environmental Threat*, ABC NEWS, Apr. 20, 2007, <http://abcnews.go.com/Technology/GlobalWarming/story?id=3057534&page=1>. See also Brent Bannon et al., *Americans’ Evaluations of Policies to Reduce Greenhouse Gas Emissions* (Working Paper, 2007), available at http://woods.stanford.edu/docs/surveys/GW_New_Scientist_Poll_Technical_Report.pdf.

¹⁰ For example, ten northeast states have developed a cap-and-trade program under their Regional Greenhouse Gas Initiative, and California’s Assembly Bill 32 may do likewise for the nation’s most populous state. Jason Patrick, *Bicoastal Carbon Trading: California and RGGI Markets Mapped Out*, EXECUTIVE BRIEF (Evolution Mkts., White Plains, N.Y.), Oct. 11, 2006.

¹¹ The U.S. Climate Action Partnership issued “A Call for Action” in January 2007, recommending “the prompt enactment of national legislation in the United States to slow, stop, and reverse the growth of greenhouse gas (GHG) emissions over the shortest time reasonably achievable.” U.S. CLIMATE ACTION P’SHIP, A CALL FOR ACTION - CONSENSUS PRINCIPLES AND RECOMMENDATIONS FROM THE U.S. CLIMATE ACTION PARTNERSHIP: A BUSINESS AND NGO PARTNERSHIP 2 (2007). The partnership consists of some of the largest U.S. companies with a stake in climate policy from a diverse set of sectors: electricity (Duke Energy, Exelon, FPL Group, NRG Energy, PG&E Corporation, and PNM Resources); oil and gas (BP, ConocoPhillips, and Shell); motor vehicles (Caterpillar, Daimler-Chrysler, Ford, GM, and John Deere); aluminum (Alcan and Alcoa); chemicals (DuPont and Dow); insurance (AIG and Marsh); mining (Rio Tinto); and manufacturing (Boston Scientific, General Electric, Johnson & Johnson, Pepsico, Siemens, and Xerox). *Id.* at 12. The coalition is rounded out by six environmental organizations: Environmental Defense, National Wildlife Federation, Natural Resources Defense Council, Nature Conservancy, Pew Center on Global Climate Change, and World Resources Institute. *Id.*

¹² *Massachusetts v. EPA*, 127 S. Ct. 1438 (2007).

ity to achieve its environmental goals, its costs, and the distribution of those costs. Even a well-designed policy ultimately will impose annual costs on the order of tens (and perhaps hundreds) of billions of dollars.¹³ That does not mean that action should not be taken, but it does suggest that the costs should be accounted for if effective and sensible policies are to be designed and implemented.

It is important to identify an appropriate policy instrument at the outset in order to avoid creating constituencies that will later resist change.¹⁴ Once a policy architecture is put in place, it can be exceptionally difficult to make a change. Thus, the stakes associated with policy design are significant. A poorly designed policy could impose unnecessarily high costs or unintended distributional consequences while providing little public benefit and could potentially detract from the development of and commitment to a more effective, long-run policy.¹⁵

1.1 Policy Instruments to Achieve Greenhouse Gas Emission Reductions

There is a general consensus among economists and policy analysts that a market-based policy instrument targeting CO₂ emissions (and potentially some non-CO₂ greenhouse gas emissions) should be a central element of any domestic climate policy.¹⁶ While there are tradeoffs between two alternative market-based instruments — a cap-and-trade system and a carbon tax — the best approach for the short- to medium-term in the United States is a cap-and-trade system. In Part IV, I provide a detailed comparison of cap-and-trade programs and carbon taxes.

The environmental integrity of a domestic cap-and-trade system for climate change can be maximized and its costs and risks minimized by: targeting all fossil fuel-related CO₂ emissions through an upstream, economy-wide cap; setting a trajectory of caps over time that begins modestly and gradually becomes more stringent; establishing a long-run price signal to encourage investment; adopting mechanisms to protect against cost uncertainty; and including linkages with the climate policy actions of other countries. Impor-

¹³ By comparison, the cost (in 2001 dollars) of all EPA regulations enacted from 1996 to 2006 was estimated at \$25 to \$28 billion annually, and a number of historical studies have estimated the annual cost of all environmental regulation in the United States to be on the order of 1% to 3% of GDP. See U.S. OFFICE OF MANAGEMENT AND BUDGET, DRAFT 2007 REPORT TO CONGRESS ON THE COSTS AND BENEFITS OF FEDERAL REGULATIONS 7 (2007); Adam B. Jaffe et al., *Environmental Regulation and the Competitiveness of U.S. Manufacturing: What Does the Evidence Tell Us?*, 33 J. ECON. LITERATURE 132, 134 (1995); Richard Morgenstern, William Pizer & Jihh-Shyang Shih, *The Cost of Environmental Protection*, 83 REV. ECON. & STAT. 732 (2001).

¹⁴ ROBERT REPETTO, NATIONAL CLIMATE POLICY: CHOOSING THE RIGHT ARCHITECTURE, at Section C (2007).

¹⁵ *Id.* at Section B.

¹⁶ ARCHITECTURES FOR AGREEMENT, *supra* note 7, at 106. This is reflected in international assessments of national policy instruments, as well. See INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007 — MITIGATION OF CLIMATE CHANGE: WORKING GROUP III CONTRIBUTION TO THE FOURTH ASSESSMENT REPORT OF THE IPCC 88 (2007).

tantly, by providing the option to mitigate economic impacts through the distribution of emission allowances, this approach can establish consensus for a policy that achieves meaningful emission reductions. It is for these reasons and others that cap-and-trade systems have been used increasingly in the United States to address an array of environmental problems.¹⁷

A cap-and-trade system should not be confused with emission reduction credit or credit-based programs, in which those reporting emission reductions generate credits that others may or must buy to offset obligations under some other policy. A credit-based program could be used as a means of encouraging emission reductions from activities outside the scope of a cap-and-trade system, emissions tax, or standards-based policy. But they typically require measurement — or, more likely, estimation — of emission *reductions*, which, unlike emissions themselves, cannot be observed directly. Hence, these programs generally face difficulties establishing that reported reductions would not have occurred absent the credit-based program. This is the baseline or “additionality” problem: making a comparison with an unobserved and fundamentally unobservable hypothetical (what would have happened had the credit *not* been generated). This problem reduces environmental effectiveness if credits generated by activities that would have occurred even without the credit program are used to satisfy real emission reduction obligations. Despite these obstacles, cost savings still may be achieved through *selective* use of credit-based programs targeting certain activities, as I later discuss, such as various types of carbon-saving land management that otherwise would be too costly or infeasible to integrate into a cap-and-trade system.¹⁸

Another major alternative to a cap-and-trade system is the use of command-and-control standards, such as energy efficiency or emission performance standards, which require firms and consumers to take particular actions that directly or indirectly reduce emissions. The costs of standards often are largely invisible except to those directly affected by them, but standards would impose significantly greater economic impacts than market-based policies. Standards would offer firms and consumers far less flexibility regarding how emission reductions are achieved and could not target many low-cost emission reduction opportunities. Moreover, the effectiveness of standards in achieving nationwide emission targets is highly uncertain, in part because they could only cover a fraction of nationwide emissions, leaving many sources unregulated. In contrast, market-based policies can cover all sources of fossil fuel-related CO₂ emissions, and, unlike other alternatives, a cap-and-trade system can essentially guarantee achievement of emission targets for sources under the cap.

¹⁷ Domestic cap-and-trade systems have been used to phase out the use of lead in gasoline, limit SO₂ and NO_x emissions, and phase out chlorofluorocarbons (“CFCs”). Robert N. Stavins, *Experience with Market-Based Environmental Policy Instruments*, in 1 HANDBOOK OF ENVIRONMENTAL ECONOMICS 356, 383, 393 (Karl-Göran Mäler & Jeffrey Vincent eds., 2003).

¹⁸ See *infra* Part 2.6.

1.2 The Focus on Cap-and-Trade

A cap-and-trade system limits the aggregate emissions of a group of regulated sources by creating a limited number of tradable emission allowances and requiring each firm to surrender a quantity of allowances equal to its own emissions.¹⁹ The government may initially distribute allowances for free or sell them through an auction. Regardless of how allowances are distributed initially, the need to surrender valuable allowances to cover any emissions and the opportunity to trade those allowances create a price signal for emissions. In turn, this price signal provides firms with an incentive to reduce emissions that influences their production and investment decisions. Because allowances are tradable, the ultimate distribution of emission reduction efforts necessary to meet the overall emissions cap is determined by market forces. Thus, the cap is placed only on aggregate emissions and imposes no particular limits on emissions from any given firm or source. Overall, a cap-and-trade system provides certainty regarding emissions from regulated sources because *aggregate* emissions from all regulated entities cannot exceed the total number of allowances.

A well-designed cap-and-trade system will minimize the costs of achieving any given emissions target.²⁰ Firms have flexibility regarding precisely how much they emit, but because they must surrender an allowance for each ton of emissions, they will undertake all emission reductions that are less costly than the market price of an allowance. Through trading, this allowance price adjusts until aggregate emissions are brought down to the level of the cap. Firms' ability to trade emission allowances creates a market in which allowances migrate toward their highest-valued use, protecting those emissions that are the most costly to reduce. Conversely, as a result of trading, the emission reductions undertaken to meet the cap are those that are least costly to achieve.

The cost of achieving significant emission reductions in future years will depend critically on the availability and cost of low- or non-emitting technologies. A cap-and-trade system that establishes caps extending decades into the future provides important price signals and hence incentives for firms to invest in the development and deployment of such technologies, thereby lowering the future costs of achieving emission reductions.

¹⁹ This introductory description of cap-and-trade is in terms of what is called a "downstream" system in the CO₂ context, where CO₂ emissions sources are regulated. Alternatively, in an "upstream" cap-and-trade system for CO₂, tradable permits regulate the carbon content of fossil fuels at the point of fuel extraction, import, processing, or distribution. The cap-and-trade program proposed in this article is an upstream system, because of its economy-wide coverage. The basic workings of cap-and-trade are explained above with a downstream (emissions) trading example, because many people find it more intuitive.

²⁰ In practice, while cap-and-trade systems may not be able to fully *minimize* emission reduction costs in the absence of idealized market conditions, experience has demonstrated the ability of cap-and-trade systems to achieve significant cost savings relative to conventional regulatory approaches. See Stavins, *supra* note 17, at 359-60.

A cap-and-trade system must provide credible commitments to long-run emission targets in order to create these investment incentives. If a lack of credibility makes the payoff from investments highly uncertain, these investments will lag.²¹ On the other hand, it also is important to maintain flexibility to adjust long-term targets as new information is obtained regarding the costs and benefits of mitigating climate change. Balancing credibility of long-run targets and flexibility is an important issue for the success of any climate policy.

Even a credible long-run cap-and-trade system may provide insufficient incentives for investment in technology development because it would not address certain well-known factors (market failures) that discourage such investment, such as those stemming from the public good nature of knowledge that comes from research and development efforts.²² Thus, a cap-and-trade system alone will not encourage the socially desirable level of investment in research, development, and deployment of new technologies that could reduce future emission reduction costs. To achieve this desired level of investment, additional policies may be necessary to provide additional government funding or increase incentives for private funding of such research activities.²³

1.3 Applications of Cap-and-Trade Mechanisms

Over the past two decades, tradable permit systems have been adopted for pollution control with increasing frequency in the U.S.²⁴ and other parts of the world. As explained above, tradable permit programs are of two basic types, credit programs and cap-and-trade systems. The focus of this brief review of other programs is on the applications of the cap-and-trade approach.²⁵ The programs described below are examined in more detail in the Appendix.

²¹ See W. David Montgomery & Anne E. Smith, *Price, Quantity, and Technology Strategies for Climate Change Policy*, in HUMAN INDUCED CLIMATE CHANGE: AN INTERDISCIPLINARY ASSESSMENT 329-30 (M.E. Schlessinger et al. eds., 2007).

²² See Adam B. Jaffe, Richard G. Newell & Robert N. Stavins, *A Tale of Two Market Failures: Technology and Environmental Policy*, 54 ECOLOGICAL ECON. 164 (2005); Richard G. Newell, *Climate Technology Policy*, BACKGROUND (RES. FOR THE FUTURE, Washington, D.C.), Feb. 2007, at 4.

²³ See, e.g., NAT'L COMM'N ON ENERGY POLICY, ENERGY POLICY RECOMMENDATIONS TO THE PRESIDENT AND THE 110TH CONGRESS 25-26 (2007). Such complementary policies are examined *infra* Part 2.8.

²⁴ For several examples of U.S. tradable permit systems, see Tom Tietenberg, *Tradable Permits and the Control of Air Pollution in the United States*, 9 ZEITSCHRIFT FÜR ANGEWANDTE UMWELTFORSCHUNG 11 (1998).

²⁵ This section of the article draws, in part, on Stavins, *supra* note 17.

1.3.1 *Previous Use of Cap-and-Trade Systems for Local and Regional Air Pollution*

The first important example of a trading program in the United States was the leaded gasoline phasedown that occurred in the 1980s. Although not strictly a cap-and-trade system, the phasedown included features, such as trading and banking of environmental credits, which brought it closer than other credit programs to the cap-and-trade model and resulted in significant cost savings. The lead program was successful in meeting its environmental targets, and the system was cost-effective, with estimated savings of about \$250 million per year.²⁶ Also, the program provided measurable incentives for cost-saving technology diffusion.²⁷

A cap-and-trade system was also used in the United States to help comply with the Montreal Protocol, an international agreement aimed at slowing the rate of stratospheric ozone depletion.²⁸ The Protocol called for reductions in the use of CFCs and halons, the primary chemical groups thought to lead to depletion.²⁹ The timetable for the phaseout of CFCs was accelerated,³⁰ and the system appears to have been relatively cost-effective.

The most important domestic application of a market-based instrument for environmental protection arguably is the cap-and-trade system regulating sulfur dioxide (“SO₂”) emissions, the primary precursor of acid rain. This program was established under the U.S. Clean Air Act Amendments of 1990.³¹ The program is intended to reduce SO₂ and nitrogen oxide (“NO_x”) emissions by 10 million tons and 2 million tons, respectively, from 1980 levels.³² A robust market of SO₂ allowance trading emerged from the program, resulting in cost savings on the order of \$1 billion annually, as compared with the costs under some command-and-control regulatory alternatives.³³ The program has also had a significant environmental impact: SO₂ emissions from the power sector decreased from 15.7 million tons in 1990 to 10.2 million tons in 2005.³⁴

In 1994, California’s South Coast Air Quality Management District launched a cap-and-trade program to reduce NO_x and SO₂ emissions in the

²⁶ See OFFICE OF POL’Y ANALYSIS, EPA, COSTS AND BENEFITS OF REDUCING LEAD IN GASOLINE: FINAL REGULATORY IMPACT ANALYSIS VIII-19 (1985) (describing monetary benefits of the program).

²⁷ Suzi Kerr & Richard Newell, *Policy-Induced Technology Adoption: Evidence from the U.S. Lead Phasedown*, 51 J. INDUS. ECON. 317 (2003).

²⁸ Robert W. Hahn & Albert M. McGartland, *The Political Economy of Instrument Choice: An Examination of the U.S. Role in Implementing the Montreal Protocol*, 83 Nw. U. L. REV. 592, 592 (1989).

²⁹ *Id.*

³⁰ *Id.* at 595-96.

³¹ Curtis Carlson et al., *Sulfur Dioxide Control by Electric Utilities: What Are the Gains from Trade?* 2 (Res. for the Future, Discussion Paper No. 98-44-REV, 2000).

³² See discussion *infra* Part A.1.3.

³³ Curtis Carlson et al., *supra* note 31, at 4.

³⁴ OFFICE OF AIR AND RADIATION, EPA, ACID RAIN PROGRAM: 2005 PROGRESS REPORT 5 (2005).

Los Angeles area.³⁵ This Regional Clean Air Incentives Market (“RECLAIM”) program set an aggregate cap on NO_x and SO₂ emissions for all significant sources, with an ambitious goal of reducing aggregate emissions by 70% by 2003.³⁶ Trading under the RECLAIM program was restricted in several ways, with positive and negative consequences.³⁷ Despite problems, RECLAIM has generated environmental benefits, with NO_x emissions in the regulated area falling by 60% and SO₂ emissions by 50%.³⁸ Furthermore, the program has reduced compliance costs for regulated facilities, with the best available analysis suggesting 42% cost savings, amounting to \$58 million annually.³⁹

Finally, in 1999, under EPA guidance, twelve northeastern states and the District of Columbia implemented a regional NO_x cap-and-trade system to reduce compliance costs associated with the Ozone Transport Commission regulations of the 1990 Amendments to the Clean Air Act. Emissions caps for two geographic regions regulated from 1999-2003 were 35% and 45% of 1990 emissions, respectively.⁴⁰ Compliance cost savings of 40% to 47% have been estimated for the period 1999-2003, compared to a base case of continued command-and-control regulation without trading or banking.⁴¹

1.3.2 CO₂ and Greenhouse Gas Cap-and-Trade Systems

Although cap-and-trade has proven to be a cost-effective means to control conventional air pollutants, it has a very limited history as a method of reducing CO₂ emissions. Several ambitious programs are in the planning stages or have been launched.

First, the Kyoto Protocol, the international agreement that was signed in Japan in 1997, includes a provision for an international cap-and-trade system among countries, as well as two systems of project-level offsets.⁴² The Protocol’s provisions have set the stage for the member states of the European Union to address their commitments using a regional cap-and-trade system.

By far the largest existing active cap-and-trade program in the world is the European Union Emissions Trading Scheme (“EU ETS”) for CO₂ allowances, which has operated for the past two years with considerable success, despite some initial — and predictable — problems. The 11,500 emitters regulated by the downstream program include large sources such as

³⁵ David Harrison, Jr., *Turning Theory into Practice for Emissions Trading in the Los Angeles Air Basin*, in POLLUTION FOR SALE 63, 63 (Steve Sorrell & Jim Skea eds., 1998).

³⁶ MKT. ADVISORY COMM., CAL. AIR RES. BD., RECOMMENDATIONS FOR DESIGNING A GREENHOUSE CAP-AND-TRADE SYSTEM FOR CALIFORNIA 100 (2007).

³⁷ *Id.* at 68.

³⁸ *Id.* at 10.

³⁹ *Id.*

⁴⁰ Alex Farrell, Robert Carter & Roger Rauffer, *The NO_x Budget: Market-Based Control of Tropospheric Ozone in Northeastern United States*, 21 RESOURCE & ENERGY ECON. 103, 110 (1999).

⁴¹ *Id.* at 116.

⁴² Kyoto Protocol, *supra* note 4.

oil refineries, combustion installations, coke ovens, cement factories, ferrous metal production, glass and ceramics production, and pulp and paper production, but the program does not cover sources in the transportation, commercial, or residential sectors.⁴³ Although the first phase, a pilot program from 2005-2007, allowed trading only in CO₂, the second phase, 2008-2012, potentially broadens the program to include other GHGs.⁴⁴ In its first two years of operation, the EU ETS produced a functioning CO₂ market, with weekly trading volumes ranging between 5 and 15 million tons, with spikes in trading activity occurring along with major price changes.⁴⁵ There have been some problems with the program's design and early implementation, but it is much too soon to provide a definitive assessment of the system's performance.⁴⁶

A frequently-discussed U.S. CO₂ cap-and-trade system that has not yet been implemented is the Regional Greenhouse Gas Initiative ("RGGI"), a program among 10 northeastern states that will be implemented in 2009 and begin to cut emissions in 2015. RGGI is a downstream cap-and-trade program intended to limit CO₂ emissions from power sector sources. Beginning in 2015, the emissions cap will decrease by 2.5% each year until it reaches a final level 10% below current emissions in 2019.⁴⁷ This goal will require a reduction that is approximately 35% below business-as-usual ("BAU") levels or, equivalently, 13% below 1990 emissions levels.⁴⁸ RGGI only limits emissions from the power sector. Thus, incremental monitoring costs are low because U.S. power plants are already required to report their hourly CO₂ emissions to the federal government (under provisions for continuous emissions monitoring as part of the SO₂ allowance trading program).⁴⁹ The program requires participating states to auction at least 25% of their allowances; the remaining 75% of allowances may be auctioned or distributed freely.⁵⁰ Given that the system will not come into effect until at least 2009, it obviously is not possible to assess its performance.

Finally, California's Greenhouse Gas Solutions Act of 2006 ("Assembly Bill 32" or "AB 32") is intended to begin in 2012 to reduce emissions to 1990 state levels by 2020 and may employ a cap-and-trade approach.⁵¹ Although the Global Warming Solutions Act does not require the use of market-based instruments, it does allow for their use, albeit with restrictions that they must not result in increased emissions of criteria air pollutants or toxins; must maximize environmental and economic benefits in California; and must account for localized economic and environmental justice concerns.⁵²

⁴³ See discussion *infra* Part A.2.2.

⁴⁴ See *id.*

⁴⁵ See *id.*

⁴⁶ See *id.*

⁴⁷ See discussion *infra* Part A.2.3.

⁴⁸ See *id.*

⁴⁹ See *id.*

⁵⁰ See *id.*

⁵¹ See discussion *infra* Part A.2.4.

⁵² See *id.*

This mixed set of objectives potentially interferes with the development of a sound policy mechanism. The Governor's Market Advisory Committee has recommended the implementation of a cap-and-trade program with a gradual phase-in of caps covering most sectors of the economy. Allowances will be freely distributed or auctioned, with a shift toward more auctions in later years.⁵³

1.4 *Criteria for Policy Assessment*

Three criteria stand out as particularly important for the assessment of a domestic climate change policy: environmental effectiveness, cost effectiveness, and distributional equity.⁵⁴

Environmental effectiveness addresses whether it is feasible to achieve given targets with a specific policy instrument. This will include the technical ability of policymakers to design and the administrative ability of governments to implement technology standards that are sufficiently diverse and numerous to address all of the sources of CO₂ emissions in a modern economy. It will also involve the ability of political systems to put in place costs that are sufficiently severe to achieve meaningful emission reductions (or limits on global greenhouse gas concentrations, or limits on temperature changes).

In addition, the environmental-effectiveness criterion considers the certainty with which a policy will achieve emission or other targets. Although alternative policy designs may aim to achieve identical targets, design choices affect the certainty with which those targets are achieved. For example, a cap-and-trade system can achieve emission targets with high certainty because emission guarantees are built into the policy. On the other hand, with policies such as carbon taxes or technology standards, actual emissions are difficult to predict because of current and future uncertainties.⁵⁵ Consequently, while such policies can aim to achieve particular emission targets,

⁵³ *See id.*

⁵⁴ Efficiency ordinarily is a key criterion for assessing public policies, but it is less useful when comparing alternative domestic policy instruments to address climate change. This is because the efficiency criterion requires a comparison of costs and benefits. Given the global commons nature of climate change, a strict accounting of the direct benefits of any U.S. policy to the United States will produce results that are small relative to costs. Clearly, the benefits of a U.S. policy can only be considered in the context of a global system. Later in this article, the marginal cost (allowance price) of the proposed policy is compared with previous estimates of the marginal benefits of globally efficient policies. *See infra* Part 3.3. In the short term, the cap-and-trade system, like any meaningful domestic climate policy, may best be viewed as a step toward establishing U.S. credibility for negotiations on post-Kyoto international climate agreements. At the same time, another argument in favor of a cap-and-trade (or carbon tax) policy is that the political likelihood of a national climate policy is increasing in the United States, and it is preferable that such a policy be implemented cost-effectively rather than through more costly, conventional regulatory approaches.

⁵⁵ Relevant uncertainties may include uncertainty over future energy prices or how quickly new technologies will be adopted.

actual emissions may exceed or fall below those targets depending on factors beyond policymakers' control.

Moreover, the tendency of taxes and standards to grant exemptions to address distributional issues weakens the environmental effectiveness of these instruments.⁵⁶ By contrast, distributional battles over the allowance allocation in a cap-and-trade system do not raise the overall cost of the program or affect its climate impacts.

To be effective globally, any domestic program needs to be accompanied by meaningful policies by other countries. For some other industrialized countries, notably the member states of the European Union, constraints are already in place under the Kyoto Protocol and are likely to be more severe in the second commitment period after 2012. Negotiations with key developing countries, including China and India, are more likely to succeed if the United States is perceived to be prepared to adopt a meaningful domestic program, because these countries have emphasized the importance of the industrialized world acting first.

The cost-effectiveness criterion considers a policy's relative cost of achieving emission targets as compared with alternative policy designs.⁵⁷ One policy is considered more cost-effective than another if it achieves a given reduction at a lower cost. Many categories of economic costs are relevant to the evaluation of alternative policy designs.⁵⁸

Economic impacts of any climate policy will be broadly felt, but impacts will vary across regions, industries, and households. The ultimate distribution of economic impacts will depend not only on the costs imposed by the policy but also on the resulting shifts in the supply of and demand for affected goods and services. These shifts will change market prices. Firms directly regulated by a climate policy typically experience two impacts: (1) direct regulatory costs that reduce their profit margins; and (2) changes in demand for their products. A policy's initial burdens on directly regulated firms may be partially offset as the introduction of direct regulatory costs leads to increases in those firms' product prices and/or reductions in prices of some inputs. As a result of these changing prices, other firms not directly regulated by the climate policy will also experience changes in profits and demand. The extent to which firms facing the direct or indirect costs of a

⁵⁶ See Denny Ellerman, *Are Cap-and-Trade Programs More Environmentally Effective than Conventional Regulation?*, in *MOVING TO MARKETS IN ENVIRONMENTAL REGULATION: LESSONS FROM TWENTY YEARS OF EXPERIENCE* 48, 48 (Jody Freeman & Charles Kolstad eds., 2007).

