THE HAMILTON PROJECT

Advancing Opportunity, Prosperity and Growth

Appendix to:
A U.S. Cap-and-Trade System to Address Global Climate Change

Applications of Cap-and-Trade Mechanisms

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Tradable permit programs are of two basic types, credit programs and cap-and-trade systems (Table 13). The focus of this appendix is on applications of the cap-and-trade approach.

A.1 Previous Use of Cap-and-Trade Systems for Local and Regional Air Pollution[a]

The first important example of a trading program in the United States was the leaded gasoline phasedown that occurred in the 1980's. 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, SO_2 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 percent of its previous level. In 1982, the U.S. Environmental Protection Agency (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 (Hahn 1989).

In 1985, EPA initiated a program allowing refineries to bank lead credits, and subsequently firms made extensive use of this option. In each year of the program, more than 60 percent of the lead added to gasoline was associated with traded lead credits (Hahn and Hester 1989), until the program was terminated at the end of 1987, when the lead phasedown was completed.[b]

The lead program was clearly successful in meeting its environmental targets, although it may have produced some (temporary) geographic shifts in use patterns (Anderson, Hofmann and Rusin 1990). 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 (Kerr and Maré 1997; Nichols 1997). The high level of trading between firms far surpassed levels observed in earlier environmental markets.[c] EPA estimated savings from the lead trading program of approximately 20 percent over alternative programs that did not provide for lead banking, a cost savings of about $250 million per year (U.S. Environmental Protection Agency, Office of Policy Analysis 1985). Further, the program provided measurable incentives for cost-saving technology diffusion (Kerr and Newell 2000).

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 CFCs and halons, the primary chemical groups thought to lead to ozone depletion.[d] The system places limitations on both the production and 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, and so each CFC is assigned a different weight on the basis of its depletion potential. If a firm wishes to produce a given amount of CFC, it must have an allowance to do so, calculated on this basis (Hahn and McGartland 1989). 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 CO_2-equivalent.

Through mid-1991, there were 34 participants in the market and 80 trades. However, the overall efficiency of the market is difficult to determine, because no studies have been conducted to estimate cost savings. The timetable for the phaseout of CFCs was subsequently accelerated, and a tax on CFCs was introduced, principally as a windfall-profits tax to prevent private industry from retaining scarcity rents created by the quantity restrictions (Merrill and Rousso 1990). The tax may have become the binding (effective) instrument. Nevertheless, low transaction costs associated with trading in the CFC market suggest that the system was relatively cost-effective.

In similar fashion, production quotas for ozone-depleting substances (ODS) were transferred within and among European Union (EU) countries between 1991 and 1994, until production was nearly phased out. During that period, there were 19 transfers (all but two of which were intrafirm), accounting for 13 percent of the EUs allowable ODS production.

Singapore has operated a cap-and-trade system for ODS 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 (Annex I Expert Group of the United Nations Framework Convention on Climate Change 1997). Likewise, New Zealand implemented a CFC import permit system in 1986, whereby CFC permits are distributed by the Ministry of Commerce (based on the Montreal Protocol), and trading is allowed among permit holders.

Canada has also used cap-and-trade systems for ozone-depleting substances 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 (Haites 1996).

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. In addition, Canada has operated an HCFC allowance system since 1996, distributing consumption permits for its maximum allowable use under the Montreal Protocol.

A.1.3 SO_2 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 system that regulates SO_2 emissions, 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.[e] The first phase of sulfur dioxide emissions reductions was started in 1995, with a second phase of reduction initiated in the year 2000.

In Phase I, individual emissions limits were assigned to the 263 most SO_2-emissions intensive generating units at 110 plants operated by 61 electric utilities, and located largely at coal-fired power plants east of the Mississippi River. 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, on an annual basis, a specified number of allowances related to its share of heat input during the baseline period (1985-87), plus bonus allowances available under a variety of special provisions.[f] Cost-effectiveness was promoted by permitting allowance holders to transfer their permits among one another and bank them for later use.

Under Phase II of the program, beginning January 1, 2000, almost all electric power generating units (all units with capacity greater than 25 MW) were brought within the system. 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 years allowances, indexed to subsequent inflation (and a requirement that excess emissions be offset the following year).

