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Cap-and-Trade for Climate Change Policy: Lessons Learned from Emissions Trading in the US and the UK

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CAP-AND-TRADE FOR CLIMATE CHANGE POLICY: LESSONS LEARNED FROM EMISSIONS TRADING IN THE US AND THE UK

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Abstract

Market-based instruments, particularly cap-and-trade programs, have been the focus of attention in environmental policy in recent years. The success of the US Acid Rain Program, dubbed the “grand policy experiment,” has inspired governments across the globe to turn to the market for the purpose of controlling pollution. This paper attempts to formulate a policy recommendation for a future domestic cap-and-trade program for climate change policy in the United States. The paper describes and evaluates the US Acid Rain Program and the UK Emissions Trading Scheme in detail in order to gain insight into two relatively successful experiences with cap-and-trade. The paper then examines lessons that can be drawn from both programs in conjunction with existing economic research on greenhouse gas trading in order to determine the precise design of a successful future climate change trading scheme for the US. The study concludes that a multiphase, upstream hybrid cap-and-trade program with a revenue-raising auction will produce least-cost reductions in carbon dioxide emissions and contribute to the mitigation of global climate change.

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"If it is feasible to establish a market to implement a policy, no policy-maker can afford to do without one. Unless I am very much mistaken, markets *can* be used to implement any anti-pollution policy that you or I can dream up." *J.H. Dales, 1968*

Introduction

In recent years, policymakers have been focusing on the creation of markets and the trading of pollution rights for the purpose of controlling environmental problems. The flexibility and cost savings associated with market-based environmental policy instruments have allowed policymakers to control pollution in an efficient manner. As a result of the success of the US Acid Rain Program, increased attention has been given to cap-and-trade schemes, defined as market-based instruments that allow firms to trade or bank emission discharge permits in order to achieve a specific environmental objective. The implementation of a cap-and-trade scheme requires the pollution control agency to determine a desired target reduction level as well as the associated level of allowable emissions. The agency then establishes an allocation process for permits, distributing just enough permits to meet the emissions target. Economists note the advantages of emissions trading in theory as being cost-effectiveness, flexibility for polluters, and static and dynamic efficiency, to name a few.

Some emissions trading began to take form in the 1970s in the US with four distinct policies that fell under a credit system: the offset policy, the bubble policy, banking, and netting—all of which will be discussed later in the paper. Still, these policies were subject to substantial regulation by the government. It was not until 1990 that significant flexibility in policy was introduced in the US with the first wide-scale cap-and-trade program.

Title IV of the US Clean Air Act of 1990, also known as the US Acid Rain Program, has an overall purpose to reduce sulfur dioxide emissions from coal- and oil-fired electricity generation plants across the country, in order to prevent the adverse effects caused by acid deposition. Acid precipitation forms when SO_2 and NO_x react in the atmosphere, primarily with water vapor, to form acidic compounds that are then deposited on to the ground in wet or dry form. SO_2 is the primary precursor for acid rain, and the one that this paper will focus on. It is emitted into the atmosphere primarily from burning sulfurous fuels, especially coal, from power stations and other combustion plants; in the US, approximately 70% of annual SO_2 emissions come from the electric power industry.[1] Acid rain has a number of negative impacts, including the acidification of lakes and streams, impaired visibility in national parks, the creation of respiratory problems in people, weakened forests, and the degradation of monuments and buildings.[2] The domestic issues caused by acid deposition are, however, only part of the problem.

Acid deposition is a known transboundary pollutant problem as a result of windfall patterns; sulfuric acid is deposited not only in the US, but is also carried across the Canadian border. The issue was first brought up in 1977, when the Canadian government called for immediate negotiations between the two countries concerning environmental policy. A scientific fact-finding committee concluded in 1980 that the US produced 70-80% of the pollutants that moved across the border to Canada, whereas Canada's production of pollutants that were deposited in the US was fairly small in comparison. Unfortunately, cooperation between the two countries did not make much progress in the 1980's, as the Canadian government made demands for rather large reductions of SO_2 emissions (usually around 50%) and President Reagan subsequently rejected every demand. It was not until 1990 that talks between the two countries picked up again, and the US Acid Rain Program was signed into law.

Title IV of the 1990 US Clean Air Act called for a cap-and-trade system consisting of a 10 million ton reduction in SO_2 emissions from 1980 levels by the year 2000. The program is composed of two phases, with reductions enforced through the annual issuance of tradable emissions permits, or "allowances." Each allowance permits a holder to emit one ton of SO_2 in a particular year or any subsequent year; in other words, allowances may be "banked" for future use, although they may not be borrowed from the future. The last main feature of the program includes the requirement for polluters to install continuous emissions monitoring equipment in order to ensure compliance with the program.

Overall, the US Acid Rain Program has been hailed as being extremely successful and economically efficient in its emission reductions.[3] As of 2006, SO_2 emissions have been reduced by more than 6.3 million tons from 1990 levels.[4] The market for allowances has proven to be efficient and competitive, and developed rather quickly, establishing itself by 1994.[5] Allowance prices were also lower than anticipated and transmitted the reduced value of marginal abatement quickly and efficiently to firms contemplating more costly abatement measures, thus minimizing the amount of unnecessary costly abatement.[6] In addition, ex post studies have found that the program has achieved results at a significantly lower cost than expected.[7] The success of the program lead to much more interest in cap-and-trade, including in the United Kingdom, where the government implemented a national cap-and-trade program for greenhouse gas emissions in 2002 as part of their Climate Change Programme.