⁵⁷ Comparisons of the cost of alternative policies should be made on an equal footing, where each policy achieves a common emissions target. Of course, less cost-effective policies may limit the extent of emission reductions that are politically tolerable. On the other hand, transparent policies which exhibit their costs in obvious ways, such as cost-effective pollution taxes, may be less politically tolerable than less transparent policies. See Nathaniel O. Keohane, Richard L. Revesz & Robert N. Stavins, *The Choice of Regulatory Instruments in Environmental Policy*, 22 *HARV. ENVTL. L. REV.* 313, 359 (1998).

⁵⁸ For a taxonomy of the costs of environmental regulation, see Robert N. Stavins, *Policy Instruments for Climate Change: How Can National Governments Address a Global Problem*, 1997 *U. CHI. LEGAL F.* 293 (1997).

climate policy pass those costs on to their consumers (or back to their suppliers) depends on the characteristics of the markets in which they compete, including the industry's cost structure and consumers' price responsiveness.

While a climate policy will adversely affect many firms, some may experience "windfall" profits. For example, less carbon-intensive firms may enjoy windfall profits if a climate policy increases market prices for their products more than it increases their costs. Thus, evaluation of a climate policy's distributional implications requires identifying its ultimate burdens and reflecting all adjustments in market prices, rather than just its initial impacts on costs.

While discussion often focuses on the impact of climate policies on firms, all economic impacts are ultimately borne by households in their roles as consumers, investors, and/or workers. As producers pass through increased costs, consumers experience increased prices of energy and non-energy goods, as well as reduced consumption. As a policy positively or negatively affects the profitability of firms, investors experience changes in the value of investments in those firms. Finally, workers experience changes in employment and wages.

2. PROPOSAL FOR A MEANINGFUL CAP-AND-TRADE SYSTEM

The U.S. can launch a scientifically sound, economically rational, and politically feasible approach to reducing its contributions to the increase in atmospheric concentrations of greenhouse gases by adopting an upstream, economy-wide CO₂ cap-and-trade system that implements a gradual trajectory of emission reductions and includes mechanisms to reduce cost uncertainty. These mechanisms might include multi-year compliance periods, provisions for banking and borrowing, and possibly a cost containment mechanism to protect against any extreme price volatility.

The permits in the system should be allocated through a combination of free distribution and open auction. This mix balances legitimate concerns by some sectors and individuals who will be particularly burdened by this (or any) climate policy with the opportunity to achieve important public purposes with generated funds. The share of allowances freely allocated should decrease over time, as the private sector is able to adjust to the carbon constraints, with all allowances being auctioned after 25 years.

In addition, it is important that offsets be made available both for underground and biological carbon sequestration to provide for short-term cost-effectiveness and long-term incentives for appropriate technological change. The federal cap-and-trade system can provide for supremacy over U.S. regional, state, and local programs to avoid duplication, double counting, and conflicting requirements. At the same time, it is important to provide for harmonization with selective emission reduction credit and cap-and-trade systems in other nations, as well as related international systems.

2.1 Major, Though Not Exclusive, Focus on CO₂

This proposal focuses on reductions of fossil fuel-related CO₂ emissions, which accounted for nearly 85% of the 7,147 million metric tons of U.S. GHG emissions in 2005, where tons are measured in CO₂-equivalent.⁵⁹ Carbon dioxide emissions arise from a broad range of activities involving the use of different fuels in many economic sectors. In addition, biological sequestration and reductions in non-CO₂ GHG emissions can contribute substantially to minimizing the cost of limiting GHG concentrations.⁶⁰ Some non-CO₂ GHG emissions might be addressed under the same framework as CO₂ in a multi-gas cap-and-trade system.⁶¹ But challenges associated with measuring and monitoring other non-CO₂ emissions and biological sequestration may necessitate separate programs tailored to their specific characteristics, as I describe later.⁶²

2.2 A Gradually Increasing Trajectory of Emission Reductions Over Time

The long-term nature of the climate problem offers significant temporal flexibility regarding emission reductions. Policies taking advantage of this “when flexibility” by setting annual emission targets that gradually increase in stringency can avoid many costs associated with taking action too quickly *without sacrificing environmental benefits*.⁶³ Such policies can also prevent premature retirement of existing capital stock and production and siting bottlenecks that may arise in the context of rapid capital stock transitions. In addition, gradually phased-in targets provide time to incorporate advanced technologies into long-lived investments.⁶⁴ Thus, for any given cumulative emission target or associated atmospheric GHG concentration objective, a

⁵⁹ U.S. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, EMISSIONS OF GREENHOUSE GASES IN THE UNITED STATES 2005, at ix (2006). Measuring greenhouse gases in CO₂-equivalent terms means standardizing their quantities in regard to their radiative forcing potential over their average duration in the atmosphere, relative to CO₂. *Id.* at x.

⁶⁰ JOHN M. REILLY, HENRY D. JACOBY & RONALD G. PRINN, MULTI-GAS CONTRIBUTORS TO GLOBAL CLIMATE CHANGE: CLIMATE IMPACTS AND MITIGATION COSTS OF NON-CO₂ GASES 12-13 (2003); ROBERT N. STAVINS & KENNETH R. RICHARDS, THE COST OF U.S. FOREST-BASED CARBON SEQUESTRATION 31-33 (2005).

⁶¹ Because landfill methane emissions are already monitored, and monitoring of industrial (as opposed to agricultural) non-CO₂ GHGs would not be difficult, regulation of these sources of non-CO₂ GHGs might be integrated with CO₂ policies. REILLY, JACOBY, & PRINN, *supra* note 60, at 34.

⁶² See *infra* Part 2.6.

⁶³ Tom Wigley, Richard Richels & Jae Edmonds, *Economic and Environmental Choices in the Stabilization of Atmospheric CO₂ Concentrations*, 379 NATURE 240, 241 (1996).

⁶⁴ LAWRENCE H. GOULDER, INDUCED TECHNOLOGICAL CHANGE AND CLIMATE POLICY 22 (2004); Adam B. Jaffe, Richard G. Newell & Robert N. Stavins, *Energy Efficient Technologies and Climate Change Policies: Issues and Evidence*, CLIMATE ISSUES BRIEF, No. 19 (Res. for the Future, Washington, D.C.), Dec. 1999, at 14. In addition, due to the time value of money (the opportunity cost of capital), environmentally-neutral delays in the timing of emission reduction investments can be socially advantageous.

climate policy's cost can be reduced by gradually phasing in efforts to reduce emissions.

Because of the long-term nature of the climate problem and because of the need for technological change to bring about lower-cost emission reductions, it is essential that the caps constitute a long-term trajectory. The development and eventual adoption of new low-carbon and other relevant technologies will depend on the predictability of future carbon prices, themselves brought about by the cap's constraints. Therefore, the cap-and-trade program should incorporate medium- to long-term targets, not just short-term ones.

While cost savings can be achieved by setting targets that gradually become more stringent, it is a mistake to conclude that "when flexibility" is a reason to delay enacting a mandatory policy. On the contrary, the *earlier* a mandatory policy is established, the more flexibility there is to set emission targets that gradually depart from BAU emission levels while still achieving a long-run atmospheric GHG concentration objective. The longer it takes to establish a mandatory policy, the more strict near-term emission targets will be needed to achieve a given long-run objective.

Gradually increasing the stringency of emission targets may also reduce the near-term burdens of a climate policy and, therefore, decrease the costs and significant challenges associated with gaining consensus. On the other hand, a policy that shifts reduction efforts too far into the future may not be credible, thus reducing incentives for investment in advanced technologies.

Several types of policy-target trajectories are possible, including emission caps, emission reduction targets, global concentration targets, and allowance price trajectories. Given the long-term nature of the climate problem described above, the best measure of policy stringency may be the sum of national emissions permitted over some extended period of time. As I explain later, if banking and borrowing of allowances is allowed, then only the sum is consequential, not the specific trajectory of legislated caps, because market activity will generate the cost-minimizing trajectory.⁶⁵

How should the sum of capped national emissions be identified? The classical economic approach would be to choose targets that would maximize the difference between expected benefits and expected costs. Such an approach is simply not feasible in the current context. First of all, reliable information about anticipated damages — even in biophysical terms, let alone economic terms — is insufficient. And such a calculation could be made only at the global (not the national) level due to the global-commons nature of the problem. Furthermore, it is increasingly clear that it is insufficient to carry out such an analysis with expected benefits and expected costs,

⁶⁵ The timing of emissions reductions can affect total environmental damages, even if cumulative emissions are the same. WILLIAM NORDHAUS, *THE CHALLENGE OF GLOBAL WARMING: ECONOMIC MODELS AND ENVIRONMENTAL POLICY* 126 (Sept. 2007).

since it is the small risks of catastrophic damages that are at the heart of the problem.⁶⁶

For illustrative purposes in my later cost assessment,⁶⁷ I adopt and assess a pair of trajectories for the period 2012-2050 to establish a reasonable range of possibilities. The less ambitious trajectory involves stabilizing CO₂ emissions at their 2008 level⁶⁸ over the 2012-2050 period. This trajectory, in terms of its cumulative cap, lies within the range defined by the 2004 and 2007 recommendations of the National Commission on Energy Policy.⁶⁹ The more ambitious framework, again defined over the years 2012-2050, involves reducing CO₂ emissions from their 2008 level to 50% below their 1990 level by 2050. This trajectory, defined by its cumulative cap, is consistent with the lower end of the range proposed by the U.S. Climate Action Partnership.⁷⁰

This illustrative pair of cap trajectories over the period 2012-2050 has several significant attributes. First, this range of trajectories is consistent with the frequently cited global goal of stabilizing atmospheric concentrations of CO₂ at between 450 and 550 ppm⁷¹ if all nations were to take commensurate action.⁷² Second, the caps gradually become more stringent over an extended period of time, thus reducing costs by avoiding the necessity of premature retirement of existing capital stock, reducing vulnerability to siting bottlenecks and other risks that arise with rapid capital stock transitions, and ensuring that long-lived capital investments incorporate appropriate advanced technology.

These two trajectories are provided for illustrative purposes only, so that the costs and other impacts of the cap-and-trade proposal can be examined in quantitative terms. The key design elements that are described in the remainder of this section should be employed with any cap-and-trade system, regardless of the specific trajectory of quantitative caps it is intended to implement.

⁶⁶ MARTIN WEITZMAN, ON MODELING AND INTERPRETING THE ECONOMICS OF CATASTROPHIC CLIMATE CHANGE 2 (2008), available at <http://www.economics.harvard.edu/faculty/weitzman/files/modeling.pdf>.

⁶⁷ See *infra* Part 3.

⁶⁸ In the cost analysis presented in Part 3, *infra*, this is the BAU level predicted for 2008 by Paltsev and colleagues. Sergey Paltsev et al., *Assessment of U.S. Cap-and-Trade Proposals* 9 (Nat'l Bureau of Econ. Research, Working Paper No. 13176, 2007) [hereinafter *Assessment*]; Sergey Paltsev et al., *Assessment of U.S. Cap-and-Trade Proposals — Appendix C: Details of Simulation Results* (Nat'l Bureau of Econ. Research, Working Paper No. 13176, 2007), available at http://mit.edu/globalchange/www/MITJPSPGC_Rpt146_AppendixC.pdf [hereinafter *Assessment Appendix C*].

⁶⁹ NAT'L COMM'N ON ENERGY POLICY, ENDING THE ENERGY STALEMATE: A BIPARTISAN STRATEGY TO MEET AMERICA'S ENERGY CHALLENGES 22 (2004) [hereinafter *ENDING THE ENERGY STALEMATE*]; NAT'L COMM'N ON ENERGY POLICY, *supra* note 23, at 13.

⁷⁰ See U.S. CLIMATE ACTION P'SHIP, *supra* note 11, at 7.

⁷¹ *Assessment*, *supra* note 68, at 57; see also Alex Michaelowa, *Graduation and Deeping*, in *ARCHITECTURES FOR AGREEMENT*, *supra* note 7, at 71.

⁷² "Commensurate action" is defined in the analysis as other countries taking action that is globally cost-effective, for example by employing cap-and-trade systems with the same allowance price or equivalent carbon taxes. See *Assessment*, *supra* note 68, at 35, 36.

2.3 *Upstream Point of Regulation and Economy-Wide Scope of Coverage*

Two important aspects in the design of a CO₂ cap-and-trade system are the set of emission sources that are capped (the scope of coverage) and the point in the fossil fuel supply chain at which that cap is enforced (the point of regulation). In order to create economy-wide coverage, an upstream point of regulation should be employed, whereby allowances are surrendered based on the carbon content of fuels at the point of fossil fuel extraction, import, processing, or distribution.⁷³ This can be thought of as a system where regulation is at the mine-mouth, well-head, and point of import. Original sellers of fossil fuels could be required to hold allowances: for coal, at the mine shipping terminus; for petroleum, at the refinery gate; for natural gas, at the first distribution point; and for imports, at the point of importation. Such a cap will cover effectively all sources of CO₂ emissions throughout the economy (Table 1).⁷⁴

The upstream program should include a credit mechanism to address the small portion of fossil fuels that are not combusted and to address the use of post-combustion emission reduction technologies, such as carbon capture and sequestration (“CCS”).⁷⁵ Emission reductions from CCS technologies can be readily measured, and, unlike some credit-based programs, a program for CCS does not introduce a risk of granting credits for fictitious emission reductions. Because there is no incentive to install CCS equipment absent a climate policy, emission reductions achieved by CCS are clearly “additional.” As CCS technologies are expected to play a significant role in achieving long-run emission reduction goals, such a credit mechanism is an essential component of an upstream cap.

⁷³ Regulating at the point of transportation or distribution is sometimes referred to as mid-stream. A downstream program imposes allowance requirements at the point of emissions, such as an electricity generator or factory. An upstream point of regulation has been used in prior policies where ultimate emissions are directly related to upstream production activity. For example, an upstream point of regulation was used to phase out automobile lead emissions by limiting the quantity of lead that refineries could use in gasoline. Stavins, *supra* note 17, at 394. Similarly, emissions of ozone depleting substances have been phased out through limits on production of those substances, rather than through direct limits on their use. *Id.* It should be noted that an upstream approach is not fully comprehensive unless provisions are made to address “process emissions” from natural gas and crude oil extraction.

⁷⁴ The electricity and transportation sectors account for over 70% of total emissions; when the industrial sector is included, these three sectors account for nearly 90% of emissions. But it is important to recognize that electricity emissions result from electricity use by other economic sectors. The last column of Table 1 includes indirect emissions from electricity use in each of the other sectors’ emissions. For purposes of brevity, this and other tables are published in a separate electronic document. See Robert N. Stavins, *A Meaningful U.S. Cap-and-Trade System To Address Climate Change: Tables 1* (2008) [hereinafter *Tables*], http://www.law.harvard.edu/students/orgs/elr/vol32_2/Stavins_cap_and_trade_tables.pdf.

⁷⁵ In addition, upstream regulation should include a credit-based program for fossil fuel exports so that they are not at a competitive disadvantage relative to supply from other countries that do not have any allowance requirements.

Although the point of regulation determines which entities are ultimately required to hold allowances, this decision can be made independently of decisions regarding how allowances are initially allocated. The point of regulation does not dictate or in any way limit who could receive allowances if allowances are freely distributed. Furthermore, the point of regulation decision also has no direct effect on either the magnitude of emission reduction costs or the distribution of the resulting economic burdens.⁷⁶ A cap has the same impact on the effective cost of fuel for downstream firms regardless of the point of regulation. With upstream regulation, the allowance cost is included in the fuel price. Since all suppliers face the same additional allowance cost, they all include it in the prices they set for downstream customers. With downstream regulation, the downstream customer pays for the allowances and fuel separately. In either case, the downstream customer ultimately faces the same additional cost associated with emissions from its fuel use.

This has two important implications. First, the distribution of costs between upstream and downstream firms is unaffected by the point of regulation decision. Second, firms and consumers will undertake the same emission reduction efforts — and thereby incur the same emission reduction costs — in either case because they face the same carbon price signal.

An upstream program will not dilute the carbon price signal, because allowance costs will be passed through to downstream emitters. In particular, higher fuel prices will reduce demand. This, in turn, will lead producers to moderate their price increases, thereby absorbing some of the allowance costs themselves. This argument is valid, but it is not unique to upstream systems. With a downstream point of regulation, fossil fuel would become more expensive because emitters would be required to surrender allowances. This would reduce their demand, and lead to the same offsetting effect on fuel prices. In a similar way, some may find an upstream point of regulation counterintuitive, since it does not control emissions *per se*. However, an upstream approach gets at the problem *more* directly: it caps the amount of carbon coming into the system.

2.3.1 *Environmental-Effectiveness of the Upstream Point of Regulation*

An economy-wide cap, which is enabled by an upstream point of regulation, provides the greatest certainty that national emission targets will be

⁷⁶ This point was established decades ago in the context of tax policy. See RICHARD A. MUSGRAVE & PEGGY B. MUSGRAVE, PUBLIC FINANCE IN THEORY AND PRACTICE (1980). However, there are a few exceptions. For example, the point of regulation will affect the distribution of administrative costs between upstream and downstream entities, although these costs would be small relative to the overall cost of a well-designed cap-and-trade system. ROBERT R. NORDHAUS & KYLE W. DANISH, PEW CENTER ON GLOBAL CLIMATE CHANGE, DESIGNING A MANDATORY GREENHOUSE GAS REDUCTION PROGRAM FOR THE U.S. (2003), available at http://www.pewclimate.org/global-warming-in-depth/all_reports/mandatory_ghg_reduction_prgm.

achieved. Limiting the scope of coverage to a subset of emission sources leads to emissions uncertainty through two channels. First, changes in emissions from unregulated sources can cause national emissions to deviate from expected levels.⁷⁷ Second, a limited scope of coverage can cause “leakage,” in which market adjustments resulting from a regulation lead to increased emissions from unregulated sources outside the cap that partially offset reductions under the cap. For example, a cap that includes electricity-sector emissions (and thereby affects electricity prices) but excludes emissions from natural gas or heating oil use in commercial and residential buildings may encourage increased use of unregulated natural gas or oil heating (instead of electric heating) in new buildings. As a result, increased emissions from greater natural gas and oil heating will offset some of the reductions achieved in the electricity sector. More generally, any cap-and-trade system that is not economy-wide in scope will encourage entities that are covered by the cap to exploit this incomplete coverage by seeking ways to avoid regulation.

Some stakeholders have argued for a downstream point of regulation for at least some emission sources.⁷⁸ If a broad scope of coverage is to be achieved, downstream regulation of some facilities will require a “hybrid” point-of-regulation approach, in which some sources are regulated upstream and others downstream. The commonly proposed means of implementing such a hybrid approach would involve upstream producers surrendering allowances for some, but not all of the fuel they sell, depending on whether or not the fuel is sold to sources subject instead to downstream regulation.⁷⁹

There are two significant problems with this approach. First, such a hybrid point of regulation may not provide complete coverage of fossil-fuel related CO₂ emissions. Some emission sources may fall through the cracks and not be covered by either downstream or upstream regulation. Second, there would need to be two classes of fuel in the market, one for which allowances have been surrendered and one intended for use by facilities subject to downstream regulation. This increases administrative complexity and the potential for noncompliance.

⁷⁷ For example, the EU’s ETS covers CO₂ emissions from facilities accounting for about 45% of the EU’s GHG emissions. As a result, the EU’s ability to meet its Kyoto Protocol target is threatened by significant growth in transportation sector emissions, which are not covered by the ETS. See EUROPEAN ENV’T AGENCY, GREENHOUSE GAS EMISSION TRENDS AND PROJECTIONS IN EUROPE 2006 (2006), available at http://www.eea.europaeu/eea_report_2007_5/en.

⁷⁸ See, e.g., the debates surrounding the development of a cap-and-trade program to implement California’s AB 32. MKT. ADVISORY COMM., *supra* note 36; Memorandum from Robert N. Stavins to Winston Hickox, Chair, & Lawrence Goulder, Vice-Chair, Mkt. Advisory Comm. to the Cal. Air Res. Bd., Comments on the Recommendations of the Market Advisory Committee to the California Air Resources Board, “Recommendations for Designing a Greenhouse Gas Cap-and-Trade System for California” (June 15, 2007), available at http://ksghome.harvard.edu/~rstavins/monographs_&_reports/stavins_comments_on_draft_mac_report.pdf [hereinafter Memorandum from Robert N. Stavins].

⁷⁹ Nordhaus, *supra* note 76, at iii.

2.3.2 Cost-Effectiveness of the Upstream Point of Regulation

An upstream point of regulation makes economy-wide scope of coverage feasible. The aggregate cost of emission reductions undertaken to meet a cap is directly affected by the scope of coverage, with costs declining more than proportionately with increases in the program's scope. While the point of regulation decision does not directly affect emission reduction costs, it does affect a cap's administrative cost.

An emission cap with broad coverage of emission sources reduces the cost of achieving a particular national emissions target. Three factors contribute to lower costs. First, a broader cap expands the pool of low-cost emission reduction opportunities that can contribute to meeting a national target. Even if a sector may contribute only a small portion of reductions, including that sector under the cap can yield significant cost savings by displacing the highest-cost reductions that would otherwise be necessary in other sectors. For example, the cost of achieving a five percent reduction in U.S. CO₂ emissions could be cut in half under an economy-wide cap compared with a cap limited to the electricity sector.⁸⁰

Second, an economy-wide cap provides important flexibility to achieve emission targets given uncertainties in emission reduction costs across sectors. By drawing from a broader, more diverse set of emission reduction opportunities, an economy-wide cap reduces the risk of unexpectedly high emission reduction costs much like a mutual fund reduces investment risk through diversification.

Third, an economy-wide cap creates incentives for innovation in all sectors of the economy. Such innovation increases each sector's potential to contribute cost-effective emission reductions in future years, and the resulting long-run cost savings from starting with a broad scope of coverage may far exceed any short-term gains. In theory, broad incentives for innovation might be introduced by a policy that proposes to eventually expand an initially narrow scope of coverage. But achieving such subsequent expansion would be difficult in practice, given that the adjustments that sectors will face upon joining the cap will only become more significant over time as the cap's stringency increases. Thus, political obstacles to expanding the cap may only grow over time as the cap becomes more stringent.

The point of regulation decision is a primary determinant of a cap-and-trade system's administrative costs through its effect on the number of sources that must be regulated.⁸¹ As the number of regulated sources increases, the administrative costs to regulators and firms rise. The point of regulation should be chosen to facilitate and minimize the administrative costs of a desired scope of coverage.⁸²

⁸⁰ William Pizer et al., *Modeling Economywide versus Sectoral Climate Policies Using Combined Aggregate-Sectoral Models*, ENERGY J., July 2006, at 165.

⁸¹ See *Tables*, *supra* note 74, at 2.

⁸² The size of regulated sources also affects aggregate administrative costs. In the downstream European Union Emissions Trading Scheme, there are approximately 11,000 sources,

The upstream point of regulation makes an economy-wide cap-and-trade system administratively feasible, making it possible to cap nearly all U.S. CO₂ emissions through regulation of just 2,000 upstream entities.⁸³ A key advantage of an upstream program is that it eliminates the regulatory need for facility-level GHG emissions inventories, which would be essential for monitoring and enforcing a cap-and-trade system that is implemented downstream at the point of emissions.⁸⁴ The fossil fuel sales of the 2,000 entities to be regulated under the upstream cap-and-trade system are already monitored and reported to the government for tax and other purposes. Monitoring is of little use without enforcement, so meaningful and credible penalties are important. These penalties might include fees set at up to ten times marginal abatement costs, plus the requirement for firms to make up the difference. Such a scheme has resulted in virtually 100% compliance in the case of the SO₂ allowance trading program.⁸⁵

2.3.3 *Distributional Consequences of Upstream Point of Regulation*

An economy-wide emissions cap spreads the cost burden of emission reductions across all sectors of the economy. In contrast, limiting the scope of coverage both increases the overall cost and shifts burdens across sectors, regions, and income groups. Sectors remaining under the cap experience a greater economic burden as the cost of achieving emission reductions is both increased and spread over fewer sources.

Limiting the scope of coverage may have unintended consequences as well. For example, limiting a cap's coverage to the electricity sector would lead to greater electricity rate impacts and more regional variation in those impacts than would be anticipated under an economy-wide cap. In addition, excluding direct emissions from residential and commercial buildings would alter regional variation in household impacts because of regional differences in household use of electricity, heating oil, and natural gas.

90% of which account for less than 10% of total emissions. ALLOCATION IN THE EUROPEAN EMISSIONS TRADING SCHEME: RIGHTS, RENTS AND FAIRNESS (Denny Ellerman, Barbara Buchner & Carlo Carraro eds., 2007). The questionable "fix" apparently being devised in that case is a set of less demanding monitoring and verification requirements for smaller sources. *See id.*

⁸³ Joel Bluestein, Presentation at the National Commission on Energy Policy Workshop: Upstream Regulation of CO₂ (Sept. 16, 2005) (on file with the Harvard Environmental Law Review).