In 2005, the Environmental Protection Agency further reduced the programs emission cap by promulgating the Clean Air Interstate Rule. This rule in effect reduced the denomination of the emissions allowances that will be issued starting in the year 2010, but did not affect current allowances that firms might bank for future years. This had the effect of encouraging firms to reduce their emissions without undermining the value of banked allowances.

A robust market of SO_2 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 (Carlson, Burtraw, Cropper, and Palmer 2000). Although the program had low levels of trading in its early years (Burtraw 1996), trading levels increased significantly over time (Schmalensee *et al.* 1998; Stavins 1998; Burtraw and Mansur 1999; Ellerman et al. 2000). The program has also had a significant environment impact: SO_2 emissions from the power sector decreased from 15.7 million tons in 1990 to 10.2 million tons in 2005 (U.S. Environmental Protection Agency 2005). Because the program allowed firms to bank allowances, SO_2 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 (Rose 1997; Bohi 1994). Other analysis suggests that this has not been a major problem (Bailey 1996). Similarly, in contrast to early assertions that the structure of EPAs small allowance auction market would cause problems (Cason 1995), the evidence indicates that this has had little or no effect on the vastly more important bilateral trading market (Joskow, Schmalensee, and Bailey 1998).

The allowance trading program has apparently had exceptionally positive welfare effects, with benefits being as much as six times greater than costs (Burtraw, Krupnick, Mansur, Austin, and Farrell 1998). The large benefits of the program are due mainly to the positive human health impacts of decreased local SO_2 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 programs enactment in 1990.

Furthermore, the geographic distribution of emissions reductions has been fairly equitable. The program did not result in significant regional shifts in pollution (Kinner and Birnbaum 2004). In fact, the largest emissions reductions occurred in Midwestern states where emissions were high and emissions reduction costs were low (Ellerman et al. 2000). Poor communities were not disproportionately affected by emissions from the program (Coburn 2001).

Ever since the programs initiation, downwind states, in particular, New York, have been somewhat skeptical about the effects of the trading scheme, driven by concern that the allowance trading program was failing to curb acid deposition in the Adirondacks in northern New York State (Dao 2000). The empirical evidence indicates that New Yorks 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.

Of course, such comparisons ignore the fact, emphasized above, 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 (Burtraw and Mansur 1999; Swift 2000).

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.[g] This Regional Clean Air Incentives Market (RECLAIM) program set an aggregate cap on NO_X and SO_2 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 percent by 2003.

Trading under the RECLAIM program was 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. In this way, this geographically-differentiated emissions trading program represents one step toward an ambient trading program. Second, temporal restrictions in the program[h] may not have provided 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 problem became particularly severe during the 2000-2001 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.[i]

By June of 1996, the participants in the RECLAIM program had traded more than 100,000 tons of NO_X and SO_2 emissions, at a value of over $10 million (Brotzman 1996). 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 percent between 1994 and 2004, and SO_X emissions fell by 50 percent over the same time period (South Coast Air Quality Management District 2006). Furthermore, the program has reduced compliance costs for regulated facilities. One prospective analysis predicted 42 percent cost savings, amounting to $58 million annually (Anderson 1997).

A.1.5 NO_X Budget Program

Under the U.S. Environmental Protection Agency 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 (OTC) regulations of the 1990 Amendments to the Clean Air Act. This program established the Northeast Ozone Transport Region, which included three geographic zones.[j] Emissions caps from 1999-2003 were 35 percent of 1990 emissions in the Inner Zone, and 45 percent in the Outer Zone (Farrell et al. 1999).

The program was modified in 2003, when a new rule (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 .49 million tons in 2006. The trading program initially covered emissions from 1,000 large stationary combustion sources, but expanded under the SIP Call to include over 2,500 sources (Market Advisory Committee 2007).

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 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 percent have been estimated for the period 1999-2003, compared to a base case of continued command-and-control regulation without trading or banking (Farrell *et al.* 1999). Due to delays in the implementation of the program and the allocation of allowances, prices were volatile in the first year of trading. But 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 (Farrell *et al.* 1999).

A.2 CO_2 and Greenhouse Gas Cap-and-Trade Systems

Although cap-and-trade has proven to be a successful means to control conventional air pollutants, cap-and-trade has a very limited history as a method of reducing CO_2 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. CO_2 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 Californias Greenhouse Gas 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 entered into force in 1994 with 190 countries as parties, and established a general longterm environmental goal of stabilizing greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system (Article 2). 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 FCCCs objective by setting ambitious, nearterm quantitative targets for industrialized countries.