⁸⁴ In contrast, it would be administratively infeasible to implement an economy-wide cap-and-trade system through downstream regulation, as this would require regulation of hundreds of millions of commercial establishments, homes, and vehicles. *See* Robert R. Nordhaus, Presentation at the National Commission on Energy Policy Workshop: Downstream Regulation-Design Options (Sept. 16, 2005) (on file with the Harvard Environmental Law Review) (discussing challenges inherent to several downstream regulation models).

⁸⁵ Robert N. Stavins, *What Can We Learn from the Grand Policy Experiment? Lessons from SO₂ Allowance Trading*, 12 J. ECON. PERSP. 69, 71 (1998).

2.4 Elements of a Cap-and-Trade System that Reduce Cost Uncertainty

While a cap-and-trade system can minimize the cost of meeting an emissions target, a poorly designed system can lead to emission reduction costs that are greater than anticipated. This risk arises because, barring mechanisms described below that control costs, regulated sources will meet an emissions cap regardless of the cost. This cost uncertainty is one factor that favors a carbon tax, which largely eliminates cost uncertainty (but introduces emissions reduction uncertainty) by setting the carbon price at a predetermined level. But policymakers can protect against cost uncertainty under a cap-and-trade system through the adoption of a few key design elements: provision for banking and borrowing of allowances and possible inclusion of a cost containment mechanism. These cap-and-trade provisions can reduce cost uncertainty while largely maintaining certainty over emissions.

2.4.1 The Nature of Cost Uncertainty

Cost uncertainties arise from numerous factors: many advanced technologies expected to contribute significantly to achieving emission reductions have highly uncertain costs and/or have not yet been commercially demonstrated; people's willingness to adopt less emissions-intensive and energy-intensive technologies is not well understood; and unanticipated events could significantly affect the cost of meeting particular emission targets, including future exogenous changes in energy prices or GDP growth, as well as future political decisions.

Concern about cost uncertainty in the context of cap-and-trade systems derives from the possibility of unexpected, significant cost increases. The experience with the southern California RECLAIM cap-and-trade system for NO_x emissions is a frequently cited example. RECLAIM had *no* automatic mechanism to relax emission caps in the face of unexpectedly high costs, and, in 2000, allowance prices spiked to more than 20 times their historical levels.⁸⁶ Cost uncertainty may increase the long-run cost of emission caps because uncertainty about future allowance prices may deter firms from undertaking socially desirable, capital-intensive emission reduction investments,⁸⁷ forcing greater reliance on costlier measures that are less capital-intensive. Furthermore, although price spikes in allowance markets may be of interest to relatively limited populations, such price spikes pass through to

⁸⁶ William Pizer, *Climate Policy Design Under Uncertainty* 3 (Res. for the Future, Discussion Paper No. 05-44, 2005). Because electricity generators were part of this cap-and-trade system, these price spikes worsened the developing West Coast electricity market crisis. See Paul Joskow, *California's Electricity Crisis*, 17 OXFORD REV. ECON. POL'Y 365 (2001). Such unexpectedly high costs, even if only temporary, may jeopardize commitments to long-run policy goals. See *infra* Part A.1.4.

⁸⁷ Firms facing investments in irreversible or sunk costs require greater returns as uncertainty in costs or revenues increase. AVINASH K. DIXIT & ROBERT S. PINDYCK, *INVESTMENT UNDER UNCERTAINTY* 46-48 (1994).

affect the prices of goods and services that are more broadly consumed, such as electricity prices in the case of RECLAIM or gasoline prices in the case of an economy-wide cap on CO₂ emissions.

2.4.2 *Include Provision for Allowance Banking and Borrowing*

Allowance banking and borrowing can mitigate some of the undesirable consequences of cost uncertainty by giving firms the flexibility to shift the timing of emission reductions in the face of unexpectedly high or low costs.⁸⁸ If the cost of achieving targets is unexpectedly and temporarily high, firms can use banked or borrowed allowances instead of undertaking costly reductions. Thus, banking and borrowing mitigate undesirable year-to-year variation in costs. Banking of allowances — undertaking extra emission reductions earlier, so that more allowances are available for later use — has added greatly to the cost-effectiveness of previous cap-and-trade systems.⁸⁹ However, banking provides little protection when costs remain high over extended periods, which could eventually lead to exhaustion of banked allowances. This problem may be particularly acute in a cap's early years, when relatively few allowances have been banked. Therefore, borrowing of allowances from future years' allocations can be a particularly useful form of cost protection in these early years.

Banking offers cost protection while guaranteeing achievement of long-run cumulative emission targets. While banking may shift some emissions from earlier to later years (from when allowances are banked to when they are used), cumulative emissions at any point during the cap's implementation can never exceed the number of allowances issued up to that point in time. Credible mechanisms need to be established to ensure that the use of borrowed allowances is offset through future emission reductions. One possible mechanism would be a provision that firms can borrow from their own future supplies, while entering into a contractual — possibly bonded — agreement with the government that the borrowed emissions will be repaid at a subsequent date. Another possible mechanism would be for the government to allocate a future year's permits that can be used in the current year, thereby decreasing a firm's future allocation by the same amount.

2.4.3 *Include Provision for a Sensible Cost-Containment Mechanism*

Ultimately, the most robust cost control feature of a cap-and-trade program is a broad and fluid market. In this sense, offsets can play a very

⁸⁸ All cap-and-trade programs have implicit provisions for banking and borrowing within the length of their compliance periods, one year in the case of the SO₂ allowance trading program, and five years in the case of the Kyoto Protocol's "commitment periods." *See infra* Parts A.1.3, A.2.1.

⁸⁹ Stavins, *supra* note 17, at 396.

important role in keeping costs down.⁹⁰ Another issue is cost uncertainty linked with short-term allowance price volatility. Banking and borrowing can be exceptionally important in reducing long-term cost uncertainty, but the possibility of dramatic short-term allowance price volatility may call for the inclusion of a sensible cost containment mechanism. Such a mechanism could allow capped sources to purchase additional allowances at a predetermined price. This price would be set sufficiently high that it would be unlikely to have any effect unless allowance prices exhibited truly drastic spikes,⁹¹ and the revenues from the fee would be dedicated exclusively to finance emissions reductions by uncapped sources like non-CO₂ greenhouse gases, or to buy back allowances in future years. This is very different from standard proposals for a “safety valve,” both because environmental integrity (the cap) is maintained by using the fees exclusively to finance additional emissions reductions or buy back allowances in future years, and because the pre-determined price is set at a high level so that it has no effect unless there are drastic price spikes.⁹²

The pre-determined fee places a ceiling on allowance prices and hence on abatement costs because no firms would undertake emission reductions more costly than the trigger price.⁹³ To be used as an insurance mechanism, the fee should be set at the maximum incremental emission reduction cost that society is willing to bear. At this level, the mechanism would be triggered only when costs are unexpectedly and unacceptably high. Of course, a cost containment mechanism that was set too high would provide no insurance against excessive costs.

Importantly, because revenues from the fee would be used to finance emissions reductions by uncapped sources or to buy back allowances in future years, the cost containment mechanism would reduce cost uncertainty and increase cost effectiveness, while simultaneously maintaining environmental effectiveness.

2.5 Allocation of Allowances

The cap-and-trade system will create a new commodity, a CO₂ allowance, which has value because of its scarcity (fostered by the cap on allowable emissions). The government can distribute allowances freely or auction

⁹⁰ See *infra* Part 2.6 (discussing this concept in more detail).

⁹¹ Thus, for example, the “trigger price” of the cost containment mechanism ought *not* to be set at 10 or 20% above the expected level of allowance prices, but twice to ten times the expected level.

⁹² See Pizer, *supra* note 86, at 7.

⁹³ See HENRY D. JACOBY & A. DENNY ELLERMAN, MIT JOINT PROGRAM ON THE SCI. AND POLICY OF GLOBAL CHANGE, *THE SAFETY VALVE AND CLIMATE POLICY* 17 (2002). An alternative to maintain and possibly exceed long-run emission targets is a complementary allowance price floor, facilitated by a government promise to *purchase* allowances at a specified price. A price floor ensures achievement of all emission reduction opportunities below a particular cost, which may exceed the amount of reductions necessary to meet the cap. The need for a price floor may decrease, however, with banking.

them. This proposal recommends an allowance allocation mechanism that combines the two, with auctions becoming more important over time.

The aggregate value of allowances will be substantial. Indeed, if all allowances are auctioned, annual auction revenues would be significant even compared with annual federal tax receipts.⁹⁴ From the perspective of firms that would need to buy auctioned allowances, total allowance costs would significantly exceed the cost of emission reductions that would be undertaken to meet a modest cap. Under an economy-wide emissions cap that reduces nationwide emissions by 5%, for example, while regulated firms would incur costs associated with reducing those emissions, they would have to purchase allowances for the remaining 95% of their emissions.

The fact that allowance requirements can contribute substantially to firm-level costs indicates that there are important distributional implications associated with the choice of allocation method (auctioning versus free distribution) and with decisions about how to distribute free allowances or how to use auction revenues. By contrast, the allocation choice does not affect achievement of emission targets, and — as emphasized above — the allocation issue is independent of the point of regulation.⁹⁵ Indeed, since alternative points of regulation lead to the same ultimate distribution of economic burdens, there is no economic rationale for tying allocation choices to the point of regulation. For example, under an upstream cap, it is possible to freely distribute allowances to downstream energy-intensive industries that are affected by the cap even though they are not directly regulated by it. This is one approach to compensating those entities for the impact of a climate policy, since they can then sell the allowances to those firms that are directly regulated under the cap.

2.5.1 *The Choice Between Auction and Free Distribution: Overall Cost Concerns*

While all allocation decisions have significant distributional consequences, whether allowances are auctioned or freely distributed can also affect the program's overall cost. Generally speaking, the choice between auctioning and freely allocating allowances does not influence firms' production and emission reduction decisions.⁹⁶ Firms face the same emission

⁹⁴ For example, with the economy-wide programs proposed here, annual auction revenues (if all allowances were auctioned) would exceed \$100 billion, compared with fiscal year 2006 Federal net tax revenues of \$351 billion (corporation income tax), \$994 billion (individual income tax), and \$810 billion (employment taxes). U.S. ENERGY INFO. ADMIN., *supra* note 59.

⁹⁵ See *supra* Part 1.4.

⁹⁶ Two exceptions where free allocations may affect pricing and production decisions (relative to auctions) are allocations to regulated utilities and "updating allocations." If permits are freely allocated, the allocation should be on the basis of some historical measures, not on the basis of measures that firms can affect. Updating allocations, which involve periodically adjusting allocations over time to reflect changes in firms' operations, contrast with this. For example, an output-based updating allocation ties the quantity of allowances that a firm receives to its output. This distorts firms' pricing and production decisions in ways that can introduce unintended consequences and can significantly increase the cost of meeting an emis-

costs regardless of the allocation method. Even when using an allowance that was received for free, a firm loses the opportunity to sell that allowance. Thus, the firm takes this “opportunity cost” into account when deciding whether to use an allowance. Consequently, in many respects, this allocation choice will not influence a cap’s overall costs. But there are two ways that the choice to freely distribute allowances can affect a cap’s cost.

First, auction revenue may be used in ways that reduce the costs of the existing tax system or fund other socially beneficial policies. Free allocations forego such opportunities. Second, free allocations may affect electricity prices in regulated cost-of-service electricity markets and thereby affect the extent to which reduced electricity demand contributes to limiting emissions cost-effectively.⁹⁷

In discussions about whether to auction or freely distribute allowances, much attention has been given to the opportunity to use auction revenue to reduce existing “distortionary” taxes.⁹⁸ Taxes on personal and corporate income discourage desirable economic activity by reducing after-tax income from work and investment. Use of auction revenue to reduce these taxes in a fiscally neutral fashion can stimulate additional economic activity, offsetting some of a cap’s costs. The magnitude of potential auction revenue, compared with existing tax receipts, suggests that auction revenue could allow for significant tax reductions. Studies indicate that “recycling” auction revenue by reducing personal income tax rates could offset 40 to 50% of the economy-wide social costs that a cap would impose if allowances were freely distributed.⁹⁹

Achieving such gains may be difficult in practice, because climate policy would need to be tied to particular types of tax reform. The estimated

sions target. While updating therefore has the potential to create perverse, undesirable incentives, selective use of updating allocations has been recommended by some to preserve competitiveness and reduce emissions leakage in sectors with high CO₂ emissions intensity and unusual sensitivity to international competition. In this proposal, I recommend an alternative approach for this purpose, namely a requirement that imports of a small set of specific commodities carry with them CO₂ allowances. See discussion *infra*, Part 2.7.3. A closely related issue, which must be addressed even under historical allocations, is whether to freely allocate allowances to new facilities and whether to strip closing facilities of their allocations. As with updating, rewarding new investments with free allowances or penalizing closures by stripping firms of their free allocations can encourage excessive entry and undesirable, continued operation of old facilities, leading to significant inefficiencies, as has apparently happened with the European Union’s Emissions Trading Scheme. Denny Ellerman, *New Entrant and Closure Provisions: How Do They Distort?* 10-11 (MIT Center for Energy and Env’tl. Policy Research, Working Paper No. 06-013, 2006).

⁹⁷ In addition, auctions eliminate the need for government to develop and implement a method of allocating allowances to individual firms, thereby reducing overall costs of program implementation, while simultaneously ensuring that allowances will be available to all participants in markets. Also, in the presence of particularly perverse types of transaction costs that reduce the cost-effectiveness of trading, auctions can be particularly attractive. Robert N. Stavins, *Transaction Costs and Tradeable Permits*, 29 J. ENVTL. ECON. & MGMT. 133, 144 (1995).

⁹⁸ See *id.* at 18-20.

⁹⁹ Lans A. Bovenberg & Lawrence H. Goulder, *Confronting Industry-Distributional Concerns in U.S. Climate Change Policy* 33 (Inst. on the Econ. of the Env’t and Sustainability, Les siminaires de l’Idrii, Discussion Paper no. 6, 2003).

cost reductions in these studies are for policies in which auction revenue is used to reduce marginal tax rates that diminish incentives to work and invest. If, instead, auction revenue funded deductions or fixed tax credits, such tax reform would have a lesser effect (and perhaps no effect) on incentives to work and invest.¹⁰⁰ On the other hand, auction revenue could yield economic gains without tax reform by reducing fiscal imbalances and, therefore, reducing the need for future tax increases.

In general, auctioning generates revenue that can be put to innumerable uses. While all uses have distributional implications, some create greater economic gains than others. Reducing tax rates is just one example of a use that creates larger overall economic gains than would result from free distribution of allowances. Other socially valuable uses of revenue include reduction of the federal debt (including offsetting a cap's potentially adverse fiscal impacts) or funding desirable spending programs (for example, research and development). On the other hand, some government uses of auction revenue may generate less economic value than could be realized by private sector use of those funds. Thus, the opportunity to reduce the aggregate cost of a climate policy through auctioning, rather than freely distributing allowances, depends fundamentally on the ultimate use of auction revenues.

2.5.2 *The Choice Between Auction and Free Distribution: Distributional Concerns*

Auctioning has the potential to reduce a climate policy's economy-wide costs. On the other hand, depending on how auction revenues are used, free distribution of allowances provides an opportunity to address the distribution of a climate policy's economic impacts.¹⁰¹ Free distribution of allowances can be used to redistribute a cap's economic burdens in ways that mitigate impacts on the most affected entities, and a sensible principle for allocation is to try to compensate the most burdened sectors and individuals. Such redistribution of impacts may help establish consensus on a climate policy that achieves meaningful emission reductions. Thus, the choice between auctioning and free allocations introduces a potential tradeoff between a cap's aggregate cost and achievement of distributional objectives.

While there are some important exceptions, in competitive markets, the benefits of free allowances generally accrue only to their recipients. While free allocations will increase recipients' profitability or wealth, free allocations generally will not benefit consumers, suppliers, or employees of those

¹⁰⁰ Unless they indirectly alter the marginal tax rates that individuals face, credits and deductions often do not affect incremental after-tax income from additional work and investment, and thereby do not affect incentives for such activity. Gilbert Metcalf, *A Proposal for a U.S. Carbon Tax Swap: An Equitable Tax Reform to Address Global Climate Change* 16 (The Brookings Inst., Discussion Paper 2007-12, 2007).

¹⁰¹ In principle, auction revenues could be redistributed in a manner equivalent to any free distribution of allowances, but such a proposal would likely encounter greater political challenges, because this would involve an explicit distribution of revenues and would require the involvement of multiple Congressional committees.

recipients. Hence, while the cost of allowance requirements can be expected to ripple through the economy, the benefits of free allocations will not do so. Therefore, in competitive markets (including deregulated electricity markets), when used for purposes of compensation, free distribution of allowances should be directly targeted at those industries, consumers, and other entities that policymakers wish to benefit.¹⁰² Having said this, it is important to keep in mind that firms *per se* are not the final recipients of these benefits. After a portion of increased profits are turned over to the government through tax payments, the remainder accrues to shareholders, a subset of the general population.

Because free allocations may increase a cap's overall cost, it is important to consider what share of allowances need to be freely distributed to meet specific compensation objectives. A permanent allocation of all allowances to affected firms would, in aggregate,¹⁰³ significantly overcompensate them for their financial losses.¹⁰⁴ This is the case because much of the cost that a cap-and-trade system initially imposes on firms will be passed on to consumers in the form of higher prices. In effect, before any free allocation, firms are already partially compensated by changes in prices that result from the cap. Thus, freely allocating *all* allowances in perpetuity to affected firms would both overcompensate them in aggregate and use up resources that could otherwise be put toward other uses, including compensating consumers that bear much of the ultimate burden.

2.5.3 *Proposal for a Mixed System of Auction and Free Distribution*

Faced with important differences in the implications of free allocation and an auction, the best alternative is to begin with a hybrid approach wherein half of the allowances are initially auctioned and half are freely distributed to entities that are burdened by the policy, including suppliers of

¹⁰² If allowance allocations are updated in future years or if they are allocated to firms in regulated markets, however, some (if not all) of the economic benefit of free allowances will flow to consumers, suppliers, and employees.

¹⁰³ Even if all firms, in aggregate, are over-compensated, some individual firms may still experience losses, because of unequal cost incidence at the firm level.

¹⁰⁴ Lawrence H. Goulder, *Confronting the Adverse Industry Impacts of CO₂ Abatement Policies: What Does it Cost?*, CLIMATE ISSUES BRIEF No. 23 (Res. for the Future, Washington, D.C.), Sept. 2000, at 4. See generally Bovenberg & Goulder, *supra* note 99; Anne E. Smith, Martin T. Ross & W. David Montgomery, *Implications of Trading Implementation Design for Equity-Efficiency Trade-offs in Carbon Permit Allocations* (Charles River Assoc., Working Paper, 2002). According to these studies, the coal, natural gas, and petroleum industries would be fully compensated if less than 25% of the allowances in an economy-wide program were freely allocated to them in perpetuity. Each industry would experience no aggregate burden, although some individual firms might suffer losses. If free allocations are phased out over time, a greater share of allowances would need to be freely allocated before the phase-out to achieve the same ultimate compensation as a smaller, but permanent allocation. For analyses of allocations to the electricity sector, see Dallas Burtraw et al., *The Effect on Asset Values of the Allocation of Carbon Dioxide Emission Allowances*, 15 ELECTRICITY J. 51 (2002); Dallas Burtraw & Karen Palmer, *Compensation Rules for Climate Policy in the Electricity Sector* (Res. for the Future, Discussion Paper No. 07-41, 2007).

primary fuels, electric power producers, energy-intensive manufacturers, and particularly trade-sensitive sectors. The share of allowances that are freely distributed should decline over time, until there is no free allocation 25 years into the program. Over time, the private sector will have an opportunity to adjust to the carbon constraints, including industries with long-lived capital assets.¹⁰⁵ Thus, the justification for free distribution diminishes over time.

In the short term, however, free distribution provides flexibility to address distributional concerns that might otherwise impede initial agreement on a policy. The half that are initially auctioned will generate revenue that can be used for public purposes, including compensation for program impacts on low-income consumers, public spending for related research and development, reduction of the federal deficit, and reduction of distortionary taxes.

The time path of the proportional division between the share of allowances that is freely allocated and the share that is auctioned (beginning with a 50-50 auction-free allocation, moving to 100% auction over 25 years) is consistent with analyses which have been carried out of the share of allowances that would need to be distributed freely to compensate firms for equity losses. In a series of analyses that considered the share of allowances that would be required in perpetuity for full compensation, Bovenberg and Goulder found that 13% would be sufficient for compensation of the fossil fuel extraction sectors.¹⁰⁶ In a scenario consistent with the Bovenberg and Goulder study, Smith, Ross, and Montgomery found that 21% would be needed to fully compensate primary energy producers and electricity generators.¹⁰⁷

The time-path recommended here for an economy-wide program — 50% of allowances initially distributed freely, with this share declining steadily (linearly) to zero after 25 years — is equivalent in terms of present discounted value to perpetual allocations (as those previously analyzed) of 15%, 19%, and 22%, at real interest rates of 3%, 4%, and 5%, respectively. Hence, the recommended allocation is consistent with the principal of targeting free allocations to burdened sectors in proportion to their relative burdens. It is also pragmatic to be more generous with the allocation in the early years of the program.

2.6 *Credits for Specified Activities*

It is important to provide credits to those who report specific activities or emission reductions. Covered firms may buy these credits to offset their obligations under the cap. This is a potentially advantageous means of lowering costs and encouraging emission reductions from activities outside the scope of the cap-and-trade system. An important concern, however, is the

¹⁰⁵ NORDHAUS, *supra* note 65, at 67.

¹⁰⁶ Bovenberg & Goulder, *supra* note 99, at 38.

¹⁰⁷ Smith et al., *supra* note 104, at 6.

additionality problem, or the challenge of identifying whether a credit is really warranted, which requires making a comparison with an unobservable hypothetical (what would have happened had the credit *not* been generated). Despite this problem, significant cost savings can be achieved through selective use of credit-based programs targeting certain activities that otherwise would be too costly or infeasible to integrate into the cap-and-trade system.

The proposed upstream program should include selective use of the credit mechanism to address the small portion of fossil fuels that are not combusted and the use of downstream emission reduction technologies, such as carbon capture and storage ("CCS"). First, credits should be issued for major non-combustion uses of fossil fuels, such as in some petrochemical feedstocks, as well as fuel exports.

Second, credits should be issued for CCS. Emission reductions from CCS technologies can be readily measured, and because there is no incentive to install CCS equipment absent a climate policy, emission reductions achieved by CCS are clearly additional.¹⁰⁸ As CCS technologies may play a significant role in achieving long-run emission reduction goals,¹⁰⁹ this credit mechanism is an essential component of the upstream cap. Indeed, it might even be desirable to intentionally over-compensate CCS activities with credits to provide a stronger incentive for research and development.

Third, a program of credits for selected cases of biological sequestration through land use changes should be included. A cost-effective portfolio of climate technologies in the United States would include a substantial amount of biological carbon sequestration through afforestation and retarded deforestation.¹¹⁰ Translating this into practical policy will be a considerable challenge, however, because of concerns about monitoring and enforcement, additionality, and permanence. In principle, monitoring and enforcement is technologically feasible via third-party verification through remote sensing, but its cost may be high. Additionality is an even greater challenge, although it is likely to be less of a problem with afforestation than with avoided deforestation. The issue of permanence can be addressed, in principle through renewal of contracts to keep carbon stored,¹¹¹ but someone must

¹⁰⁸ Jennie Stephens & Bob Van Der Zwaan, *The Case for Carbon Capture and Storage*, 22 ISSUES IN SCI. AND TECH. POLICY 69, 70 (2005), available at <http://www.issues.org/22.1/stephens.html>.

¹⁰⁹ U.S. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, ENERGY MARKET AND ECONOMIC IMPACTS OF A PROPOSAL TO REDUCE GREENHOUSE GAS INTENSITY WITH A CAP AND TRADE SYSTEM (2007); Mass. Inst. Of Tech., THE FUTURE OF COAL: OPTIONS FOR A CARBON-CONSTRAINED WORLD 5-16 (2007).

¹¹⁰ Robert N. Stavins, *The Costs of Carbon Sequestration: A Revealed-Preference Approach*, 89 AM. ECON. REV. 994, 1006 (1999); STAVINS & RICHARDS, *supra* note 60, at 31; Ruben N. Lubowski, Andrew J. Plantinga & Robert N. Stavins, *Land-Use Change and Carbon Sinks: Econometric Estimation of the Carbon Sequestration Supply Function*, 51 J. ENVTL. ECON. & MGMT. 135, 150 (2006). For example, Stavins and Richards estimated that more than one billion metric tons of CO₂ could be sequestered annually at a cost ranging from about \$8 to \$23 per ton of CO₂. See STAVINS & RICHARDS, *supra* note 60, at 32.

¹¹¹ Andrew J. Plantinga, President, Energy and Environmental Analysis, Inc., Presentation at Workshop on Carbon Sequestration in Agriculture and Forestry, Thessaloniki, Greece:

bear the risk of default. Despite these challenges, it would be important to begin to develop at least a limited system of credits for biological sequestration, partly because otherwise there may be significant leakage due to policies that affect biofuel production.¹¹²

Fourth, provision should be made to provide coverage over time of non-CO₂ greenhouse gases. Although CO₂ is by far the most important anthropogenic greenhouse gas (84% of radiative forcing linked with emissions in 2005), it is by no means the only greenhouse gas of concern.¹¹³ Carbon dioxide, methane (“CH₄”), nitrous oxide (“N₂O”), and three groups of fluorinated gases — sulfur hexafluoride (“SF₆”), HFCs, and PFCs — are the major greenhouse gases and the focus of the Kyoto Protocol.¹¹⁴ The non-CO₂ GHGs are significant in terms of their cumulative impact on climate change, representing about 16% of radiative forcing in 2005.¹¹⁵ Because some emission reductions could be achieved at relatively low cost, their inclusion in a program would be attractive in principle.¹¹⁶

The sources of some of these gases are many in number and highly dispersed, making their inclusion in a cap-and-trade program problematic. The answer may be to phase in regulation selectively over time with credit (offset) mechanisms, being careful to grant credits in CO₂-equivalent terms only for well-documented reductions. Over time, such approaches could be developed for industrial¹¹⁷ emissions of methane and NO₂ and for the manufacture of key industrial gases in the case of refrigerants (HFCs), circuits (PFCs), and transformers (SF₆). Thus, cap-and-trade of non-CO₂ GHGs would likely combine upstream and downstream points of regulation.

More broadly, because of concerns about additionality and related perverse incentives, the role of project-based offsets should be defined carefully.¹¹⁸ In particular, it is important that offsets be real, additional, verifiable, and permanent. Constraints should not be created in quantitative or geographic terms, however. Allowing even a small number of bad offsets does not make sense, nor does it make sense to deny high-quality offsets. Instead, strict criteria should be developed for allowing the generation of approved offsets, but without reference to quantity or location.

Land-Use Change and Biological Carbon Sequestration 22 (June 27, 2007) (on file with the Harvard Environmental Law Review).

¹¹² *Assessment*, *supra* note 68, at 30-32.

¹¹³ U.S. ENERGY INFO. ADMIN., *supra* note 59, at ix–xxii.

¹¹⁴ Kyoto Protocol, *supra* note 4. CFCs, although greenhouse gases, are regulated by the Montreal Protocol, which was motivated by the impacts of CFCs on stratospheric ozone depletion, rather than by their contribution to global climate change. Montreal Protocol on Substances That Deplete the Ozone Layer, Sept. 16, 1987, S. Treaty Doc. No. 100-10, 1522 U.N.T.S. 3 [hereinafter Montreal Protocol].

¹¹⁵ U.S. ENERGY INFO. ADMIN., *supra* note 109, at 5.

¹¹⁶ *Assessment*, *supra* note 68, at 13-14.

¹¹⁷ Agricultural emissions probably are too dispersed to be subject to a sound credit program.

¹¹⁸ For an optimistic assessment of the role of offsets, see NATSOURCE LLC, *REALIZING THE BENEFITS OF GREENHOUSE GAS OFFSETS: DESIGN OPTIONS TO STIMULATE PROJECT DEVELOPMENT AND ENSURE ENVIRONMENTAL INTEGRITY* (2007) (prepared for the National Commission on Energy Policy).

2.7 *Linkage with Other Cap-and-Trade Systems and Other Nations' Policies*

Three distinct linkage issues are important. These are: the relationship of the proposed national cap-and-trade system with any existing state or regional systems in the United States; the linkage of the proposed cap-and-trade system with other such systems in other parts of the world; and, more broadly, the relationship between the proposed cap-and-trade system and other nations' climate policies.

2.7.1 *Linkage with Other Domestic Cap-and-Trade Systems*

In the absence of a national climate policy, ten northeast states have planned a downstream cap-and-trade program among electricity generators in their RGGI, and California is considering implementing a cap-and-trade program at the state level. The proposed economy-wide, national, upstream cap-and-trade system could take the place of any regional, state, and local systems to avoid duplication, double counting, and conflicting requirements.¹¹⁹ It is likely that a decision will be reached on a national cap-and-trade system before any of the regional or state programs have actually been implemented.

2.7.2 *Linkage with Cap-and-Trade and Emission Reduction Credit Systems Outside of the United States*

In the long run, linking the U.S. cap-and-trade system to cap-and-trade systems in other countries or regions, such as the EU ETS, will clearly be desirable to reduce the overall cost of reducing GHG emissions and achieving any global GHG concentration targets.¹²⁰ But there is a question of what level and type of linkage is desirable in the early years of the development of a U.S. cap-and-trade system. In the short term, it may be best for the United States to focus on linkage with emission reduction credit ("ERC") programs, such as the Kyoto Protocol's Clean Development Mechanism ("CDM").¹²¹

First, by tapping low-cost emission reduction opportunities in developing countries, linkage of the U.S. system with CDM has a greater potential to achieve significant cost savings for the United States than does linkage with cap-and-trade systems in other industrialized countries (where abatement costs are similar to those in the United States).¹²²

¹¹⁹ Memorandum from Robert N. Stavins, *supra* note 78.

¹²⁰ JUDSON JAFFE & ROBERT N. STAVINS, LINKING TRADABLE PERMIT SYSTEMS FOR GREENHOUSE GAS EMISSIONS: OPPORTUNITIES, IMPLICATIONS, AND CHALLENGES (2007).

¹²¹ Kyoto Protocol, *supra* note 4, art. 12.

¹²² This raises concerns about additionality associated with CDM credits. *See infra* note 124 and accompanying text.

Second, linkage with an ERC system such as CDM can only have the effect of decreasing domestic allowance prices, since transactions are unidirectional (i.e., U.S. purchases of low-cost CDM credits). In contrast, bidirectional linkage of the U.S. system with another cap-and-trade system can either increase or decrease the domestic allowance price, depending upon whether marginal abatement costs (and hence allowance prices) are lower or higher in the other cap-and-trade system. Similarly, other countries contemplating linking their cap-and-trade systems with a U.S. system may object to buying allowances from the U.S. system if the U.S. cap is less stringent (and hence has a lower allowance price).

Third, the U.S. may have to choose between adopting a cost-containment mechanism and linking with cap-and-trade systems in other countries. It appears unlikely that the European Union would agree to linking its Emissions Trading Scheme with a U.S. system that employed a safety valve or other such cost-containment measure.¹²³ On the other hand, the U.S. could link with ERC systems, such as CDM, even with a cost-containment measure in place. In summary, compared with linking with other cap-and-trade systems, linking with CDM would give the United States greater autonomy over the allowance price that emerges from its system and over efforts to control cost uncertainty.

Fourth, given that other cap-and-trade systems likely will be linked with CDM, linking the U.S. system with CDM will have the effect of indirectly linking it with those other cap-and-trade systems in a way that avoids the short-term problems identified above. For example, to the extent that the U.S. system bids CDM credits away from Europe, the offsetting emission reductions associated with resulting increased emissions in the United States would come from Europe, not from the countries that originally supply the CDM credits.

Fifth, this indirect linkage should reduce concerns about additionality normally associated with linking with CDM. If another country or region (for example, the European Union) has already linked with CDM, the effect of U.S. linkage with CDM will differ significantly from the effect if the United States were the only country linking with CDM. While there may indeed be significant additionality concerns associated with CDM credits,¹²⁴ many of the credits that the U.S. system would ultimately purchase would be used by other linked cap-and-trade systems if the United States did not link with CDM. Hence, for these credits, there is no incremental additionality concern regarding the U.S. decision to link with CDM. Any U.S. use of these credits would result in emission reductions in the other linked cap-and-trade system that would otherwise have used the credits.

¹²³ JACOBY & ELLERMAN, *supra* note 93.

¹²⁴ Michael Wara, *Measuring the Clean Development Mechanism's Performance and Potential* (Stanford Univ. Program on Energy and Sustainable Dev., Working Paper No. 56, 2006), available at http://iis-db.stanford.edu/pubs/21211/Wara_CDM.pdf.

Sixth and finally, the indirect linkage created by a U.S. link with CDM can achieve some and perhaps much of the cost savings that would arise from direct linkage with other cap-and-trade systems. CDM credits can be sold on the secondary market and ultimately will go to the linked cap-and-trade system with the highest allowance price, thereby pushing the allowance prices of the various cap-and-trade systems toward the convergence that would be achieved by direct linkage among cap-and-trade systems. If there is a sufficient supply of low-cost CDM credits, linkage between the various cap-and-trade systems and CDM would achieve the same outcome as direct linkage among cap-and-trade systems. Therefore, at least in the short term, bilateral linkage between the various national and regional cap-and-trade systems and CDM will achieve significant cost savings.

For these reasons, linkage of the U.S. cap-and-trade system with CDM may be a sensible first step as cap-and-trade systems begin to develop around the world, with the expectation that the United States will explore direct linkage with these other systems over time.

2.7.3 *Linkage with Other Countries' Climate Policies*

The fact that climate change is a global-commons phenomenon means that it can be sensible to condition the goals and operations of the proposed U.S. cap-and-trade program on the GHG emissions reductions efforts that other countries are employing. One approach is to include a provision for the overall U.S. emissions cap to be tightened if the President or Congress determines that other major CO₂-emitting nations have taken specific climate policy actions. Such "issue linkage" — making the cap contingent upon the actions of other key countries — can make sense, particularly absent U.S. participation in a binding international agreement. This links the goals of the U.S. system with other countries' actions.

In addition, the operation of the cap-and-trade system should be linked with the actions of other key nations. As part of the cap-and-trade program, imports of specific highly carbon-intensive goods (in terms of their emissions generated during manufacture) from countries which have not taken climate policy actions comparable to those in the United States should be required to hold appropriate quantities of allowances (mirroring the allowance requirements on U.S. sources). These allowances can be purchased from any participants in the domestic cap-and-trade system. If designed and implemented properly, this mechanism can help establish a level playing field in the market for domestically produced and imported products, and thereby reduce emissions leakage and induce key developing countries to join an international agreement.¹²⁵

There are some understandable concerns with such a mechanism. First of all, there is the economist's natural resistance to tampering with free inter-

¹²⁵ Michael G. Morris & Edwin D. Hill, *Trade is the Key to Climate Change*, ENERGY DAILY, Feb. 20, 2007.

national trade in order to achieve other ends. Second, there is the difficulty of making the needed calculations of appropriate quantities of allowances on imports of manufactured goods. Third, there is the inescapable irony that the United States might adopt a mechanism for use against other countries that recently had been proposed by Europeans for use against the United States (although with a border tax) because of U.S. non-ratification of the Kyoto Protocol.¹²⁶ More broadly, there is the risk that this mechanism would be abused and inappropriately applied as a protectionist measure.

These concerns can be addressed by properly constraining the mechanism to apply only to primary highly energy-intensive commodities — such as iron and steel, aluminum, cement, bulk glass, and paper — and possibly a very limited set of other particularly energy-intensive (i.e., CO₂ emissions-intensive) goods. The requirement would not apply to countries that are taking comparable actions to reduce their GHG emissions, and exemptions could be provided for countries with very low levels of GHG emissions and the lowest levels of economic development.

In order to be compatible with World Trade Organization rules, it is key that the burden imposed on imported and domestic goods be roughly comparable and that there not be discrimination among nations with similar conditions.¹²⁷ Also, this requirement should become binding only after ten years, to allow time for an international climate agreement to be negotiated that includes all key countries in meaningful ways and thereby obviates the need for the mechanism.¹²⁸ If properly designed and constrained, this mechanism can be a useful intermediate step of international linkage on the way to U.S. participation in a sound international agreement.

2.8 *Associated Climate Policies*

From an economic perspective, the price signals generated by a well-functioning upstream cap-and-trade system will be insufficient for their purpose if there are remaining market failures that render those price signals ineffective. For example, there may be market failures other than the environmental externality of global climate change associated with energy-efficiency investments. If the magnitude of these non-environmental market

¹²⁶ Jagdish Bhagwati & Petros C. Mavroidis, *Is Action Against US exports for failure To Sign Kyoto Protocol WTO-legal?*, 6 *WORLD TRADE REV.* 299 (2007).

¹²⁷ Joost Pauwelyn, *U.S. Federal Climate Policy and Competitiveness Concerns: The Limits and Options of International Trade Law* 27-33 (Duke Univ., Nicholas Inst. for Envtl. Policy Solutions, Working Paper No. 07-02, 2007). For further discussion of the relationship between WTO rules and such mechanisms, including the use of border taxes, see Jeffrey Frankel, *Climate and Trade: Links Between the Kyoto Protocol and WTO*, 47 *ENVIRONMENT* 8, 15-18 (2005).

¹²⁸ For a variety of potential post-Kyoto international policy architectures, see ARCHITECTURES FOR AGREEMENT, *supra* note 7. For an example of a specific proposal that would include all key countries in a meaningful international agreement, see Sheila M. Olmstead & Robert N. Stavins, *An International Policy Architecture for the Post-Kyoto Era*, 96 *AM. ECON. REV. PAPERS AND PROC.* 35 (2006).

failures is large enough and the cost of correcting them small enough to warrant policy intervention, then an argument can be made to attack these other market failures directly.¹²⁹

Examples of such relevant market failures include information problems that lead consumers to undervalue expected energy cost savings when purchasing energy-consuming durable goods, ranging from room air conditioners to motor vehicles. Likewise, there is in theory the principal-agent problem of landlords who may underinvest in energy-efficient appliances, because electricity costs are paid by tenants. Perhaps most important is the example of the public good nature of research and development, which leads to underinvestment because knowledge generated may not be exclusive and so economic returns cannot be fully captured. To achieve the desired levels of investment, additional public policies of various kinds may be necessary, beyond the price signals generated by the cap-and-trade system. Many such policies have been recommended by the National Commission on Energy Policy.¹³⁰

3. ECONOMIC ASSESSMENT OF THE PROPOSAL

This section of the article begins with a qualitative examination of implications of the proposed cap-and-trade system for both short-term cost-effectiveness and long-term dynamic incentives for cost-saving technological change. Empirical estimates of costs, price impacts, and other aggregate economic measures are provided for the two illustrative trajectories of CO₂ emissions caps. In addition, I consider the challenge of estimating the benefits of a U.S. program addressing a global-commons problem and provide numerical benefit estimates from previous sources to place the cost estimates in context. The section closes with an extensive consideration of distributional impacts of the proposed system, including illustrative numerical estimates of sectoral cost impacts.

3.1 *A General Cost Assessment of the Cap-and-Trade Approach*

The opportunity for cost savings through the use of a cap-and-trade approach to CO₂ emission reductions stems largely from the natural scientific characteristics of global climate change. First, climate impacts depend on the stock of GHGs that accumulate in the atmosphere, not on the flow at

¹²⁹ Jaffe, Newell & Stavins, *supra* note 64, at 16.

¹³⁰ ENDING THE ENERGY STALEMATE, *supra* note 69, at 103-12; NAT'L COMM'N ON ENERGY POLICY, *supra* note 23, at 25-26. A conceptually distinct issue is the existence of other policy problems, like "energy security," which may call for public policies that also have climate impacts. *See, e.g.*, David Sandalow, *Ending Oil Dependence* 13-20 (The Brookings Inst., Working Paper, 2007) (proposing various policy solutions to end the United States' oil dependence).

any point in time.¹³¹ Given the long lag-time of GHGs in the atmosphere, it is cumulative emissions over decades that are the appropriate focus of policy actions. Second, any particular emissions have the same effect on the atmospheric stock no matter where in the country (or the world, for that matter) they are generated. Thus, GHG emission reductions have the same beneficial effects no matter how, where, and, to a large extent, when they are achieved. As a result, compliance flexibility can be used to lower costs without compromising environmental integrity. A cap-and-trade system (and likewise a carbon tax) offers this flexibility and takes advantage of what has been termed “what, where, and when” flexibility.

The cap-and-trade system minimizes compliance costs through “what flexibility” by exploiting the fact that many types of actions offer low-cost CO₂ emission reduction opportunities, including adopting more efficient or lower-emitting technologies, adjusting use of equipment that generates emissions, and accelerating the replacement of existing equipment. The cap-and-trade system allows — indeed encourages — emission reductions through whatever measures are least costly.

The cap-and-trade system also minimizes compliance costs through “where flexibility” by allowing for the fact that control costs vary widely across industries and within an industry. Costs can vary significantly even across households or firms that use exactly the same equipment.¹³² The cap-and-trade system exploits this variation by achieving reductions wherever they are least costly. Emission reduction costs will change over time as new technologies are developed. So what may be a cost-effective distribution of emission reduction efforts across sectors, technologies, and regulated entities today may not be ten years from now. The cap-and-trade system adjusts automatically as control costs change over time.¹³³

As emphasized earlier in the discussion of emission trajectories, the cap-and-trade system also minimizes costs through “when flexibility.” Climate change results from cumulative GHG emissions over decades to centuries, and it is therefore cost-effective to allow for flexibility in the timing of emission reductions. The cap-and-trade system can provide temporal flexibility through the design elements proposed above: allowing the banking of allowances for use in future years; allowing the borrowing of allowances from future allocations for use now; and multi-year compliance periods, where firms have flexibility about how they distribute their emissions within the compliance period. By allowing firms to minimize their costs of complying with the long-term trajectory of caps, the cap-and-trade system avoids requiring premature retirement of existing capital stock or locking in ex-

¹³¹ WILLIAM NORDHAUS, *THE CHALLENGE OF GLOBAL WARMING: ECONOMIC MODELS AND ENVIRONMENTAL POLICY* 91 (2007), available at http://nordhaus.econ.yale.edu/dice_mss_091107_public.pdf.

¹³² Tietenberg *supra* note 24, at 11.

¹³³ Furthermore, lower-cost opportunities to reduce emissions may exist in other countries, and the cap-and-trade system creates a common currency — the emissions allowance — that makes it possible to link with efforts to reduce GHGs in other regions.

isting emission reduction technologies in long-lived capital investments when better technologies may be available later. Likewise, the system avoids putting complying firms in the position of undertaking unnecessarily costly emission reductions in one year that may be caused by unusual circumstances, when less costly offsetting reductions can be achieved in other years.¹³⁴ By incorporating “when flexibility,” cost effectiveness is achieved without compromising the achievement of cumulative emissions targets.

Given the long-term nature of climate change, it is exceptionally important that the cap-and-trade approach provides incentives for long-term technological change. New technologies will have the potential to significantly reduce the long-run cost of achieving climate policy objectives.¹³⁵ It is critical that climate policies encourage innovations in technologies and in how fossil fuels are used. By rewarding any means of reducing emissions, the cap-and-trade system provides broad incentives for any innovations that lower the cost of achieving emission targets.

3.2 Empirical Cost Assessment of the Cap-and-Trade Proposal

A considerable number of analytical models have been employed over the past several years to estimate the aggregate costs (and in some cases, the distributional impacts) of a cost-effective set of emission-reduction actions to achieve various national CO₂ and GHG targets. Such analyses have been used to provide estimates of the costs associated with a domestic cap-and-trade system (and, for that matter, a carbon tax). These include three modeling groups that carried out analyses under the U.S. government’s Climate Change Science Program¹³⁶ and a much larger set of modeling teams that worked together under Stanford University’s Energy Modeling Forum project, “EMF-21.”¹³⁷

Two models have had a distinctly U.S. focus and have been used to give particular attention to the costs associated with domestic cap-and-trade systems: the National Energy Modeling System (“NEMS”) of the U.S. Depart-

¹³⁴ For example, annual variations in weather may affect the availability of renewable energy resources, such as hydroelectric power.

¹³⁵ See generally Jaffe, Newell & Stavins, *supra* note 17, at 461 (Karl-Göran Mäler & Jeffrey Vincent eds., 2003).

¹³⁶ The three models are the Integrated Global Systems Model (“IGSM”) of the Massachusetts Institute of Technology’s Joint Program on the Science and Policy of Global Change; the MiniCAM Model of the Joint Global Change Research Institute, itself a partnership of the Pacific Northwest National Laboratory and the University of Maryland; and the Model for Evaluating the Regional and Global Effects (“MERGE”) of greenhouse gas emission-reduction policies, a joint effort of Stanford University and the Electric Power Research Institute. See Richard G. Newell & Daniel Hall, *U.S. Climate Mitigation in the Context of Global Stabilization*, BACKGROUNDER (Res. for the Future, Washington, D.C.), Sept. 2007, at 3-6; Leon Clarke et al., CCSP Synthesis and Assessment Product 2.1, Part A: Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations (Dec. 6, 2006) (unpublished draft, on file with the Harvard Environmental Law Review) (summarizing results of these models).

¹³⁷ See generally 27 ENERGY J., (*Multi-Greenhouse Gas Mitigation and Climate Pol’y*, Special Issue) (2006) (Francisco C. de la Chesnaye & John P. Weyant eds., 2006) (detailing the results in a series of articles).

ment of Energy¹³⁸ and the Emissions Prediction and Policy Analysis (“EPPA”) model of the Massachusetts Institute of Technology’s Joint Program on the Science and Policy of Global Change.¹³⁹

None of the models or their results is easily comparable. The cost estimates they produce depend upon the structure of the models, as well as key assumptions regarding the magnitude of a wide variety of current and future parameters and variables. The factors that stand out as having the greatest effects on respective cost estimates are: the forecasted BAU emissions path; policy stringency and the trajectory of stringency; the scope of policy coverage across the economy; assumed opportunities for fuel switching and energy-efficiency improvements; availability of credits; and use of revenues from auctioned allowances.

To provide illustrative empirical cost estimates, this proposal draws on recent results from MIT’s EPPA model, both because of the recent vintage of the analysis and because the model was applied by its authors to examining an upstream cap-and-trade system that is — in its stylized form — close to what is proposed here.¹⁴⁰ As with any analytical model, there are particular aspects of the model and analysis which affect the cost estimates.

Some of the EPPA model’s characteristics and assumptions may lead to underestimates of the costs of the proposed cap-and-trade system. First, the model is a stylized computable general equilibrium (“CGE”) model which assumes perfect frictionless markets (marginal costs equated among emissions sources), full employment of resources, and no costs of transition (important for the short term).¹⁴¹ In essence, emission reductions — but not policies — are modeled, which is the case with virtually all such analytical models. Likewise, the costs of monitoring emissions are ignored, as are the transaction costs of firms engaging in allowance trades.¹⁴² Second, EPPA is a deterministic model, that is, uncertainty is not explicitly included.¹⁴³ If uncertainty and risk aversion increase costs, then the model’s assumption of perfect information tends to understate costs. On the other hand, the cost-saving properties of specific design elements that reduce cost uncertainty cannot really be captured. Third, it is assumed that other regions of the

¹³⁸ See U.S. ENERGY INFO. ADMIN., *supra* note 109, at 5-8. In addition to the Energy Information Administration’s own use of the NEMS model, the National Commission on Energy Policy has used the NEMS model to estimate the costs of its proposals. See ENDING THE ENERGY STALEMATE, *supra* note 69, at 9, 34-35; NAT’L COMM’N ON ENERGY POLICY, *supra* note 23, at 14-15.

¹³⁹ *Assessment*, *supra* note 68, at 7-8, 10-11. Note that EPPA is a component of the IGSM. For a summary of findings from the models for reducing U.S. greenhouse gas emissions, see Joseph E. Aldy, *Assessing the Costs of Regulatory Proposals for Reducing U.S. Greenhouse Gas Emissions*, BACKGROUND (Res. for the Future, Washington, D.C.), Sept. 2007, at 11-17.

¹⁴⁰ *Assessment*, *supra* note 68, at 2.

¹⁴¹ *Id.* at 48.

¹⁴² See *id.* at 7-8.

¹⁴³ *Id.* at 8.

world undertake commensurate climate policies, which is significant because of effects on international fuel and other prices.¹⁴⁴

Other characteristics and assumptions of the model are likely to lead to overestimates of the costs of the proposed system. First, the EPPA model analyzes an all-GHG program, in which each gas is reduced cost-effectively and in the proper proportion.¹⁴⁵ Compared with a CO₂-only program, it is not a problem for the estimated CO₂ allowance prices, but it does result in overestimates of impacts on gross domestic product (“GDP”) as reported in this article. The reported GDP impacts are for more ambitious programs that include both the indicated CO₂ emissions reductions and additional reductions in non-CO₂ GHGs.¹⁴⁶ Second, the model does not allow for biological carbon sequestration either directly in the cap-and-trade system or through credits.¹⁴⁷ Third, it is assumed that there is no linkage and no international trade of allowances or credits for project-level activities.¹⁴⁸ Fourth, nuclear power is assumed to be limited by concerns for safety and siting of new plants, so nuclear capacity is not allowed to expand despite economic signals.¹⁴⁹

With various model characteristics and assumptions operating in opposite directions, on balance the EPPA analysis can be employed simply to offer some illustrative cost estimates.¹⁵⁰

¹⁴⁴ *Id.* at 10. In particular, Europe, Canada, Australia, and New Zealand are modeled as complying with the Kyoto Protocol in 2012, with their emissions falling gradually to 50% below 1990 levels by 2050. Developing countries are treated as adopting a policy in 2025 that returns and holds them at their year 2015 emissions through 2034, and then returns and holds them at their year 2000 emissions for 2035 through 2050. *Id.* The cost of a U.S. cap-and-trade program is affected by these policies in the rest of the world through international fuel and other prices. *Id.* at 11-12. Likewise, if a carbon tax were employed, the effectiveness of a U.S. policy would depend on policies in the rest of the world.