The agreement was intended to result in industrialized countries' emissions declining in aggregate by 5.2 percent below 1990 levels by the year 2012. In 2001, industrialized countries began to ratify the Kyoto Protocol. Despite the withdrawal of the United States and Australia, the Kyoto Protocol entered into force in 2005, having met the dual requirements that 55 Annex I countries had ratified the agreement and that they jointly accounted for 55 percent of 1990 Annex I emissions.

The Protocol includes provision for costeffective 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 which countries can employ. There are few details available on the international cap-and-trade system laid out in Article 17,[k] but that article together with the Kyoto Protocols 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.

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 CO_2 allowances. This system, which was adopted in 2003 and became active with a pilot phase in 2005, covers about half of EU CO_2 emissions in a region of the world that accounts for about 20 percent of global GDP and 17 percent of world energy-related CO_2 emissions (Ellerman and Buchner 2007). The 11,500 emitters regulated by the *downstream* program include large sources such as oil refineries, combustion installations over 20 MWth, 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 (Ellerman and Buchner 2007).

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 2008 to 2012, and a series of subsequent phases. Penalties for violations increase from 40 Euros per ton of CO_2 in the first phase to 100 Euros in the second phase. Although the first phase allows trading only in carbon dioxide, the second phase potentially broadens the program to include other GHGs.

The process for setting caps and allowances in member states is decentralized (Kruger, Oates, and Pizer 2007). 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, and these caps are subject to review by the European Commission. This created incentives for individual countries to try to be generous with their allowances to protect their economic competitiveness (Convery and Redmond 2007). 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, overall had exceeded emissions by about 4 percent of the overall cap. This led, as would 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 (Convery and Redmond 2007). This volatility has been attributed to the absence of good emissions 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 (Market Advisory Committee 2007). 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 (Ellerman and Buchner 2007).

The intention 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 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 emissions allowances (95 percent and 90 percent, 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 $40 billion, compared with about $5 billion under the U.S. SO_2 allowance trading program (Ellerman and Buchner 2007).

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 having played a role; and it is 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 (Ellerman and Buchner 2007).

In its first two years of operation, the EU ETS has produced a functioning CO_2 market. Weekly CO_2 trading volumes have typically ranged between 5 million tons 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 systems 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 CO_2 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 percent each year until it reaches an ultimate level 10 percent below current emissions in 2019. This goal will require a reduction that is approximately 35 percent below business-as-usual, or equivalently, 13 percent below 1990 emissions levels.

Because RGGI only limits emissions from the power sector, incremental monitoring costs are low, because U.S. power plants are already required to report their hourly CO_2 emissions to the Federal government (under provisions for continuous emissions monitoring as part of the SO_2 allowance trading program). The system sets standards for certain categories of CO_2 offsets, and limits the number and geographic distribution of offsets, in contrast to what is proposed above. The program requires participating states to auction at least 25 percent of their allowances and to use the proceeds for energy efficiency and consumer-related improvements. The remaining 75 percent 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 performance. 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 inter-connected nature of electricity markets (Burtraw, Kahn, and Palmer 2005). Second, the program is downstream for just one sector of the economy, and so very limited in scope. Third, despite considerable cost uncertainty, a true firm safety-valve mechanism was not adopted. Instead, there are trigger price that allow greater reliance on offsets and external credits in the expectation that these can increase supply. Fourth, as mentioned above, the program limits the number and geographic origin of offsets.

A.2.4 Californias Global Warming Solutions Act

Californias 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 Californias 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 level using the most cost-effective policies possible, a requirement that has caused considerable debate and some confusion.

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, that they must maximize environmental and economic benefits in California, and that they must account for localized economic and environmental justice concerns (Market Advisory Committee 2007). This mixed set of objectives potentially interferes with the development of a sound policy mechanism (Stavins 2007).

To explore the potential role of market-based tools, Governor Schwarzenegger asked the California Secretary for 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 the implementation of a cap-and-trade program in California (Market Advisory Committee 2007). The report suggests a gradual phase-in of emissions 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 out of state surrender allowances to cover the out-of-state emissions 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 (Market Advisory Committee 2007).

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