¹⁴⁵ *Id.* at 12.

¹⁴⁶ *Id.* On the other hand, any given set of climate targets (such as those expressed in terms of CO₂-equivalent) can be achieved at lower cost with a multi-gas program than with a CO₂-only program. However, the EPPA model’s treatment of non-CO₂ GHGs, in which measurement and policy implementation problems are assumed away, likely has the effect of understating to some degree the aggregate costs of control.

¹⁴⁷ *Id.* at 32.

¹⁴⁸ *Id.* at 10, 18.

¹⁴⁹ *Id.* at 10.

¹⁵⁰ Also, the EPPA model does not take into account the existence of state and regional programs, such as the Regional Greenhouse Gas Initiative in the Northeast, and AB 32 in California. *See id.* at 3-11 (outlining model parameters). Ignoring such programs in place could tend to overstate the costs of achieving some national cap, but the presence of such programs can also lead to inefficiencies via path dependence, leading to a sub-optimal national program and driving up costs. However, the major impacts of state or regional programs — assuming they are binding — will primarily be distributional, driving up costs (requiring more abatement) by states with such policies in place and reducing the costs of the national program for other states. Memorandum from Robert N. Stavins, *supra* note 78, at 15-17.

3.2.1 *Anticipated Emissions Under Two Illustrative Cap Trajectories*

The first illustrative trajectory involves stabilizing CO₂ emissions at their 2008 level over the period from 2012 to 2050 (Table 3).¹⁵¹ This trajectory, in terms of its cumulative cap, lies within the range defined by the 2004 and 2007 recommendations of the National Commission on Energy Policy.¹⁵² The second illustrative trajectory — also defined over the years 2012-2050 — involves reducing CO₂ emissions from their 2008 level to 50% below their 1990 level by 2050 (Table 3).¹⁵³ This trajectory — defined by its cumulative cap — is slightly below the lower end of the range proposed by the U.S. Climate Action Partnership.¹⁵⁴ The anticipated emissions paths under the two illustrative caps differ from the cap trajectories themselves because of the use of emissions banking (Table 4).¹⁵⁵ A comparison of Tables 3 and 4 makes clear that it is cost-effective for sources to reduce CO₂ emissions well below the cap in early years, generating a bank of allowances that can then be used in later years.¹⁵⁶

Relative to respective forecasted BAU CO₂ emissions, both implementations of a cap-and-trade system would achieve dramatic emission reductions. In the “Stabilization” case (“stabilization case,” or “stabilization policy”), emissions will be 10% below BAU in 2015, three years after the program commences, and fall to 38% below BAU by 2050. In the more aggressive “50% below 1990 Level by 2050” case (“aggressive case,” or “aggressive policy”), emissions are predicted to be 18% below BAU in 2015 and 75% below BAU in 2050 (Table 5).¹⁵⁷

3.2.2 *CO₂ Allowance and Fossil Fuel Prices*

The tradable CO₂ allowances have value because of their scarcity, and it is their market-determined price that provides incentives for cost-effective emission reductions and investments that bring down abatement costs over time. As the required emission reductions (relative to BAU) increase over time under both cap trajectories (Table 5),¹⁵⁸ the market prices of the allowances also increase, rising from \$18/ton of CO₂ in 2015 to \$70/ton of CO₂ in 2050 for the stabilization policy, and rising from \$41/ton of CO₂ in

¹⁵¹ See *Tables, supra* note 74, at 3.

¹⁵² ENDING THE ENERGY STALEMATE, *supra* note 69, at 22-23; NAT'L COMM'N ON ENERGY POLICY, *supra* note 23, at 12.

¹⁵³ Tables 3 and 4 provide the caps and anticipated emissions, respectively, for CO₂ and other greenhouse gases. *Tables, supra* note 74, at 3, 4. Although the focus of the proposed cap-and-trade system is initially on CO₂, it can be expanded over time to include some of the other GHGs. See *supra* Part 2.1. The EPPA model, which is the source of the cost estimates reported here, was applied by Paltsev and his colleagues to an analysis of a cap-and-trade system that reduced all GHGs, not just CO₂.

¹⁵⁴ U.S. CLIMATE ACTION P'SHIP, *supra* note 11, at 7.

¹⁵⁵ Paltsev et al., *Assessment, supra* note 68, at 12. *Tables, supra* note 74, at 4.

¹⁵⁶ *Id.* at 3-4.

¹⁵⁷ *Id.* at 5.

¹⁵⁸ *Id.*

2015 to \$161/ton of CO₂ in 2050 for the aggressive policy (Table 6).¹⁵⁹ Actual current allowance prices for the Kyoto Protocol phase of the EU ETS — about \$20/ton of CO₂ — are consistent with these predictions.

Fossil fuel prices are also predicted to change as a result of the cap-and-trade system because of effects on the supply and demand for those fuels in various markets. As Table 6 indicates, the net effect of both caps on coal and petroleum prices is to depress those prices relative to what they would be in the absence of climate policy because of reduced fuel demand.¹⁶⁰ It is important to note, however, that although these prices include the effects of allowance prices on fossil fuel supply and demand, they do not include the cost of allowances *per se*.¹⁶¹

3.2.3 Impacts on the Cost of Using Fossil Fuels

As indicated above, the cap-and-trade system reduces demand for fossil fuels relative to BAU conditions and, hence, reduces fossil fuel prices relative to what those prices would be in the absence of the policy. There is an important distinction, however, between the price of fuels themselves (illustrated in Table 6) and the cost of using those fuels, which is illustrated in Table 8.¹⁶² For sample allowance prices of \$25, \$50, and \$100/ton of CO₂, the added cost is estimated for major fuels, including crude oil, gasoline, heating oil, wellhead natural gas, residential natural gas, and utility coal. These added costs of allowances to fuel users (which do not include the adjustment for the effects of the cap-and-trade policies on producer prices from Table 6) are compared with the average prices of the respective fuels over a recent period of time.¹⁶³

Not surprisingly, the percentage impacts on costs for users of crude oil are greater than for users of derived products, such as gasoline and heating oil, because the costs of these products include capital and labor for refining beyond the cost of crude oil itself. Likewise, the percentage impact on the cost of wellhead natural gas is much greater than residential natural gas, which includes costs of transportation and distribution. Of course, by far the greatest impacts are on users of coal. In the case of gasoline, natural gas, and electricity, anticipated price impacts are actually relatively modest when compared with historical changes in prices since 1990. Also, the anticipated price increases will take place gradually over much longer periods of time than did recent spikes in energy prices.¹⁶⁴

¹⁵⁹ *Id.* at 6.

¹⁶⁰ *See id.* at 6.

¹⁶¹ There is a key distinction between the prices of the fuels themselves (Table 6), and the costs of using those fuels, which include the allowance prices and are examined below (Table 8). *Compare id.* at 6, with *id.* at 8.

¹⁶² *Id.* at 6, 8.

¹⁶³ *Id.* at 6.

¹⁶⁴ Aldy, *supra* note 139, at 18.

3.2.4 *Impacts on Electricity Production*

One of the ways in which the cap-and-trade system cost-effectively decarbonizes the economy is through its impact on the production of electricity from various sources. Because of significant carbon intensity differences among sources of electricity, the gradually increasing CO₂ allowance prices that characterize both cap trajectories lead not only to (relatively small) reductions in electricity production, but also to dramatic changes in the mix of fuels used to generate electricity (Table 7).¹⁶⁵ Conventional coal-fired generation drops significantly even under the stabilization policy and disappears completely by 2040 under the aggressive policy, being replaced mainly by generation from new plants with CCS. In the short term, electricity generation from natural gas increases with CO₂ price increases, but this source of generation eventually declines with the higher CO₂ prices at the end of the period of analysis, as CCS technology becomes increasingly attractive.¹⁶⁶

3.2.5 *Impacts on Aggregate Costs to the Economy*

The cap-and-trade system, like any regulatory initiative, affects the behavior of individuals and firms, causing reallocation of resources. Therefore, economic output grows more slowly than it would in the absence of the policy. Impacts on GDP are measured relative to BAU, so the reductions in GDP do not indicate that output would be lower than current levels, but rather that output would be lower than would otherwise be expected.¹⁶⁷

Consistent with findings from other studies, the analysis indicates significant but affordable impacts on GDP levels: generally reductions below BAU of less than one-half of one percent in each year of the program for the less aggressive cap trajectory and ranging up to one percent below BAU each year for the more aggressive policy (Table 9).¹⁶⁸ These impacts on GDP by 2050 are equivalent to average annual GDP growth in the BAU case of

¹⁶⁵ *Tables, supra* note 74, at 7.

¹⁶⁶ As explained above, the predictions from the use of the EPPA model — like those from any model — depend to a large degree on characteristics and assumptions of the model. As noted, the analysis assumes that nuclear power is constrained to current levels and also is quite optimistic regarding CCS potential. *See supra* note 149 and accompanying text.

¹⁶⁷ The EPPA model predicts that GDP will increase from 2005 to 2050 in the BAU case from \$11,981 billion to \$44,210 billion (2005 dollars), that is, by 269%. *Assessment, supra* note 68, at 49. The model predicts that GDP will increase over those years under two cap-and-trade scenarios from \$11,981 billion to \$44,086 billion (268%) and \$43,998 billion (267%), respectively. *Assessment Appendix C, supra* note 68, at 2, 3.

¹⁶⁸ *See Tables, supra* note 74, at 9. Given the monotonic increases in CO₂ allowance prices over the entire time period, continuous increases in GDP impacts might be expected, but the costs are driven by both direct cost of abatement and by price impacts resulting from climate policies in other countries. Thus, emissions paths and costs are driven partly by assumptions in the EPPA model regarding policies in other countries, in particular the increased stringency of policies in developing countries in 2035.

2.901%, and average annual GDP growth of 2.895% and 2.891%, respectively, under the two cap trajectories.¹⁶⁹

3.2.6 Potential Revenue from CO₂ Allowance Auctions

Under the proposal, half of the allowances would be auctioned initially, with the proportion of freely distributed allowances gradually diminishing to zero over 25 years. How much revenue would auctions generate? If all allowances were auctioned, potential revenue would be very significant, equal to \$119 billion per year in 2015, increasing to \$473 billion by 2050 under the less aggressive program, and ranging from \$269 billion in 2015 to \$404 billion in 2050 under the more aggressive policy (Table 10).¹⁷⁰

To place these numbers in context, Table 10 also provides the potential tax reduction per family of four.¹⁷¹ With the stabilization policy, this potential tax reduction increases from \$1,490 per family in 2015 to \$4,770 in 2050. With the policy of returning 2050 emissions to 50% of their 1990 level, the potential tax reduction increases from \$3,360 in 2015 to \$4,260 in 2040, and then decreases to \$4,060. The reason for the non-monotonic result is that, while the CO₂ emissions price consistently increases, the number of allowances to be auctioned decreases as emissions decline.

The EPPA model, as employed by Paltsev and his colleagues,¹⁷² cannot be used to examine quantitatively the cost savings associated with using such auction revenues to cut distortionary taxes, but a related study found — in the case of the aggressive policy — that welfare costs would be reduced by 24% if all auction revenues were used to lower taxes on capital, and welfare costs would be reduced by 9% if auction revenues were used to cut labor taxes.¹⁷³

¹⁶⁹ A more robust measure of aggregate cost is provided by the change in welfare (equivalent variation), which includes not only changes in market consumption but also endogenous changes in the labor market. The estimated impacts of the two policies remain costly but affordable, but in this case the difference between the cost implications of the two cap trajectories is somewhat greater, with the less ambitious policy causing welfare losses of less than one-half of one percent, and the more ambitious policy causing losses of up to 1.5% annually by 2050 (Table 9). *Id.*

¹⁷⁰ *Id.* at 10.

¹⁷¹ In keeping with Paltsev, these calculations divide annual auction revenue by anticipated national households, which is simply anticipated population divided by four. *Id.*; *Assessment*, *supra* note 68.

¹⁷² *Assessment*, *supra* note 68; *Assessment Appendix C*, *supra* note 68.

¹⁷³ See ANGELO GURGEL ET AL., MIT JOINT PROGRAM ON THE SCIENCE AND POLICY OF GLOBAL CHANGE, U.S. GREENHOUSE GAS CAP-AND-TRADE PROPOSALS: APPLICATION OF A FORWARD-LOOKING COMPUTABLE GENERAL EQUILIBRIUM MODEL 17 (2007). The cost reductions would be greater in the stabilization scenario, because emissions are greater and hence there are more allowances to be auctioned.

3.3 Empirical Benefit Estimates

Given the global commons nature of climate change, a strict accounting of the direct benefits of either policy to the United States will produce results that are small relative to costs. Clearly, the benefits of the program can only be considered in the context of a global system. In the short term, the cap-and-trade system — like any meaningful domestic climate policy — may best be viewed as a step toward establishing U.S. credibility for negotiations on post-Kyoto international climate agreements.

To place the cost estimates in context, it is possible to ask how the estimated CO₂ allowance prices compare with marginal benefit estimates for what some analysts have indicated would be efficient policies. For example, a recent estimate from the DICE model suggests an optimal (efficient) allowance price (or tax) of approximately \$27/ton of CO₂ in 2005, rising to about \$90/ton of CO₂ in 2050.¹⁷⁴

More broadly, over 100 estimates of the marginal damages of CO₂ emissions from 28 published studies were analyzed, with the result that the median marginal damage (hence, marginal benefit) estimate was approximately \$7/ton of CO₂, the mean about \$16/ton of CO₂, and the 95th percentile of the highly right-skewed distribution approximately \$62/ton of CO₂.¹⁷⁵ These numbers illustrate the difficulty of relying on estimates of expected benefits, because small risks of catastrophic damages may be central to the problem.¹⁷⁶

3.4 Distributional Impacts

Despite the fact that aggregate impacts on GDP and welfare are relatively small, there can be very substantial impacts on particular sectors or groups of people. Regardless of how allowances are distributed, most of the cost of the program will be borne by consumers facing higher prices of products (e.g., electricity and gasoline) — impacts that will continue as long as the program is in place. Also, workers and investors in energy sectors and energy-intensive industries will experience losses in the form of lower wages, job losses, or reduced stock values. Such impacts are temporary, and workers or investors who enter an industry after the policy takes effect typically will not experience such losses.¹⁷⁷ The fact that the policy is phased in gradually provides more time for firms and people to adapt.

¹⁷⁴ Nordhaus, *supra* note 131, at 18.

¹⁷⁵ See Richard S.J. Tol, *The Marginal Damage Costs of Carbon Dioxide Emissions: An Assessment of the Uncertainties*, 33 ENERGY POL'Y 2064, 2064 (2005). The numbers reported are for Tol's calculations using a reasonable 3% pure rate of time preference, corresponding to a social rate of discount of 4-5%, consistent with government practice for long-term investments.

¹⁷⁶ See generally WEITZMAN, *supra* note 66.

¹⁷⁷ Terry Dinan, *Trade-Offs in Allocating Allowances for CO₂ Emissions*, ECON. & BUDGET ISSUE BRIEF (U.S. Cong. Budget Office, Washington, D.C.), Apr. 25, 2007, at 3.

The cost impacts can be regressive, because lower income households spend a larger share of their income than wealthier ones, and energy products account for a larger share of spending by low-income households than wealthier ones. As explained below, however, the distributional impacts of the policy will depend greatly on the specifics of policy design, including how allowances are allocated and how auction revenues are used.¹⁷⁸

3.4.1 *Effects on Industry*

A cap will have broad economic effects because it raises the cost of fossil fuel use and electricity generation. But certain sectors and firms will be particularly affected, including fossil fuel producers, the electricity sector, and energy-intensive industries.

Variation in a cap's economic impacts on fossil fuel producers illustrates that impacts on a particular sector do not depend on the sector's carbon-intensity alone. Coal production will be the most affected because coal is the most carbon-intensive fuel and opportunities exist for electricity generators and some industrial consumers to switch to less carbon-intensive fuels.¹⁷⁹ Petroleum sector output will be much less affected, partly because demand for gasoline and other petroleum products is fairly insensitive to increased prices, at least in the short-term.¹⁸⁰ Finally, even though natural gas accounts for about 20% of U.S. fuel-related CO₂ emissions, uncertainty exists regarding whether a cap would benefit or adversely affect output and profitability of natural gas producers.¹⁸¹

Assessments of impacts on the natural gas industry are complicated by changing conditions in natural gas markets. The increased cost of natural gas use under a cap-and-trade system tends to reduce demand for natural gas, but demand may increase because natural gas is the least carbon-intensive fossil fuel, making fuel switching to natural gas a potentially attractive emission reduction strategy. However, as the price of natural gas has increased considerably in recent years, so too has the cost of achieving emission reductions through fuel switching.¹⁸² While the cost of natural gas for electricity generation was roughly twice that of an equivalent amount of coal (on an energy content basis) in 1999, it grew to more than five times the cost of coal in 2005.

Of course, the extent of impacts on coal producers and other industries depends on a cap's stringency — the more stringent the cap, the higher the

¹⁷⁸ See *infra* Part 3.4.7.

¹⁷⁹ ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, ENERGY MARKET IMPACTS OF ALTERNATIVE GREENHOUSE GAS INTENSITY REDUCTION GOALS vii (2006).

¹⁸⁰ *Id.*

¹⁸¹ See ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, ANALYSIS OF S.139, THE CLIMATE STEWARDSHIP ACT OF 2003, at xvii, 22-24 (2003) [hereinafter ANALYSIS OF THE CLIMATE STEWARDSHIP ACT]; U.S. ENERGY INFO. ADMIN., *supra* note 179, at 36-37. There will likely be positive distributional impacts on non-fossil fuel producers of energy, including nuclear and renewable generators.

¹⁸² U.S. ENERGY INFO. ADMIN., *supra* note 109, at 7 (noting increased natural gas prices).

market price of allowances and the greater the impact on affected industries. Rather than creating abrupt and significant impacts, policies that gradually increase a cap's stringency may instead slow the expansion of even the most affected industries, lessening transition costs as workers, communities, and regions adjust to a cap.¹⁸³

Among firms that consume fossil fuels and electricity, impacts will likely be most pronounced in energy- and emission-intensive industries.¹⁸⁴ For example, some of the most affected industries will be petroleum refiners and manufacturers of chemicals, primary metals, and paper.¹⁸⁵ Among industries experiencing similar increases in their costs, impacts will be greatest in globally competitive industries that are least able to pass through higher costs without experiencing reduced demand for their output. Also, some of the most economically affected industries may be relatively small, even with respect to their contribution to aggregate CO₂ emissions.¹⁸⁶ Finally, industry-level impacts may obscure significant variation in firm-level impacts within an industry. The electricity sector offers an important example of this point.

3.4.2 *Effects on the Electricity Sector*

Regional variation in electricity sector impacts will be greater than in many other sectors because of regional differences in the composition of power plants (including fuel type), physical limits on interregional electricity trading, and state regulation of electricity markets. Increases in the cost of electricity generation depend on the carbon intensity of a region's generation, which varies widely across the country. For example, Washington

¹⁸³ For example, an EIA analysis of the National Commission on Energy Policy's 2004 proposed cap estimated that coal production would continue to grow through at least 2025, though at a slower rate than would be the case without a climate policy. See U.S. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, *IMPACTS OF MODELED RECOMMENDATIONS OF THE NATIONAL COMMISSION ON ENERGY POLICY 32* (2005).

¹⁸⁴ Bovenberg & Goulder, *supra* note 99; Smith, Ross & Montgomery, *supra* note 104; ANALYSIS OF THE CLIMATE STEWARDSHIP ACT, *supra* note 181, at 13-15; DALE W. JORGENSEN, RICHARD J. GOETTLE, PETER J. WILCOXEN & MUN SING HO, PEW CTR. ON GLOBAL CLIMATE CHANGE, *THE ROLE OF SUBSTITUTION IN UNDERSTANDING THE COSTS OF CLIMATE CHANGE POLICY 18* (2000).

¹⁸⁵ These industries accounted for two-thirds of manufacturing sector CO₂ emissions in 2002, but only 13% of manufacturing employment and 25% of the value of manufacturing shipments. Unlike other industries listed here, refiners experience both increased production costs for their production-related emissions and reduced demand as consumers seek to limit emissions from the use of petroleum products. U.S. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, *ENERGY-RELATED CARBON DIOXIDE EMISSIONS IN U.S. MANUFACTURING 7* (2006); BUREAU OF THE CENSUS, U.S. DEP'T OF COMMERCE, *2002 ECONOMIC CENSUS: MANUFACTURING SUBJECT SERIES EC02-31SG-1* (2005).

¹⁸⁶ For example, lime manufacturing accounts for less than one percent of fuel-related manufacturing emissions, but it may incur among the greatest percentage increases in costs. Richard Morgenstern et al., *The Near Term Impacts of Carbon Mitigation Policies on Manufacturing Industries*, 32 ENERGY POL'Y 1825, 1831 (2002); U.S. Energy Info. Admin., U.S. Dep't of Energy, *Carbon Emissions in the Stone, Clay and Glass Industry* (Feb. 28, 2008), http://www.eia.doe.gov/emeu/efficiency/carbon_emissions/stone.html.

State, which has abundant hydroelectric power, emitted 0.15 tons of CO₂ per megawatt hour in 2005, while Indiana, which depends largely on coal-fired generation, emitted 0.94 tons per megawatt hour.¹⁸⁷

The ultimate impact of these costs on consumers and generators depends, in large part, on state regulation of electricity markets. The mechanism by which generation costs are passed through to consumer rates fundamentally differs between states under traditional cost-of-service regulation and those with restructured electricity markets.¹⁸⁸ Under cost-of-service regulation, rates reflect the average cost of all generation necessary to meet demand. Therefore, in cost-of-service regions, the cost of a cap will be passed through to consumers (net of the cost of allowance purchases or sales) in the form of rate increases that reflect increases in average generation costs. As a result, consumers in cost-of-service regions effectively bear all of the costs that a cap initially imposes on generators, while generators typically recover all compliance costs through higher rates.¹⁸⁹ Two-thirds of U.S. electricity generation and more than three-quarters of all coal-fired generation are located in states with cost-of-service regulation. Therefore, much of a cap's impact on the electricity sector will be passed on to consumers directly.

In restructured markets, rates are based on wholesale electricity prices where, under typical conditions, those prices are determined by the incremental cost of the most expensive generation required to meet demand.¹⁹⁰ Therefore, in restructured markets, rate increases from a cap will depend on the cap's effect on the cost of marginal generation, regardless of its effect on total generation costs or the method of allowance allocation. The cost of marginal generation typically varies less across the country than does average generation cost. As a result, there will likely be less regional variation in rate impacts across restructured markets than across markets still under cost-of-service regulation.

While generators subject to cost-of-service regulation will generally fully recover increased costs under a climate policy, a cap-and-trade system's effect on generator profitability in restructured regions depends on several factors, including how an individual generator's costs change relative to the cap's effect on wholesale electricity prices, the resulting effects on plant utilization, and the mechanism used for allowance allocation. For some genera-

¹⁸⁷ U.S. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, ELECTRIC POWER ANNUAL 2006 – DATA TABLES: ESTIMATED EMISSIONS FOR U.S. ELECTRIC POWER INDUSTRY BY STATE, 1990-2006 (2007), http://www.eia.doe.gov/cneaf/electricity/epa/emission_state.xls; U.S. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, ELECTRIC POWER ANNUAL 2006 – DATA TABLES: NET GENERATION BY STATE BY TYPE OF PRODUCER BY ENERGY SOURCE, 1990-2006 (2007), http://www.eia.doe.gov/cneaf/electricity/epa/generation_state.xls.

¹⁸⁸ This description of regulated and restructured markets simplifies many of the institutional differences that will affect the pass-through of allowance costs.

¹⁸⁹ Of course, regulated utilities experience some impacts, such as reduced electricity sales.

¹⁹⁰ U.S. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, THE ELECTRICITY MARKET MODULE OF THE NATIONAL ENERGY MODELING SYSTEM: MODEL DOCUMENTATION REPORT 7 (2007), available at [http://tonto.eia.doe.gov/FTP/ROOT/modeldoc/m068\(2007\).pdf](http://tonto.eia.doe.gov/FTP/ROOT/modeldoc/m068(2007).pdf).

tors, such as non-emitting renewable and nuclear plants that have no allowance costs, electricity price increases from the cap will lead to increased profitability. For others, such as coal-fired generators, price increases will not sufficiently offset increases in costs, leading to reduced profitability. However, even among the most adversely affected coal generators, some of a cap's costs will be offset by increased electricity prices.

3.4.3 *Effects on Household Expenditures and Income*

While attention often focuses on a cap's impacts on particular industries, the ultimate burden will be borne by households, primarily in the form of increased expenditures on energy and other goods and services, but also through changes in labor income (including job losses) and investment income (i.e., stock and mutual fund returns) that arise from impacts on firms. Low-income households tend to spend a larger share of their income on energy-intensive (and, therefore, carbon-intensive) goods and services than do high-income households.¹⁹¹ As a result, higher fuel prices will likely have a regressive effect on households; that is, expenditures will increase by a greater percentage of household income for low-income than for high-income households. However, the degree of regressivity may not be very large.¹⁹² Further, this regressivity may be counterbalanced by the fact that adverse impacts on investment returns resulting from a cap's effect on the profitability of firms will fall most heavily on high-income households.

3.4.4 *Effects on Government*

Federal and state governments will also bear a significant share of the costs imposed by an emissions cap. By increasing energy and goods prices, a cap directly increases the level of government expenditures that is necessary to provide government services. These increased prices also indirectly lead to higher government spending on programs such as Social Security in which outlays are adjusted to account for inflation. In addition, by reducing economic activity and thereby the tax base, a cap reduces government tax receipts. The federal government can retain a share of auction revenue to offset any increased deficits.¹⁹³ On the other hand, the government will receive increased corporate tax revenues from firms with increased profitability due to the cap-and-trade system.

¹⁹¹ See James M. Poterba, *Tax Policy to Combat Global Warming: On Designing a Carbon Tax*, in GLOBAL WARMING: ECONOMIC POLICY RESPONSES 71, 77 (Rudiger Dornbusch & James M. Poterba eds., 1991) (noting surveys to that effect); Gilbert Metcalf, *A Distributional Analysis of Green Tax Reforms*, 52 NAT'L TAX J. 655 (1999); Ian Parry, *Are Emissions Permits Regressive?*, 47 J. ENVTL. ECON. & MGMT. 364, 365 (2004).

¹⁹² Dinan, *supra* note 177, at 8. See Poterba, *supra* note 191, at 79-80; Metcalf, *supra* note 191, at 663.

¹⁹³ Smith, Ross & Montgomery, *supra* note 104, at 15; Dinan, *supra* note 177, at 8.

3.4.5 *Regional Variation in Impacts*

Many effects from a CO₂ emissions cap will be similar nationwide, including impacts on the cost of using fossil fuels. However, there will be significant regional variation in economic impacts due to factors such as regional differences in electricity rate impacts and in the intensity of energy use. For example, one study found that an economy-wide cap imposing an allowance price of \$10 per ton of CO₂ would increase average annual household energy expenditures by a range of about \$100 to \$240 across different counties.¹⁹⁴ Because electricity accounts for a significant share of household energy use, regional differences in rate impacts are a key driver of this variation.

A cap's impact on regional economic activity and employment may vary more dramatically than impacts on household energy expenditures. First, regional economies vary greatly in their reliance on the industrial sectors that are most likely to be adversely affected by a cap. Second, the factors affecting impacts on a particular industry are quite varied, including the industry's energy-intensity, the carbon intensity of energy used, electricity rate impacts, and the industry's ability to pass on increased costs to consumers. The carbon intensity of commercial and industrial output provides a proxy for some, but not all, of these factors. The carbon-intensity of output in some states can be over 13 times that in other states.¹⁹⁵

3.4.6 *Illustrative Numerical Distribution of Costs*

Given the nature of the EPPA analysis used to estimate costs of the proposed cap-and-trade system,¹⁹⁶ that analysis cannot yield numerical estimates of the distribution of costs of the two policies. Instead, for illustrative purposes, Table 11 provides the approximate distribution of costs of another cap-and-trade proposal, the first of two from the National Commission on Energy Policy.¹⁹⁷ The distribution is based upon an analysis using the U.S. Energy Information Administration's NEMS model, and, importantly, does not account for any cost-offsetting effects of the allowance allocation. That is, the potential effects of free distribution of allowances and the use of any auction revenues are not included. As discussed below, either auctioned or freely distributed allocations can be used to offset the costs to particular sectors.

¹⁹⁴ William Pizer, James N. Sanchirico & Michael Batz, *Regional Patterns of U.S. Household Carbon Emissions* 8 (Res. for the Future, Discussion Paper 01-59, 2006).

¹⁹⁵ U.S. CONG. RESEARCH SERV., STATE GREENHOUSE GAS EMISSIONS: COMPARISON AND ANALYSIS, at CRS-6 (2007), available at http://assets.opencrs.org/rpts/RL34272_20071205.pdf.

¹⁹⁶ See generally *Assessment*, *supra* note 68.

¹⁹⁷ NATIONAL COMMISSION ON ENERGY POLICY, ALLOCATING ALLOWANCES IN A GREENHOUSE GAS TRADING SYSTEM (2007); *Tables*, *supra* note 74, at 11.

Table 11 illustrates several general points (keep in mind that the distribution of the actual cost burden of the program is largely independent of the point of regulation).¹⁹⁸ First, the “overall”¹⁹⁹ cost burden to fossil fuel producers represents a relatively small share of the total burden, less than 4% in this example.²⁰⁰ This is because most of the costs are passed forward. Likewise, fossil-fuel fired electricity generators bear a relatively small share of the burden, about 7% in this case, largely passing on costs to customers.²⁰¹ Business and industry account for about 29% of the total cost burden for their primary energy use and another 26% for their electricity use, so that the total increase in business and industry expenditures amounts to about 55% of the total cost burden.²⁰² The remaining 35% of the costs are borne by households in terms of their increased expenditures for primary energy (22%) and electricity (13%).²⁰³ In truth, the final household share of the cost burden is likely to be greater than this, because many businesses will pass some of their costs forward to consumers in the form of higher prices for goods and services.²⁰⁴

3.4.7 *Distributional Impacts of the Allowance Allocation*

This proposal recommends that the cap-and-trade system begin with a hybrid approach to allowance allocation wherein half of the allowances are auctioned and half are freely distributed to entities in proportion to their burden under the policy. The half that are auctioned will generate revenue that can be used for public purposes, including compensation for program impacts on low-income consumers, public spending for related research and development, reduction of the federal deficit, and reduction of distortionary taxes. The share of allowances that are freely distributed should decline over time, until there is no free allocation 25 years into the program.²⁰⁵

The aggregate value of allowances will be much greater than the total cost burden to the economy. The value of allowances will be two to four times greater than the total cost of the program in most years under either of

¹⁹⁸ *Tables, supra* note 74, at 11.

¹⁹⁹ “Overall” refers to the fact that the statement is about the sector as a whole. Individual firms can bear disproportionately large or small burdens.

²⁰⁰ *Tables, supra* note 74, at 11.

²⁰¹ *Id.*

²⁰² *Id.*

²⁰³ *Id.*

²⁰⁴ NATIONAL COMMISSION ON ENERGY POLICY, *supra* note 197, at 12. Another perspective on the distribution of costs was provided by Goulder for a program that would cut emissions by 23%. He found that this would lower stock values by 54% in the coal sector, 20% for firms in the oil and gas sector, and 4% for electric and gas utilities. It should be noted that such losses in stock values are widely dispersed among investors. Lawrence H. Goulder, *Mitigating the Adverse Impacts of CO₂ Abatement Policies on Energy Intensive Industries* 26 (Res. for the Future, Discussion Paper No. 02-22, 2002).

²⁰⁵ Over time the private sector will adjust to the carbon constraints, including industries with long-lived capital assets, reducing the justification for free distribution.

the cap trajectories (Table 12).²⁰⁶ Therefore, even a partial free distribution of allowances provides an opportunity to address the distributional cost burdens of the policy by using allowances to compensate the most burdened sectors and individuals.

Generally, freely distributed allowances benefit only their recipients and not consumers, suppliers, or employees of these recipients. Free distribution, therefore, should be targeted at particularly burdened entities. As the numbers in Table 12 indicate, only a share of allowances needs to be freely distributed to meet compensation objectives.²⁰⁷

On the other hand, in cost-of-service regulated markets, utilities pass allowance costs on to consumers through modified rates. Thus, consumers are likely to be the beneficiaries of the value of freely distributed allowances.²⁰⁸ Free allocations to these utilities will reduce the rate impacts on consumers by reducing the net cost of the policy for the utilities.

4. COMPARISON OF CAP-AND-TRADE PROPOSAL WITH ALTERNATIVE PROPOSALS

The alternatives to the cap-and-trade approach that are most frequently considered by policy makers for the purpose of reducing CO₂ and other GHG emissions fall within the general category of standards-based policies (also often characterized as conventional regulatory approaches).²⁰⁹ In addition, among economists and other policy analysts, there has been considerable discussion of the possible use of carbon taxes. In this section of the article, these two approaches are compared with cap-and-trade.

4.1 Standards-Based Policies

Technology or performance standards are commonly proposed as a means of achieving emission reductions. Examples include efficiency standards for appliances, vehicle fuel economy standards, Best Available Control Technology (“BACT”) standards, and renewable portfolio standards for electricity generators. Standards could serve as either substitutes or complements to a cap-and-trade system. For example, instead of including vehicle emissions under a cap, as proposed here, emission reductions from those sources could be achieved through more stringent Corporate Average Fuel

²⁰⁶ *Tables, supra* note 74, at 12.

²⁰⁷ *Id.*

²⁰⁸ In the case of the SO₂ allowance trading program, Lile and Burtraw found that state utility commissions required utilities to pass through to consumers nearly all the cost savings from the use of freely allocated allowances (including any revenues from allowance sales). Ron Lile & Dallas Burtraw, *State Level Policies and Regulatory Guidance for Compliance in the Early Years of the SO₂ Emission Allowance Trading Program* 10 (Res. for the Future, Discussion Paper No. 98-23, 1998).

²⁰⁹ Such policies are also frequently referred to as “command-and-control” regulation because they dictate the adoption of particular measures to reduce emissions or set source-specific emission limits.

Economy (“CAFE”) standards. Alternatively, CAFE standards could be increased within the context of an economy-wide cap.²¹⁰ The following sections compare standards with cap-and-trade in regard to environmental effectiveness, cost effectiveness, and distributional equity.

4.1.1 *Environmental-Effectiveness of Standards*

Because of practical limitations, most standards to address CO₂ emissions would target energy use or emission rates from new capital equipment, such as appliances, cars, or electricity generators. The fact that standards would only affect new equipment limits the opportunity for near-term emission reductions. It also makes the level and timing of those reductions difficult to predict, since they are dependent on the rate of capital stock turnover.

Moreover, by increasing the cost of new capital stock without affecting the cost of using existing capital stock, standards for new sources have the perverse effect of creating incentives to delay replacement of existing capital stock, which can significantly delay the achievement of emission reductions.²¹¹ New Source Review regulations are a prominent example of how new source standards can delay capital stock turnover.²¹²

In addition, the tendency of standards (and taxes) to grant exemptions to address distributional issues weakens the environmental effectiveness of these instruments (and drives up costs), whereas distributional battles over the allowance allocation in a cap-and-trade system do not raise the overall cost of the program or affect its climate impacts.

More broadly, if standards are applied for selective purposes but within the umbrella of an economy-wide CO₂ cap-and-trade system, the standards will offer no additional CO₂ benefits, as long as the cap-and-trade system is binding.

4.1.2 *Cost Effectiveness of Standards*

When considered as an alternative to a well-designed cap-and-trade system, standards-based approaches are less cost-effective.²¹³ The extent to which they are less cost-effective depends on several factors. First, administrative limitations constrain the scope of sources that can be covered by a standards-based approach, compared with an upstream, broad-based cap-and-trade system. For example, standards could not practically target all

²¹⁰ See, e.g., ENDING THE ENERGY STALEMATE, *supra* note 69, at ix.

²¹¹ Robert N. Stavins, *Vintage-Differentiated Environmental Regulation*, 25 STAN. ENVTL. L.J. 29, 30 (2006).

²¹² See *id.* (describing New Source Review and associated problems). Incentives to delay new investments would be lessened if standards were implemented along with a cap-and-trade system, which raises the cost of operating existing, more emissions-intensive equipment. *Id.* at 55-56.

²¹³ In theory, standards could potentially be more cost-effective when the measurement and monitoring of actual emissions or fuel use is particularly costly, compared with the measurement and monitoring of actions that could be required by standards.

types of energy-consuming industrial equipment. As with a cap of limited scope, this constraint on the scope of sources that standards can cover increases the cost of achieving emission reductions.

Second, standards may not target all determinants of emissions from covered sources. Consequently, they may not bring about many types of potentially cost-effective emission reductions from a given source. For example, technology standards do not influence the rate at which less-efficient capital stock is replaced or the intensity with which old and new capital stock are used. In fact, by lowering operating costs, standards that increase the energy efficiency of equipment can create incentives for more intensive use than would otherwise occur.²¹⁴

Third, standards often impose uniform requirements on all entities using a given type of equipment or operating a given type of facility, even though the cost of emission reductions achieved by such standards may vary widely across regulated entities.²¹⁵ Important sources of variation that standards typically fail to account for include variation in how intensively regulated equipment is used by different firms or households and variations in the carbon-intensity of energy consumed. For example, air conditioner efficiency standards impose uniform requirements nationwide despite significant differences in air conditioner use — and hence differences in the value of increased efficiency — between hot and cool climates. Furthermore, these standards have the same effect on electricity use for carbon-intensive (such as generation from coal plants in the Midwest) and non-emitting (such as generation from hydro facilities in the Northwest) electricity sources. While policymakers could lower the overall cost of standards by targeting them to reflect the myriad different circumstances of affected sources, such efforts are administratively infeasible.²¹⁶

Compared with market-based policies, standards yield weaker incentives for the development of new emission-reduction technologies. For example, air conditioner standards would not provide clear or certain rewards for the development of air conditioners that are more efficient than required by the standards. By contrast, market-based policies do not have such a threshold effect: they offer incentives for innovations that yield any level of

²¹⁴ This “rebound effect” leads to an increase in emissions that offsets, to some degree, the reductions achieved by standards.

²¹⁵ Richard G. Newell & Robert N. Stavins, *Cost Heterogeneity and the Potential Savings from Market Based Policies*, 23 J. REG. ECON. 43, 44 (2003).

²¹⁶ Some of the cost disadvantages associated with standards can be reduced through careful design, including providing firms with greater compliance flexibility. For example, while air conditioning standards impose minimum efficiency requirements on all air conditioning units, CAFE standards allow manufacturers to meet fuel efficiency requirements on average. Moreover, a Congressional Budget Office study found that the cost of CAFE standards could be reduced by 16% if manufacturers were offered more flexibility to meet those standards, in the form of credits that could be traded among manufacturers. U.S. CONG. BUDGET OFFICE, *THE ECONOMIC COSTS OF FUEL ECONOMY STANDARDS VERSUS A GASOLINE TAX* 18 (2003). In addition, many state Renewable Portfolio Standards allow utilities the flexibility to meet standards for minimum shares of renewable generation by purchasing credits from renewable electricity generators. See, e.g., MD. CODE REGS. 20.61.01.01.04.03 (2007).

increased efficiency or emission reductions. This difference in incentives is particularly acute for more advanced technologies that are still in the innovation phase and have not yet been sufficiently deployed to have any associated standards.

As new technologies emerge and increasingly stringent emission targets must be met, pursuit of a standards-based approach would require continual adjustments to the standards to ensure that emission reduction responsibilities continue to be distributed across regulated sources in a reasonably cost-effective manner. The administrative costs associated with this need for continual adjustments would be significant. By contrast, under a cap-and-trade system, only the emissions cap needs to be changed over time. Firms and households will respond to emerging technologies and increasing carbon price signals by adopting those technologies, measures, and efficiency improvements that offer the least costly emission reductions.

Standards have also been proposed as complements to market-based policies.²¹⁷ A number of factors affect whether complementary use of standards would affect overall emission reduction costs. On the one hand, standards may needlessly restrict the flexibility that allows market-based policies to minimize the cost of achieving emission targets. For example, air conditioner standards require consumers to purchase more expensive, efficient equipment, regardless of whether they use the equipment enough to justify the increased cost. In contrast, a market-based policy would provide consumers with incentives to adopt more efficient equipment. But such a policy would still allow consumers to purchase equipment that strikes the best balance between long-run efficiency and up-front costs.

As indicated above, if standards are applied within the umbrella of an economy-wide CO₂ cap-and-trade system, the standards will offer no additional CO₂ benefits, as long as the cap-and-trade system is binding. Depending upon the nature of the standard and its associated costs, its placement can actually drive up aggregate costs.²¹⁸

On the other hand, as emphasized above, some market failures affecting the development and adoption of less emissions-intensive technologies may not be addressed by a cap-and-trade (or carbon tax) policy. For example, consumers may not have sufficient information to properly evaluate energy-efficiency investment decisions, such as information relating to the full life-cycle costs of alternative product models.²¹⁹ Simply increasing the cost of emitting GHGs will not address the core sources of this market failure. Standards can mandate desirable investments that would not otherwise be

²¹⁷ See, e.g., A. DENNY ELLERMAN ET AL., MIT JOINT PROGRAM ON THE SCIENCE AND POLICY OF GLOBAL CHANGE, BRINGING TRANSPORTATION INTO A CAP-AND-TRADE REGIME (2006).

²¹⁸ For an examination of how to merge CAFE standards cost-effectively with a cap-and-trade system by allowing emissions trading between the CAFE program and the cap-and-trade system, see *id.*

²¹⁹ For a more complete discussion of the types of market failures that may make additional complementary policies desirable, see Jaffe et al., *supra* note 22.

undertaken because of this market failure. However, the resulting gains from addressing the market failure may be less than the costs of the standard, such as the costs of imposing a uniform requirement even though some individuals will not benefit from it. Furthermore, other policies may better address market failures that inhibit the development and deployment of new technologies without introducing the additional costs that can make standards undesirable. Examples of such alternative policies include programs targeted at promoting R&D or information provision.

4.1.3 *Distributional Impacts of Standards*

The distributional consequences of standards depend on the specific standards being implemented and the characteristics of the markets they affect. However, a key difference exists between the distributional effects of standards and those of a cap-and-trade system: standards only impose costs associated with the emission reductions and investments required by the standards, whereas market-based policies also impose costs associated with remaining emissions.²²⁰ Although standards do not impose allowance (or tax) costs, the differences in distributional outcomes between standards and market-based policies can be complex. Any comparison must also consider the higher social cost of the standards-based approach and the fact that, unlike standards, market-based policies offer opportunities to mitigate distributional impacts through initial allocation decisions or redistribution of tax or auction revenue.²²¹

4.2 *Carbon Taxes*

A carbon tax is a market-based alternative to a cap-and-trade system. Both policies create a carbon price signal by placing a price on CO₂ emissions. However, there is a fundamental difference in the way in which the level of that carbon price signal is determined under these two policy instruments. A carbon tax fixes the price of CO₂ emissions and allows the quantity of emissions to adjust in response to the level of the tax. In contrast, a cap-and-trade system fixes the quantity of aggregate emissions and allows the price of CO₂ emissions to adjust to ensure that the emissions cap is met.

4.2.1 *Environmental Effectiveness, Cost Effectiveness, and Distributional Impacts of a Carbon Tax*

In terms of environmental effectiveness, a tax does not guarantee achievement of a given emissions target, unlike a cap-and-trade system. In-

²²⁰ The costs associated with remaining emissions do not represent true social costs. Rather, they are transfers from those that must pay a tax to, or purchase allowances from, either the government or firms that receive freely allocated allowances.

²²¹ Social cost refers to all of the costs associated with an economic activity. It includes costs borne by the economic agent as well as costs borne by society at large.

dividual sources reduce emissions up to the point where it is less costly to pay the tax than to achieve additional reductions. Given uncertainty regarding emission reduction costs, resulting emissions may either exceed or fall below the policy target. However, because a tax limits the costs that firms will incur to achieve additional emission reductions, it provides greater certainty regarding policy marginal costs. By contrast, a cap-and-trade system that establishes rigid annual caps offers less certainty about policy costs *because* it provides greater certainty about emissions.

As with a cap-and-trade system, a tax can achieve emission reductions in a cost-effective manner. Furthermore, if credible commitments are made to maintain a carbon tax in future years, a tax also lowers the long-run cost of achieving emission reductions — as does a cap-and-trade system — by providing incentives for investments in the development and deployment of new technologies.

As with a cap-and-trade system, an upstream, economy-wide carbon tax would be more cost-effective than a tax with a more limited scope of coverage. A tax with a narrower scope of coverage would achieve fewer emission reductions than a comparable economy-wide tax. Consequently, a higher tax rate would be required to maintain a given level of reductions. Similarly, as with a cap, a tax can be imposed upstream on fuel suppliers or downstream on emission sources. The administrative costs for an economy-wide tax would be minimized through an upstream point of regulation, that is, a tax on the carbon content of fossil fuels. While such a tax on the carbon content of fuel (or on direct emissions) would minimize the cost of emission reductions, that cost would be increased if the tax were set on some other basis, such as the energy content or value of fuel. Such taxes would create inefficient and uneven incentives for emission reductions.²²²

The distributional consequences of a carbon tax would be similar to those of a cap-and-trade system in which all allowances are auctioned. Both approaches put policymakers in the position of having to decide how to use resulting revenues. Moreover, before any use or redistribution of that revenue, a tax's impacts on affected firms and households are the same as those from a cap-and-trade with an auction in which the resulting allowance price is identical to the tax. However, a carbon tax and a cap-and-trade system do differ in the options each presents to mitigate economic impacts. Although a tax cannot compensate affected entities through free allocation of allowances, policymakers can mitigate a tax's burden by redistributing tax revenue — much like in an auction — or by granting fixed tax exemptions.²²³

Fixed exemptions reduce a firm's overall tax burden by taxing emissions only when they exceed the amount of the exemption. Unless the exemptions are tradable, however, their use may adversely affect the cost-

²²² Compared with a carbon tax, it would cost 20% to 40% more to achieve a particular emissions target through a tax on energy content (for example, a BTU tax), and two to three times more through an *ad valorem* tax. Stavins, *supra* note 58, at 304.

²²³ Goulder, *supra* note 104, at 10-11; NORDHAUS & DANISH, *supra* note 76, at 33.

effectiveness of a tax if a firm's exemption exceeds its actual emissions. In this case, the firm has no incentive to undertake emission reductions (no matter how cost-effective such reductions might be). In contrast, because a firm under a cap-and-trade system can sell any excess allowances (whether it purchased them or received them for free), it always has an incentive to reduce emissions, regardless of the initial quantity of allowances that it receives.

As with free allocations to a firm, exemptions for a taxed firm do not benefit that firm's workers, customers or suppliers, who indirectly experience a portion of the tax's burden. Thus, additional measures would be needed to compensate entities that are not directly subjected to the carbon tax. While tradable tax exemptions and redistribution of tax revenues theoretically provide flexibility to achieve the same distributional outcomes as could be achieved under a cap-and-trade approach, political and practical considerations may impose constraints on achieving similar outcomes in practice.

4.2.2 *Apparent Advantages of a Carbon Tax*

An upstream carbon tax, like an upstream cap-and-trade system, could include tax credits to provide incentives for downstream carbon capture and sequestration at electricity generators. Such an upstream carbon tax would appear to have some advantages over an equivalent upstream cap-and-trade system.

The first advantage is the simplicity of the carbon tax system, in which firms would not need to manage and trade allowances, and the government would not need to track allowance transactions and ownership. Experience with previous cap-and-trade systems, however, indicates that the costs of trading institutions are not great.²²⁴ Whether a policy as significant as a meaningful national carbon tax would turn out to be simple in its implementation is an open question. Second, the tax approach avoids the political difficulties related to making allowance allocations among economic sectors, but it would, on the other hand, create pressures for tax exemptions.

Third, a carbon tax would raise revenues that can be returned to individuals or be used to lower distortionary taxes, finance climate-related programs, fund other government programs, reduce the deficit, or provide assistance to sectors most burdened by the policy. Of course, an auction mechanism under a cap-and-trade system can do the same. Particular attention has been given by economists to the potential use of tax revenue for reducing distortionary taxes,²²⁵ and thereby reducing the aggregate net costs of the policy. Considering the fact that a \$10/ton CO₂ tax would raise about \$50 billion per year — more than 7% of federal personal income taxes — this is an attractive possibility. It should be recognized, however, that the

²²⁴ See Stavins, *supra* note 17, at 355-435.

²²⁵ Bovenberg & Goulder, *supra* note 99.

carbon tax revenue might be spent on the “wrong tax cuts” and/or on other government programs that have benefits smaller than costs, thereby increasing the social costs of the climate policy, relative to free distribution of allowances under a cap-and-trade system.

Fourth, a tax approach eliminates the potential for price volatility that can exist under a cap-and-trade system. Some emissions trading markets have exhibited significant volatility in their early years, including: the U.S. NO_x Budget Program (where prices increased in the presence of uncertainty about whether Maryland, a net supplier, would enter the program on time);²²⁶ the RECLAIM program in southern California (where price spikes were linked with flawed design and problems with electricity deregulation);²²⁷ and the EU ETS (where a dramatic price crash occurred when data revealed that the overall allocation had been above the BAU level).²²⁸ In principle, such price volatility with a cap-and-trade approach could deter investments in carbon-reducing capital and in R&D with high up-front costs and uncertain longer-term payoff. From an economic perspective, it makes sense to allow emissions to vary from year to year with economic conditions that affect aggregate abatement costs, and this happens automatically with a carbon tax. With a cap-and-trade system, this temporal flexibility needs to be built in through provisions for banking and borrowing, as proposed above.

4.2.3 *Apparent Disadvantages of a Carbon Tax*

First among the disadvantages of a carbon tax, relative to a cap-and-trade regime, is the overriding resistance to new taxes in the current political climate. However, no policy proposal should be ruled out on this basis, and it is conceivable that carbon taxes may be politically feasible in future years, when and if there are changes in political leadership and public opinion. In the meantime, a distinct advantage of a cap-and-trade system is the greater familiarity and comfort with it that exists among key stakeholders. Phrased differently, a tax approach focuses political attention on prices, revenues, and costs, whereas cap-and-trade discussions tend to keep the focus on the environment.

Second, in their simplest respective forms (a carbon tax without revenue recycling and a cap-and-trade system without auctions), a carbon tax is more costly than a cap-and-trade system to the regulated sector. With a carbon tax, firms incur both abatement costs and the cost of tax payments to the government. With a cap-and-trade system, the regulated sector experiences only abatement costs, since the transfers associated with allowance purchase and sale remain within the private sector. This straightforward difference between taxes and cap-and-trade can be diminished or even eliminated, however, in the presence either of tax revenue recycling or allowance auctioning.

²²⁶ Pizer, *supra* note 86, at 4.

²²⁷ *Id.* at 3.

²²⁸ Frank Convery & Luke Redmond, *Market and Price Developments in the European Union Emissions Trading Scheme*, 1 REV. ENVTL. ECON. & POL'Y 88, 104 (2007).

Third, cap-and-trade approaches leave distributional issues up to politicians, provide a straightforward means of compensating burdened sectors, and address so-called “competitiveness concerns,” wherein particular firms or sectors are concerned about being economically disadvantaged. Of course, the compensation associated with free distribution of allowances based on historical activities can be mimicked under a tax regime, but it is legislatively more complex. The cap-and-trade approach avoids likely battles over tax exemptions among vulnerable industries and sectors that would drive up the costs of the program, as more and more sources (emission-reduction opportunities) are exempted from the program, thereby simultaneously compromising environmental integrity. Instead, a cap-and-trade system leads to battles over the allowance allocation, but these battles do not raise the overall cost of the program or affect its climate impacts. Some observers seem to worry about the propensity of the political process under a cap-and-trade system to compensate sectors that effectively claim burdens (through free allowance allocations).²²⁹ A carbon tax is sensitive to the same pressures and may be expected to succumb to them in ways that are ultimately more dangerous.

Fourth, a carbon tax provides much less certainty regarding emissions levels (in exchange for greater certainty over costs). Most climate policy proposals are for progressively greater cuts in emissions over time.²³⁰ Cap-and-trade is fundamentally well suited to this because it is a quantity-based approach. Progress under a carbon tax will be uncertain, mainly due to variations in economic conditions. More broadly, the flexibility provided by cap-and-trade means that it can replicate virtually all of the key aspects of a tax, such as by employing allowance auctions and a cost containment mechanism.

Fifth and finally, a cap-and-trade system is much easier to harmonize with other countries’ carbon mitigation programs, which are more likely to employ cap-and-trade than tax approaches. Cap-and-trade systems generate a natural unit of exchange for harmonization: allowances denominated in units of carbon content of fossil fuels (or CO₂ emissions).

Despite the differences between carbon taxes and cap-and-trade systems in specific implementations, the two approaches have much in common. The differences between them begin to fade when various specific implementations of either program are carried out. Hybrid schemes that include features of taxes and cap-and-trade systems blur the distinctions between the two.²³¹ In terms of the allocation mechanism, the government can auction allowances in a cap-and-trade system, thereby reproducing many of the properties of a tax approach. Mechanisms that deal with uncertainty in a cap-and-trade system also bring it closer to a tax approach. These include a

²²⁹ See, e.g., Burtraw & Palmer, *supra* note 104.

²³⁰ See Aldy et al., *supra* note 5, at 373-97.

²³¹ Ian W. H. Parry & William A. Pizer, *Emissions Trading Versus CO₂ Taxes*, BACK-GRINDER (Res. for the Future, Washington, D.C.), May 2007.

cost containment mechanism that places a cap on allowance prices, banking that creates a floor under prices, and borrowing that provides flexibility similar to a tax. To some degree, the dichotomous choice between taxes and permits turns out to be a choice of design elements along a policy continuum.

In the meantime, debate continues among economists regarding cap-and-trade and carbon taxes. In a recent comparison of these two approaches, the Hamilton Project staff at the Brookings Institution concluded that a well-designed carbon tax and a well-designed cap-and-trade system would have similar economic effects. Hence, the two primary questions that should be used to decide between these two policy approaches are: (1) which is more politically feasible; and (2) which is more likely to be well-designed?²³² In the context of the United States (and many other countries, for that matter), the answer to the first question is obvious. For the political economy reasons I described above, the answer to the second question also favors cap-and-trade. In other words, it is important to identify and design policies that will be “optimal in Washington,” not just from the perspective of Cambridge, New Haven, or Berkeley.

5. COMMON OBJECTIONS AND RESPONSES

In the past, a variety of objections have been raised to the use of cap-and-trade systems in general or to the specific application of the cap-and-trade mechanism to CO₂ and other GHG reduction. In this section, these objections are briefly described, and brief responses are provided.

5.1 “Cap-and-Trade is Unethical — It Allows Firms to Buy and Sell the Right to Pollute”

Over the 25 years in which market-based instruments have become an accepted part of the portfolio of environmental regulation, there has been a considerable decline in the frequency of claims that cap-and-trade systems are morally flawed because they allow firms to “buy and sell the right to pollute.” But the argument has been made as recently as the late 1990s, in the context of global climate change policy, that the cap-and-trade approach is unethical because it eliminates the moral stigma which should exist for polluting.²³³ However, few would agree that people are behaving immorally by cooking dinner, heating their homes, turning on a light, or using a computer, despite the fact that all of these activities result in CO₂ emissions.²³⁴

²³² JASON FURMAN ET AL., THE BROOKINGS INSTITUTION, AN ECONOMIC STRATEGY TO ADDRESS CLIMATE CHANGE AND PROMOTE ENERGY SECURITY 18 (2007).

²³³ Michael J. Sandel, Op-Ed., *It's Immoral to Buy the Right to Pollute*, N.Y. TIMES, Dec. 15, 1997, at A23.

²³⁴ Sanford E. Gaines, Letter to the Editor, *Technology, Not Stigma*, N.Y. TIMES, Dec. 17, 1997, at A30.

Under conventional regulatory approaches, the “right to pollute” is not sold by government. Rather, it is given away for free.

5.2 “Cap-and-Trade Creates Hot Spots of Pollution”

Because GHG emissions uniformly mix in the atmosphere, there are no hot spots of GHG emissions themselves. The question is whether localized pollutants whose emissions are correlated with the emissions of a GHG might become excessively concentrated in particular areas as a result of allowance trading activity. This concern has frequently been expressed in California’s debates regarding a potential cap-and-trade system to implement AB 32.²³⁵

The answer to this concern is simple: a cap-and-trade system for GHG emissions would not supplant existing local air quality regulations. If a firm’s actions in engaging in an emission trade would violate local air quality regulations for NO_x emissions, for example, then such actions would be illegal and disallowed no matter how many GHG emission allowances were obtained. Thus, a cap-and-trade system for GHG emissions would not interfere with local air quality regulations — only legal trades would be allowed.

5.3 “Upstream Cap-and-Trade Will Have Minimal Effects on the Transportation Sector”

Approximately one-third of U.S. CO₂ emissions from energy consumption are from the transportation sector.²³⁶ An upstream cap-and-trade system that provides a uniform price signal for cost-effective, economy-wide emission reductions will lead to the achievement of those emission reductions wherever they are least costly. This almost certainly will not mean proportionate reductions in emissions from each type of source or each economic sector. And it is quite true that the greatest percentage of emission reductions would be in the electric power sector, followed by the industrial sector, with much smaller percentage reductions in the commercial, transportation, and residential sectors. From an economic perspective (that is, cost-effectiveness), this is both appropriate and desirable if the reason for the policy is climate change. If there are other, non-climate related reasons for concerns about the use of transportation fuels, such as oil dependence, then those concerns should be addressed through other, appropriate policies.²³⁷

²³⁵ Memorandum from Robert N. Stavins, *supra* note 78.

²³⁶ U.S. ENERGY INFO. ADMIN., *supra* note 59 at xii.

²³⁷ See Sandalow, *supra* note 130.

5.4 “*It Would Be Better to Begin with Narrow Coverage Across a Few Sectors*”

It has been argued that, for political expediency, it would be better to initiate a cap-and-trade system with narrow coverage of only a few sectors and to broaden that coverage over time, rather than employing an economy-wide system such as that proposed here.²³⁸ There are several problems with beginning with narrow coverage. First, narrow coverage is inevitably more costly for whatever environmental gains are achieved, because some of low-cost emission reduction opportunities are unavailable. Second, in terms of the political forces that are at the heart of the recommendation for narrow coverage, it makes much more sense to begin broadly and then go deep.²³⁹ Resistance from uncovered sectors will only increase with the stringency of policy and its associated economic burdens. This lesson can be observed in the debates surrounding proposals to expand the sectoral coverage of the European Union’s downstream cap-and-trade program.

5.5 “*A Cap-and-Trade System Will Create Barriers to Entry and Reduce Competition*”

It is true — in principle — that emission allowances have considerable value and could be used strategically by incumbent firms to keep new entrants from competing in respective product markets. It is for this reason that the SO₂ allowance trading program provides an annual allowance auction so that the government can be a source of last resort. There has been no evidence in any implemented cap-and-trade system, however, that allowances have been withheld from the market by incumbent firms for strategic purposes. Furthermore, the CO₂ cap-and-trade system proposed here includes a large auction of allowances from the very beginning.

5.6 “*The Price Spike in RECLAIM and the Price Drop in the EU ETS Demonstrate that Extreme Price Volatility is an Inherent Part of Cap-and-Trade Systems*”

It is unquestionably true that a cap-and-trade system fixes the quantity of aggregate emissions and allows the price of CO₂ emissions to adjust to ensure that the emissions cap is met. A cap-and-trade system (at least one that establishes rigid annual caps) therefore offers less certainty about costs *because* it provides greater certainty about emissions. But the significant price volatilities that were observed in the RECLAIM program and the EU ETS were associated with particular, problematic design features, as well as special circumstances.

²³⁸ See Richard Schmalensee, *Greenhouse Policy Architectures and Institutions*, in *ECONOMICS AND POLICY ISSUES IN CLIMATE CHANGE* 137, 147-48 (William D. Nordhaus ed., 1998).

²³⁹ *Id.*

The price spike observed for NO_x allowances during the California electricity crisis was partly a consequence of design flaws in the RECLAIM program and partly a consequence of the electricity crisis itself. RECLAIM does not allow banking from one period to the next. Therefore, it did not provide incentives for facilities to install pollution control equipment that would have allowed them to reduce their current emissions and bank allowances for the future. The result was that, during the 2000-01 electricity crisis, some units facing high demand levels were unable to purchase allowances for their emissions.²⁴⁰ When emissions essentially exceeded allowances, an allowance price spike occurred. Even in the context of the electricity crisis and the absence of an allowance bank, the price spike would still not have occurred had a safety valve or other cost-containment mechanism been available in the RECLAIM market.²⁴¹

The allowance price collapse observed in the spring of 2006 during the pilot phase of the EU ETS was a consequence of a combination of the design of the system, generous allowance allocations, data problems, and modeling mistakes. In the spring of 2006, when it became clear that the allocation of allowances had exceeded emissions, a dramatic fall in allowance prices occurred.

Another claim has been that as it now appears that the EU may not meet its aggregate target under Kyoto, the fault is with the EU ETS. The real reason is that the downstream system covers only 45% of European CO₂ emissions.²⁴² The failures to reduce emissions are concentrated in the sectors *not* covered by the program.

Likewise, observations of windfall profits among electric power producers have been used as evidence of an inherent problem with cap-and-trade. Here too, the evidence is otherwise. As explained above, the ETS guidelines called for at least 95% of allowances to be freely distributed in the first compliance period, and most countries freely distributed 100% of their allowances. This is in contrast with the cap-and-trade system proposed here, which provides for 50% of the allowances to be auctioned initially, with this share rising to 100% over 25 years.

5.7 “A Cap-and-Trade System Will Put the United States at a Competitive Disadvantage with Other Countries”

Ever since the passage of the Byrd-Hagel resolution in the U.S. Senate in 1997,²⁴³ there has been great concern, much of it understandable, about

²⁴⁰ MKT. ADVISORY COMM., *supra* note 36, at 101.

²⁴¹ In RECLAIM, a “safety-valve” price of \$15,000/ton had been written into the regulations as a feature that *could* be made operational. See S. COAST AIR QUALITY MGMT. DIST., ANNUAL RECLAIM AUDIT REPORT FOR THE 2004 COMPLIANCE YEAR 3-9 (2006). It was *not* operational, however, when the price spike occurred and it was needed.

²⁴² Convery & Redmond, *supra* note 228, at 93.

²⁴³ S. Res. 98, 105th Cong. (1997).

the effects of climate policy on domestic manufacturing and employment.²⁴⁴ In principle, any domestic policy that drives up the cost of producing goods and services in proportion to their CO₂ emissions can have the effect of shifting comparative advantage in the production of those goods and services to other countries that are not taking on similar costs. This is the phenomenon behind emissions leakage.

It is for this reason that the cap-and-trade system proposed here is linked with the actions of other key nations. In particular, importers of highly carbon-intensive goods (in terms of their emissions generated during manufacture) from countries which have not taken climate policy actions comparable to the United States would be required to hold appropriate quantities of allowances. This will establish a level playing field between domestically produced and imported products, reduce emissions leakage, and may help induce some key developing countries to join an international agreement.

6. SUMMARY AND CONCLUSIONS

The need for a domestic U.S. policy that seriously addresses climate change is increasingly apparent. A cap-and-trade system is the best approach for the United States in the short to medium term. Besides providing greater certainty about emissions levels, cap-and-trade offers an easy means of compensating for the inevitably unequal burdens imposed by climate policy; it is straightforward to harmonize with other countries' climate policies; it avoids the current political aversion in the United States to taxes; and it has a history of successful adoption.

The system described in this article has several key features. It imposes an upstream cap on CO₂ emissions (carbon content measured at the point of fuel extraction, refining, distribution, or importation), with gradual inclusion of other greenhouse gases, to ensure economy-wide coverage while limiting the number of entities to be monitored. It sets a gradual downward trajectory of emissions ceilings over time to minimize disruption and allow firms and households time to adapt. It also includes mechanisms to reduce cost uncertainty. These include provisions for banking and borrowing of allowances and a cost containment mechanism to protect against price volatility.

Initially, half of the program's allowances would be allocated through auctioning and half through free distribution, primarily to those entities most burdened by the policy. This arrangement should help limit potential inequities while bolstering political support. The share distributed for free would be phased out gradually over 25 years. The auctioned allowances would generate revenue that could be used for a variety of worthwhile public purposes.

²⁴⁴ ANALYSIS OF THE CLIMATE STEWARDSHIP ACT, *supra* note 181.

The system would operate at the federal level, eventually asserting supremacy over all regional, state, and local systems, while building on any institutions already developed at those levels. The system would also provide for linkage with international emission reduction credit arrangements, harmonization over time with effective cap-and-trade systems in other countries, and appropriate linkage with other actions taken abroad to maintain a level playing field between imports and competing domestic products. To address potential market failures that might render the system's price signals ineffective, certain complementary policies should be implemented, for example in the areas of consumer information and research and development.

Like other market-based emissions reduction schemes, the one described here reduces compliance costs by offering regulated entities flexibility. Rather than mandating specific measures on all sources, it allows emissions to be reduced however, wherever, and, to some extent, whenever they are least costly. To illustrate the potential cost savings, I have reported empirical cost estimates for two hypothetical trajectories for emissions caps. The first stabilizes CO₂ emissions at their 2008 level by 2050, whereas the second reduces emissions from their 2008 level to 50% below the 1990 level by 2050. Both are consistent with the often cited global goal of stabilizing CO₂ atmospheric concentrations at between 450 and 550 ppm, provided all countries take commensurate action. The analysis found significant but affordable impacts on GDP levels under both trajectories: generally below 0.5% a year for the less aggressive trajectory, ranging up to 1% a year for the more aggressive one.

The impact of any U.S. policy will ultimately depend on the actions of other nations around the world. Without an effective global climate agreement, each country's optimal strategy is to free-ride on the actions of others. But if all countries do this, nothing will be accomplished, and the result will be the infamous tragedy of the commons. A cooperative solution — one that is scientifically sound, economically rational, and politically pragmatic — must remain the ultimate goal. Given these realities, a major strategic consideration in initiating a U.S. climate policy should be to establish international credibility. The cap-and-trade system described and assessed in this article offers a way for the United States to demonstrate its commitment to an international solution while making its own real contribution to addressing climate change.

Getting serious about greenhouse gas emissions will not be cheap and it will not be easy. But if the current state-of-the-science predictions about the consequences of another few decades of inaction are correct, the time has arrived for a serious and sensible approach.

APPENDIX: APPLICATIONS OF CAP-AND-TRADE MECHANISMS

Tradable permit programs are of two basic types, credit programs and cap-and-trade systems.²⁴⁵ This appendix describes several past and current applications of the cap-and-trade approach.

*A.1 Use of Cap-and-Trade Systems for Local and Regional Air Pollution*²⁴⁶

The first important example of a trading program in the United States was the leaded gasoline phasedown that occurred in the 1980s. Although not strictly a cap-and-trade system, the phasedown included features, such as trading and banking of environmental credits, that brought it closer than other credit programs to the cap-and-trade model and resulted in significant cost-savings. Subsequent examples of cap-and-trade systems include CFC trading under the Montreal Protocol to protect the ozone layer, SO₂ allowance trading under the Clean Air Act Amendments of 1990, the Regional Clean Air Markets (“RECLAIM”) program in the Los Angeles area, and the NO_x trading program initiated in 1999 to control regional smog in the eastern United States.

A.1.1 Leaded Gasoline Phasedown

The purpose of the U.S. lead trading program, developed in the 1980s, was to allow gasoline refiners greater flexibility in meeting emission standards and thereby cut compliance costs at a time when the lead-content of gasoline was reduced to 10% of its previous level. In 1982, EPA authorized inter-refinery trading of lead credits, a major purpose of which was to lessen the financial burden on smaller refineries, which were believed to have significantly higher compliance costs. If refiners produced gasoline with a lower lead content than was required, they earned lead credits. Unlike a cap-and-trade program, there was no explicit allocation of permits, but to the degree that firms’ production levels were correlated over time, the system implicitly awarded property rights on the basis of historical levels of gasoline production.²⁴⁷

In 1985, EPA initiated a program allowing refineries to bank lead credits. Firms subsequently made extensive use of this option. In each year of the program, more than 60% of the lead added to gasoline was associated

²⁴⁵ See *Tables, supra* note 74, at 13.

²⁴⁶ The appendix draws, in part, on Stavins, *supra* note 17 at 356.

²⁴⁷ Robert Hahn, *Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor’s Orders*, 3 J. ECON. PERSP. 95, 101-03 (1989).

with traded lead credits,²⁴⁸ until the program was terminated at the end of 1987, when the lead phasedown was completed.²⁴⁹

The lead program was clearly successful in meeting its environmental targets, although it may have produced some temporary geographic shifts in use patterns.²⁵⁰ Although the economic benefits of the trading scheme are more difficult to assess, the level of trading activity and the rate at which refiners reduced their production of leaded gasoline suggest that the program was cost-effective.²⁵¹ The high level of trading among firms far surpassed levels observed in earlier environmental markets.²⁵² EPA estimated savings from the lead trading program of approximately 20% over alternative programs that did not provide for lead banking, a cost savings of about \$250 million per year.²⁵³ Furthermore, the program provided measurable incentives for cost-saving technology diffusion.²⁵⁴

A.1.2 Ozone-Depleting Substances Phaseout

A cap-and-trade system was used in the United States to help comply with the Montreal Protocol, an international agreement aimed at slowing the rate of stratospheric ozone depletion. The Protocol called for reductions in the use of chlorofluorocarbons (“CFCs”) and halons, the primary chemical groups thought to lead to ozone depletion.²⁵⁵ The system places limitations

²⁴⁸ Robert Hahn & Gordon Hester, *Marketable Permits: Lessons for Theory and Practice*, 16 *ECOLOGY L.Q.* 361, 384-91 (1989).

²⁴⁹ Under the banking provisions of the program, excess reductions made in 1985 could be banked until the end of 1987, thereby providing an incentive for early reductions to help meet the lower limits that existed during the later years of the phasedown. The official completion of the phasedown occurred on January 1, 1996, when lead was banned as a fuel additive. Suzi Kerr & Richard Newell, *Policy-Induced Technology Adoption: Evidence from the U.S. Lead Phasedown*, 51 *J. INDUS. ECON.* 317 (2003).

²⁵⁰ See Robert C. Anderson, Lisa A. Hofmann & Michael Rusin, *The Use of Economic Incentive Mechanisms in Environmental Management* 29 (American Petroleum Inst., Research Paper No. 051, 1990).

²⁵¹ Suzi Kerr & David Maré, *Transactions Costs and Tradeable Permit Markets: The United States Lead Phasedown* (June 30, 1998) (unpublished manuscript, on file with the Harvard Environmental Law Review); see also Albert L. Nichols, *Lead in Gasoline*, in *ECONOMIC ANALYSES AT EPA: ASSESSING REGULATORY IMPACT* 49, 75-76 (Richard D. Morgenstern ed., 1997).

²⁵² See Robert W. Hahn & Robert N. Stavins, *Incentive-Based Environmental Regulation: A New Era From an Old Idea?*, 18 *ECOLOGY L.Q.* 1, 17 (1991); see also *Tables*, *supra* note 74, at 13 (listing these earlier programs). The program did experience some relatively minor implementation difficulties related to imported leaded fuel. It is not clear that a comparable command-and-control approach would have done better in terms of environmental quality. See generally U.S. GENERAL ACCOUNTING OFFICE, *VEHICLE EMISSIONS: EPA PROGRAM TO ASSIST LEADED-GASOLINE PRODUCERS NEEDS PROMPT IMPROVEMENT* (1986).

²⁵³ See OFFICE OF POL'Y ANALYSIS, *supra* note 26, at VIII-19.

²⁵⁴ Kerr & Newell, *supra* note 249, at 317-18.

²⁵⁵ The Montreal Protocol called for a 50% reduction in the production of particular CFCs from 1986 levels by 1998. In addition, the Protocol froze halon production and consumption at 1986 levels beginning in 1992. Montreal Protocol on Substances That Deplete the Ozone Layer, Sept. 16, 1987, S. Treaty Doc. No. 100-10, 1522 U.N.T.S. 3 art. 2A, 2B.

on both the production and the consumption of CFCs by issuing allowances that limit these activities.

The Montreal Protocol recognized the fact that different types of CFCs are likely to have different effects on ozone depletion. Each CFC is assigned a different weight on the basis of its depletion potential. If a firm wishes to produce a given amount of a CFC, it must have an allowance to do so, calculated on this basis.²⁵⁶ This is the approach that would be used for a multi-GHG trading system, where allowances would be denominated in terms of their radiative-forcing potential, often characterized as CO₂-equivalent. The overall efficiency of the market is difficult to determine because no studies have been conducted to estimate cost savings.

Singapore has operated a cap-and-trade system for ozone-depleting substances ("ODSs") since 1991. The government records ODS requirements and bid prices for registered end-users and distributors, and total national ODS consumption (based on the Montreal Protocol) is distributed to registered firms by auction and free allocation. Firms can trade their allocations. Auction rents, captured by the government, have been used to subsidize recycling services and environmentally-friendly technologies.²⁵⁷

Canada has also used cap-and-trade systems for ODSs since 1993. A system of tradable permits for CFCs and methyl chloroform operated from 1993 to 1996, when production and import of these substances ceased. Producers and importers received allowances for use of CFCs and methyl chloroform equivalent to consumption in the base year and were permitted to transfer part or all of their allowances with the approval of the federal government. There were only a small number of transfers of allowances during the three years of market operation, however.²⁵⁸

Canada first distributed tradable allowances for methyl bromide in 1995. Due to concerns about the small number of importers (five), allowances were distributed directly to Canada's 133 users of methyl bromide. Use and trading of allowances was active among large allowance holders.²⁵⁹ In addition, Canada has operated an HCFC allowance system since 1996, distributing consumption permits for 80% of its maximum allowable use under the Montreal Protocol.²⁶⁰

A.1.3 *SO₂ Allowance Trading Program*

The most important application made in the United States of a market-based instrument for environmental protection is arguably the cap-and-trade

²⁵⁶ Hahn & McGartland, *supra* note 28 at 592-97.

²⁵⁷ Annex I Expert Group on the United Nations Framework Convention on Climate Change, *International Greenhouse Gas Emission Trading* 53-56 (OECD Working Paper No. 9, 1997).

²⁵⁸ Erik Haites & Tallat Hussain, *The Changing Climate for Emissions Trading in Canada*, 9 REV. EUR. CMTY. & INT'L ENVTL. L. 264, 265 (2000).

²⁵⁹ *Id.* at 265-66.

²⁶⁰ *Id.* at 265.

system that regulates emissions of SO₂, the primary precursor of acid rain. This system, which was established under Title IV of the U.S. Clean Air Act Amendments of 1990, is intended to reduce sulfur dioxide and nitrogen oxide emissions by 10 million tons and 2 million tons, respectively, from 1980 levels.²⁶¹ The first phase of sulfur dioxide emissions reductions was started in 1995, with a second phase of reduction initiated in the year 2000.²⁶²

In Phase I, individual emissions limits were assigned to the targeted plants.²⁶³ After January 1, 1995, these utilities could emit sulfur dioxide only if they had adequate allowances to cover their emissions. During Phase I, the EPA allocated each affected unit a specified number of annual allowances related to its share of heat input during the baseline period (1985-87), plus bonus allowances available under a variety of special provisions.²⁶⁴ Cost-effectiveness was promoted by permitting allowance holders to transfer their permits among one another and bank them for later use.²⁶⁵

Under Phase II of the program, beginning January 1, 2000, almost all electric power generating units were brought within the system.²⁶⁶ If trading allowances represent the carrot of the system, its stick is a penalty initiated at \$2,000 (in 1990 dollars) per ton of emissions that exceed any year's allowances, indexed to subsequent inflation (and a requirement that excess emissions be offset the following year).²⁶⁷

A robust market of SO₂ allowance trading emerged from the program, resulting in cost savings on the order of \$1 billion annually, compared with the costs under some command-and-control regulatory alternatives.²⁶⁸ Although the program had low levels of trading in its early years,²⁶⁹ trading increased significantly over time.²⁷⁰ The program has also had a significant

²⁶¹ For a description of the legislation, see Brian Ferrall, *The Clean Air Act Amendments of 1990 and the Use of Market Forces to Control Sulfur Dioxide Emissions*, 28 HARV. J. ON LEGIS. 235, 236-44 (1991).

²⁶² *Id.*

²⁶³ *Id.*

²⁶⁴ *Id.* at 242 n.57. Utilities that installed scrubbers received bonus allowances for early cleanup. Also, specified utilities in Ohio, Indiana, and Illinois received extra allowances during both phases of the program. *Id.* All of these extra allowances were essentially compensation intended to benefit Midwestern plants that rely on high-sulfur coal. On the political origins of this aspect of the program, see Paul L. Joskow & Richard Schmalensee, *The Political Economy of Market-Based Environmental Policy: The U.S. Acid Rain Program*, 41 J. L. & ECON. 37 (1998).

²⁶⁵ Ferrall, *supra* note 265, at 242.

²⁶⁶ *Id.*

²⁶⁷ *Id.*

²⁶⁸ Curtis Carlson, Dallas Burtraw, Maureen Cropper & Karen Palmer, *Sulfur Dioxide Control by Electric Utilities: What Are the Gains from Trade?*, at 4 (Res. for the Future, Discussion Paper No. 98-44-REV, 2000).

²⁶⁹ Dallas Burtraw, *The SO₂ Emissions Trading Program: Cost Savings Without Allowance Trades*, 14 CONTEMP. ECON. POL'Y 79, 79 (1996).

²⁷⁰ See Richard Schmalensee et al., *An Interim Evaluation of Sulfur Dioxide Emissions Trading*, 12 J. ECON. PERSP. 53, 63 (1998); Robert N. Stavins, *What Can We Learn from the Grand Policy Experiment? Lessons from SO₂ Allowance Trading*, 12 J. ECON. PERSP. 69, 71 (1998); DENNY ELLERMAN, PAUL JOSKOW, RICHARD SCHMALENSEE, JUAN-PABLO MONTERO & ELIZABETH BAILEY, *MARKETS FOR CLEAN AIR: THE U.S. ACID RAIN PROGRAM* 317-18 (2000).

environment impact: SO₂ emissions from the power sector decreased from 15.7 million tons in 1990 to 10.2 million tons in 2005.²⁷¹ Because the program allowed firms to bank allowances, SO₂ emissions dropped quickly in the early years of the program, leading to environmental benefits that were earlier and larger than expected.

Concerns were expressed early on that state regulatory authorities would hamper trading in order to protect their domestic coal industries, and some research indicates that state public utility commission cost-recovery rules provided poor guidance for compliance activities.²⁷² Other analysis suggests that this has not been a major problem.²⁷³ Similarly, in contrast to early assertions that the structure of EPA's small allowance auction market would cause problems,²⁷⁴ the evidence indicates that this structure has had little or no effect on the vastly more important bilateral trading market.²⁷⁵

The allowance trading program has had exceptionally positive welfare effects, with benefits being as much as six times greater than costs.²⁷⁶ The large benefits of the program are due mainly to the positive human health impacts of decreased local SO₂ and particulate concentrations, not to the ecological impacts of reduced long-distance transport of acid deposition. This contrasts with what was assumed and understood at the time of the program's enactment in 1990.

Furthermore, the geographic distribution of emission reductions has been fairly equitable. The program did not result in significant regional shifts in pollution.²⁷⁷ In fact, the largest emission reductions occurred in Midwestern states where emissions were high and emission reduction costs were low.²⁷⁸ Poor communities were not disproportionately affected by emissions from the program.²⁷⁹

²⁷¹ OFFICE OF AIR AND RADIATION, EPA, ACID RAIN PROGRAM: 2005 PROGRESS REPORT 5 (2005).

²⁷² Kenneth Rose, *Implementing an Emissions Trading Program in an Economically Regulated Industry: Lessons from the SO₂ Trading Program*, in MARKET BASED APPROACHES TO ENVIRONMENTAL POLICY: REGULATORY INNOVATIONS TO THE FORE 101, 120, 122 (Richard Kosobud and Jennifer Zimmerman eds., 1997); Douglas Bohi, *Utilities and State Regulators Are Failing to Take Advantage of Emissions Allowance Trading*, 7 ELECTRICITY J. 20, 25-27 (1994).

²⁷³ Elizabeth Bailey, *Allowance Trading Activity and State Regulatory Rulings: Evidence from the U.S. Acid Rain Program* (Massachusetts Institute of Technology, Center for Energy and Environmental Policy Research Working Paper No. 98005, 1998), available at <http://web.mit.edu/ceepr/www/publications/workingpapers/98005.pdf>.

²⁷⁴ Timothy Cason, *An Experimental Investigation of the Seller Incentives in EPA's Emission Trading Auction*, 85 AM. ECON. REV. 905, 920-21 (1995).

²⁷⁵ Paul Joskow, Richard Schmalensee & Elizabeth Bailey, *Auction Design and the Market for Sulfur Dioxide Emissions*, 88 AM. ECON. REV. 669 (1998).

²⁷⁶ Dallas Burtraw et al., *The Costs and Benefits of Reducing Air Pollution Related to Acid Rain*, 16 CONTEMP. ECON. POL'Y 379, 397-99 (1998).

²⁷⁷ Amy Kinner & Rona Birnbaum, Address at the Emissions Marketing Association Annual Spring Meeting, *The Acid Rain Experience: Should We Be Concerned about SO₂ Emissions Hotspots?* (May 4, 2004).

²⁷⁸ ELLERMAN ET AL., *supra* note 270, 129-36.

²⁷⁹ See generally Jason Corburn, *Emissions Trading and Environmental Justice: Distributive Fairness and the USA's Acid Rain Programme*, 28 ENVTL. CONSERVATION 323 (2001).

Ever since the program's initiation, downwind states, particularly New York, have been somewhat skeptical about the effects of the trading scheme. This skepticism is driven by concern that the allowance trading program was failing to curb acid deposition in the Adirondacks in northern New York State.²⁸⁰ The empirical evidence indicates that New York's concern is essentially misplaced. The first question is whether acid deposition has increased in New York State. If the baseline for comparison is the absence of the Clean Air Act Amendments of 1990, then clearly acid deposition is less than it would have been otherwise. If the baseline for comparison is the original allocation of allowances under the 1990 law, but with no subsequent trading, then acid deposition in New York State is approximately unchanged.²⁸¹

Of course, such comparisons ignore the fact that the greatest benefits of the program have been with regard to human health impacts of localized pollution. When such effects are also considered, it becomes clear that the welfare effects of allowance trading on New York State, using *either* baseline, have been positive and significant.²⁸²

A.1.4 RECLAIM Program

The South Coast Air Quality Management District, which is responsible for controlling emissions in a four-county area of southern California, launched a cap-and-trade program in 1994 to reduce nitrogen oxide and sulfur dioxide emissions in the Los Angeles area. This Regional Clean Air Incentives Market ("RECLAIM") program set an aggregate cap on NO_x and SO₂ emissions for all power plants, cement factories, refineries, and other industrial sources with emissions greater than four tons per year. Although these 353 sources accounted for only a quarter of ozone-forming emissions in the four county area (the remainder of emissions were primarily from the transportation sector), the program set an ambitious goal of reducing aggregate emissions from regulated sources by 70% by 2003.

Trading under the RECLAIM program is restricted in several ways, with positive and negative consequences. First, the trading program incorporates zonal restrictions, whereby trades are not permitted from downwind to upwind sources. This geographically-differentiated emission trading program represents one step toward an ambient trading program. Second, temporal restrictions in the program²⁸³ may not provide incentives for facilities to install pollution control equipment that would have allowed them to reduce their current emissions and bank allowances for the future. This prob-

²⁸⁰ James Dao, *Acid Rain Law Found to Fail in Adirondacks*, N.Y. TIMES, March 27, 2000, at A1.

²⁸¹ See Burtraw et al., *supra* note 276, at 397-99.

²⁸² See generally Dallas Burtraw & Erin Mansur, *The Environmental Effects of SO₂ Trading and Banking*, 33 ENVTL. SCI. & TECH. 3489 (1999); Byron Swift, *Allowance Trading and SO₂ Hot Spots: Good News from the Acid Rain Program*, 31 ENV'T REP. 954 (2000).

²⁸³ Although the program does not have an explicit provision for banking from one period to the next, there is limited banking and borrowing in RECLAIM through the device of overlapping compliance periods.

lem became particularly severe during the 2000-01 electricity crisis, when some units facing high demand levels were unable to purchase allowances for their emissions. As a result, emissions exceeded allowances, and allowance price spikes occurred, as would be expected under such conditions.²⁸⁴

By June of 1996, the participants in the RECLAIM program had traded more than 100,000 tons of NO_x and SO₂ emissions, at a value of over \$10 million.²⁸⁵ Despite problems with a surplus of allowances in the first years of the program, RECLAIM has generated environmental benefits: NO_x emissions in the regulated area fell by 60% between 1994 and 2004, and SO_x emissions fell by 50% over the same time period.²⁸⁶ Furthermore, the program has reduced compliance costs for regulated facilities. One prospective analysis predicted 42% cost savings, amounting to \$58 million annually.²⁸⁷

A.1.5 NO_x Budget Program

Under EPA guidance, twelve northeastern states and the District of Columbia implemented a regional NO_x cap-and-trade system in 1999 to reduce compliance costs associated with the Ozone Transport Commission regulations of the 1990 Amendments to the Clean Air Act. This program established the Northeast Ozone Transport Region, which includes three geographic zones.²⁸⁸ Emissions caps from 1999-2003 were 35% of 1990 emissions in the Inner Zone and 45% of 1990 emissions in the Outer Zone.²⁸⁹

The program was modified in 2003, when a new rule (the “NO_x SIP Call”) reduced the cap on emissions and created a larger trading region that included nineteen states plus the District of Columbia. Including reductions achieved under the NO_x SIP Call, NO_x emissions fell from 1.86 million tons in 1990 to 0.49 million tons in 2006.²⁹⁰ The trading program initially covered emissions from 1,000 large stationary combustion sources, but it expanded under the NO_x SIP Call to include over 2,500 sources.²⁹¹

Under the program, EPA distributes NO_x allowances to each state, and states then allocate allowances to sources in their jurisdictions. Each source receives allowances equal to its restricted percentage of 1990 emissions, and sources must turn in one allowance for each ton of NO_x emitted during the

²⁸⁴ See MKT. ADVISORY COMM., *supra* note 36, at 101.

²⁸⁵ Thomas Brotzman, *Opening the Floor to Emissions Trading*, CHEMICAL MKTG. REP., May 27, 1996.

²⁸⁶ S. COAST AIR QUALITY MGMT. DIST., *supra* note 241, at 3-3.

²⁸⁷ ROBERT C. ANDERSON & ANDREW Q. LOHOF, ENVTL. LAW INST., THE UNITED STATES EXPERIENCE WITH ECONOMIC INCENTIVES IN ENVIRONMENTAL POLLUTION CONTROL POLICY § 6 at 9 (1997).

²⁸⁸ The Inner Zone includes the Atlantic coast from Northern Virginia to New Hampshire and various distances inland. The Outer Zone is adjacent to the Inner Zone, from western Maryland through most of New York State. The Northern Zone includes northern New York, New Hampshire, all of Vermont, and Maine. See Farrell, Carter & Raufer, *supra* note 40, at 110.

²⁸⁹ *Id.*

²⁹⁰ See MKT. ADVISORY COMM., *supra* note 36, at 103.

²⁹¹ See *id.*

ozone season. Sources may buy, sell, and bank allowances, although a system of progressive flow control limits the total number of banked allowances that can be used during the ozone season.

Potential compliance cost savings of 40% to 47% have been estimated for the period 1999-2003, compared to a base case of continued command-and-control regulation without trading or banking.²⁹² Due to delays in the implementation of the program and the allocation of allowances, prices were volatile in the first year of trading. In subsequent years, prices stabilized as the market equilibrated. NO_x allowance trading is complicated by existing command-and-control regulations on many sources, the seasonal nature of ozone formation, and the fact that problems tend to result from a few high-ozone episodes and are not continuous.²⁹³

A.2 CO₂ and Greenhouse Gas Cap-and-Trade Systems

Although cap-and-trade has proven to be a successful means to control conventional air pollutants, it has a very limited history as a method of reducing CO₂ emissions. But several ambitious programs are in the planning stages or have been launched. First, the Kyoto Protocol, the international agreement that was signed in Japan in 1997, includes a provision for an international cap-and-trade system among countries. Second, by far the largest existing active cap-and-trade program in the world is the European Union Emissions Trading Scheme, which has operated for the past two years with considerable success, despite some initial and predictable problems. Two frequently discussed U.S. CO₂ cap-and-trade systems that have not yet been implemented are the Regional Greenhouse Gas Initiative, a program among 10 northeastern states that will be implemented in 2009 and begin to cut emissions in 2015, and California's Global Warming Solutions Act of 2006, which is intended to begin to reduce emissions in 2012 and may employ a cap-and-trade approach.

A.2.1 Kyoto Protocol (Article 17)

In 1990, the United Nations General Assembly initiated negotiations that led to the Framework Convention on Climate Change ("FCCC"), which began in 1994 with 190 countries as parties and established a long-term goal of stabilizing greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system.²⁹⁴ In Kyoto, Japan, in December 1997, the parties to the FCCC agreed on the terms of what came to be known as the Kyoto Protocol. This agreement took a step toward the FCCC's objective by setting ambitious, near-term quantitative GHG targets for industrialized countries.

²⁹² Farrell, Carter & Raufer, *supra* note 40, at 119.

²⁹³ *Id.* at 113.

²⁹⁴ Kyoto Protocol, *supra* note 4.

The agreement was intended to result in industrialized countries' emissions declining in aggregate by 5.2% below 1990 levels by the year 2012.²⁹⁵ In 2001, industrialized countries began to ratify the Kyoto Protocol. Despite the withdrawal of the United States and Australia, the Kyoto Protocol became effective in 2005, having met the requirement that 55 Annex I countries, jointly accounting for 55% of 1990 Annex I emissions, had ratified the agreement.

The Protocol includes a provision for cost-effective implementation through a set of tradable permit mechanisms, two of which are credit programs (Joint Implementation and the Clean Development Mechanism) and one of which is a cap-and-trade system (the international trading provision in Article 17). These are provided as options that countries can employ. There are few details available on the international cap-and-trade system laid out in Article 17,²⁹⁶ but that Article — together with the Kyoto Protocol's special provision (in Annex B) that allows European emissions to be counted as a whole, rather than individually — has set the stage for the member states of the European Union to address their commitments under the Kyoto Protocol partially through a regional cap-and-trade system.²⁹⁷

A.2.2 *European Union Emissions Trading Scheme*

In order to meet its commitments in part under the Kyoto Protocol, the European Union created the European Union Emissions Trading Scheme ("EU ETS"), a cap-and-trade system for CO₂ allowances. This system, which was adopted in 2003 and became active with a pilot phase in 2005, covers about half of EU CO₂ emissions in a region of the world that accounts for about 20% of global GDP and 17% of world energy-related CO₂ emissions.²⁹⁸ The 11,500 emitters regulated by the downstream program include large sources such as oil refineries, combustion installations over 20 MW, coke ovens, cement factories, ferrous metal production, glass and ceramics production, and pulp and paper production. The program does not cover sources in the transportation, commercial, or residential sectors.²⁹⁹

The EU ETS was designed to be implemented in phases: a pilot or learning phase from 2005 to 2007, a Kyoto commitment period phase from

²⁹⁵ See *id.* at Art. 3.

²⁹⁶ Article 17 reads as follows: "The Conference of the Parties shall define the relevant principles, modalities, rules and guidelines, in particular for verification, reporting and accountability for emissions trading. The Parties included in Annex B may participate in emissions trading for the purposes of fulfilling their commitments under Article 3. Any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments under that Article." *Id.* Art. 17. For an assessment of the limitations of this cap-and-trade system, see ROBERT HAHN & ROBERT STAVINS, *WHAT HAS THE KYOTO PROTOCOL WROUGHT? THE REAL ARCHITECTURE OF INTERNATIONAL TRADEABLE PERMIT MARKETS* (1999).

²⁹⁷ Kyoto Protocol, *supra* note 4, Art. 17, Annex B.

²⁹⁸ Denny Ellerman & Barbara Buchner, *The European Union Emissions Trading Scheme: Origins, Allocation, and Early Results*, 1 REV. ENVTL. ECON. & POL'Y 66, 66 (2007).

²⁹⁹ *Id.* at 72.

2008 to 2012, and a series of subsequent phases. Penalties for violations increase from 40 Euros per ton of CO₂ in the first phase to 100 Euros per ton of CO₂ in the second phase. Although the first phase allows trading only in CO₂, the second phase potentially broadens the program to include other GHGs.

The process for setting caps and allowances in member states is decentralized.³⁰⁰ Each member state is responsible for proposing its own national carbon cap that reflects variables such as the source mixture and carbon intensity of national energy supplies, GDP, and expected growth rates. These caps are subject to review by the European Commission. Decentralization created incentives for individual countries to try to be generous with their allowances to protect their economic competitiveness.³⁰¹ By analogy, picture a U.S. national program that left it up to individual states to establish their own caps. The anticipated result might be an aggregate cap that exceeded BAU emissions, which is what happened initially in the EU ETS.

In the spring of 2006, it became clear that the allocation of allowances in 2005, on net, had exceeded emissions by about 4% of the overall cap. This led, as might be anticipated, to a dramatic fall in allowance prices. In January 2005, the price per ton was approximately € 8; by December 2005, it reached € 21; and in the next year, it fluctuated and then fell back to about € 8.³⁰² This volatility has been attributed to the absence of good emission data at the beginning of the program, a surplus of allowances, energy price volatility, and a program feature that prevents banking of allowances from the first phase to the second phase.³⁰³ In truth, the over-allocation (which might, in principle, be due to low electricity output, abatement, or a generous allocation) was concentrated in a few countries, particularly in Eastern Europe, and in the non-power sectors.³⁰⁴

The intention of the EU ETS is that scarcity (a cap below BAU) will be enforced by the European Commission, which reviews national plans and can reduce caps as necessary to ensure that they are compatible with achievement of Kyoto commitments and do not exceed BAU emissions. Within each country, allocation of allowances is based on distributional and political economy concerns. The first and second phases of the EU ETS require member states to distribute almost all of the emission allowances (95% and 90%, respectively) freely to regulated sources, but, beginning in 2013, member states may be allowed to auction larger shares of their allowances. The value of allowances distributed under the EU ETS is over

³⁰⁰ Joseph Kruger, Wallace E. Oates & William A. Pizer, *Decentralization in the EU Emissions Trading Scheme and Lessons for Global Policy*, 1 REV. ENVTL. ECON. & POL'Y 112, 113 (2007).

³⁰¹ Convery & Redmond, *supra* note 228, at 94.

³⁰² *Id.* at 104.

³⁰³ MKT. ADVISORY COMM., *supra* note 36, at 104-05.

³⁰⁴ Ellerman & Buchner, *supra* note 298, at 72.

\$40 billion, compared with about \$5 billion under the U.S. SO₂ allowance trading program.³⁰⁵

The free distribution of allowances led to complaints from energy-intensive industrial firms about “windfall” profits among electricity generators when energy prices increased significantly in 2005. But the higher electricity prices were only partly due to allowance prices; higher fuel prices also played a role. It is also unclear whether the large profits reported by electricity generators were due mainly to their allowance holdings or to having low-cost nuclear or coal generation in areas where the marginal electricity price was set by higher-cost natural gas.³⁰⁶

In its first two years of operation, the EU ETS has produced a functioning CO₂ market. Weekly CO₂ trading volumes have typically ranged between 5 million and 15 million tons, with spikes in trading activity occurring along with major price changes. Beyond the observations above regarding the design of the EU ETS, it is much too soon to provide a definitive assessment of the system’s performance.

A.2.3 *Regional Greenhouse Gas Initiative*

The Regional Greenhouse Gas Initiative (“RGGI”) is a downstream cap-and-trade program that is intended to limit CO₂ emissions from power sector sources in ten northeastern states (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont). The program will take effect in 2009, pending approval by individual state legislatures, and sets a goal of limiting emissions from regulated sources to current levels in the period from 2009 to 2014. Beginning in 2015, the emissions cap will decrease by 2.5% per year until it reaches an ultimate level 10% below current emissions in 2019.³⁰⁷ This goal will require a reduction that is approximately 35% below BAU or, equivalently, 13% below 1990 emission levels.

Because RGGI only limits emissions from the power sector, incremental monitoring costs are low, since U.S. power plants are already required to report their hourly CO₂ emissions to the federal government (under provisions for continuous emission monitoring as part of the SO₂ allowance trading program). The system sets standards for certain categories of CO₂ offsets and limits the number and geographic distribution of offsets, in contrast to what is proposed in the present paper. The program requires participating states to auction at least 25% of their allowances and to use the proceeds for energy efficiency and consumer-related improvements. The remaining 75% of allowances may be auctioned or distributed freely.

Given that the RGGI cap-and-trade system will not come into effect until 2009 at the earliest, it is obviously not possible to assess its perform-

³⁰⁵ *Id.* at 68.

³⁰⁶ *Id.* at 74-75.

³⁰⁷ See MKT. ADVISORY COMM., *supra* note 36, at 106.

ance. Several problems with its design, however, should be noted. First is the leakage problem, which is potentially severe for any state or regional program, particularly given the interconnected nature of electricity markets.³⁰⁸ Second, the program is downstream for just one sector of the economy, making it very limited in scope. Third, despite considerable cost uncertainty, a true firm safety-valve mechanism was not adopted. Instead, there are trigger prices that allow greater reliance on offsets and external credits with the expectation that these can increase supply. Fourth, as mentioned above, the program limits the number and geographic origin of offsets.

A.2.4 *California's Global Warming Solutions Act*

California's Assembly Bill 32, the Global Warming Solutions Act, was signed into law in 2006, and assigns the California Air Resources Board the task of adopting measures to reduce California's emissions of greenhouse gases to 1990 levels by the year 2020. The Act provides for the reductions of emissions of six types of greenhouse gases — carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride — to the “maximum technologically feasible and cost-effective” levels, a requirement that has caused considerable debate and some confusion.³⁰⁹

Although the Global Warming Solutions Act does not require the use of market-based instruments, it does allow for their use, albeit with restrictions that they must not result in increased emissions of criteria air pollutants or toxics; they must maximize environmental and economic benefits in California; and they must account for localized economic and environmental justice concerns.³¹⁰ This mixed set of objectives potentially interferes with the development of a sound policy mechanism.³¹¹

To explore the potential role of market-based tools, Governor Schwarzenegger asked the California Secretary of Environmental Protection to create a Market Advisory Committee of experts and stakeholders. On June 30, 2007, the Committee submitted its non-binding advisory report recommending a design for the implementation of a cap-and-trade program in California.³¹² The report suggests a gradual phase-in of emission caps leading up to a reduction to 1990 levels by 2020. Other features of the program include coverage of most sectors of the economy, with an initial focus on targeting limited sectors through what may be a downstream or a mixed point of regulation; a requirement that the first seller of electricity generated outside California surrender allowances to cover the out-of-state emissions

³⁰⁸ Dallas Burtraw, Danny Kahn & Karen Palmer, *CO₂ Allowance Allocation in the Regional Greenhouse Gas Initiative and the Effect on Electricity Investors*, at 2 (Res. for the Future, Discussion Paper CP 05-55, 2005).

³⁰⁹ CAL. HEALTH & SAFETY CODE § 38560 (2007).

³¹⁰ MKT. ADVISORY COMM., *supra* note 36, at iii-v.

³¹¹ Memorandum from Robert N. Stavins, *supra* note 78.

³¹² MKT. ADVISORY COMM., *supra* note 36.

from generation; an allowance distribution system that uses both free distribution and auctions of allowances, with a shift toward more auctions in later years; and recognition of offsets.³¹³

³¹³ *Id.*