The UK's Climate Change Programme has three parts to it, with one of those parts being a cap-and-trade scheme for a basket of greenhouse gas emissions, measured in terms of CO_2 equivalent. CO_2 emissions have increased roughly 30% since the year 1750[8], and to understand the problem with this increase, one must be familiar with the general climate change problem. The climate system is driven by energy from the sun, which enters the atmosphere in the form of radiation. The greenhouse gases (which include CO_2, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride) absorb this radiation and thus retain heat. The problem is that emissions have increased dramatically over time, as previously stated, making it difficult for energy to be released back into space and thus creating a build-up of greenhouse gases. In order to make up for the added energy in the atmosphere, the earth's climate adjusts itself—this is known as the "enhanced greenhouse gas effect." In order to adjust itself, the earth experiences an increase in the global mean temperature, increases or decreases in precipitation, and an increase in extreme weather events. CO_2 is arguably the most important greenhouse gas as it accounts for 60% of the enhanced greenhouse gas effect and has a lifetime of approximately 100 years.

The UK's Emissions Trading Scheme was the first large-scale greenhouse gas trading program. As part of the Kyoto Protocol, the UK agreed to reduce its emissions by 12.5% below 1990 levels by 2012; however, internally, they decided on a target of 20% below 1990 levels by 2010. The UK's Emissions Trading Scheme was launched in April 2002 as part of their Climate Change Programme, with the objectives of achieving a significant amount of emission reductions in an economically efficient manner, and also of enabling businesses to gain experience in the practice of emissions trading in order to prepare them for the upcoming EU trading program. The UK's program was voluntary, freely allocated allowances that they allowed to be banked, and ran from January 2002 to

December 2006. As of 2008, the government projects that the nation will meet its Kyoto target of a 12.5% reduction by 2012. Direct participants have reduced their greenhouse gas emissions by over 7.2 million tonnes against their baselines at the start of the scheme in 2002.[9] The market has also proven to be quite liquid with broad participation—on average over 176,000 allowances were traded per month in the first three years of the scheme.[10] Lastly, there is also evidence of static efficiency and the attempt to satisfy the equimarginal principle in the program given by the fact that firms with low marginal abatement costs tended to sell allowances to firms with high marginal abatement costs.[11] While evaluations of the US and UK programs have provided positive results, what does this mean for the future of cap-and-trade?

This study on cap-and-trade schemes will have two main areas of concentration: evaluations of the successes and failures of two wide-scale trading programs—the US and the UK programs, and lessons that can be drawn from those evaluations for a future national US greenhouse gas cap-and-trade program. When I compose possible lessons for a future program, I will ask the following: What can be learned from the already established US and UK programs to help form a national US greenhouse gas cap-and-trade program? In addition, what does economic theory imply for an efficient greenhouse gas trading program? In particular, what design options should be considered, in terms of voluntary or compulsory participation, distribution of permits, the extent of monitoring, the sectors covered by the scheme, and more.

The remainder of this paper will be structured as follows: In Chapter One, I will describe the US Acid Rain Program in detail, followed by an evaluation of the program structured around economic efficiency. Chapter Two will examine the UK Emissions

Trading Scheme, describing the program in detail and evaluating it. In Chapter Three, I will analyze several design aspects of emissions trading programs in general, while also discussing lessons learned from the designs of the US and UK programs. I will conclude this chapter with my presentation of a possible greenhouse gas cap-and-trade scheme for the US, followed by a conclusion.

Chapter One: The US Acid Rain Program

Chapter One will focus on the US Acid Rain Program, with the purpose of investigating the effectiveness of a domestic cap-and-trade scheme in the US, and, in particular, which elements of the program's design made it successful. The chapter is structured as follows: Part I will discuss the history of acid rain legislation in the US, Part II will describe the Acid Rain Program in detail, and Part III will discuss evaluations of the program based on economic studies.

Part I: The History

In order to understand the context in which Title IV of the 1990 Clean Air Act Amendments was passed, it is necessary to review the history of acid rain legislation in the US. During the 1970s and 1980s, the majority of SO_2 emissions was generated from thermal power plants, particularly those located in the Midwestern part of the US that were also quite old and large, and burning medium- or high-sulfur coal.[12] Scientists working for the Ontario government brought attention to the problem in the 1970s by showing that lakes were being acidified in a county north of Toronto. Environment Canada scientists conducted further meteorological research that indicated that the acid rain falling in Eastern Canada was not all from domestic sources, but rather it was due to the long-range transport of pollutants from the US.

The 1970 Clean Air Act was the first major piece of environmental legislation put into place by the US, and it provided the government with increased regulation over emissions. It established four major systems: NAAQS, SIPS, NSPS, and NESHAPS. NAAQS set up a system of National Ambient Air Quality Standards for "criteria" pollutants, including SO_2, which set limits in order to protect public health and welfare. SIPs, or State Implementation Plans, were also set up in order to provide a description of how individual states intended to comply with the Clean Air Act requirements and maintain the NAAQSs, as well as to provide a means of regulating existing stationary sources' air emissions. NSPS, or New Source Performance Standards, placed regulations on new units, and NESHAPS, or National Emission Standards for Hazardous Air Pollutants, were set up to ensure protection of public health and to prevent adverse environmental effects of select air pollutants.

Analysis done by Portney (2007) concerning the 1970 program indicates that it was not particularly successful, mostly because it provided no incentive for technological innovation.[13] To obtain local ambient standards, plants would simply build taller emissions stacks; unfortunately, these actions merely passed the pollution problem on to geographically distant areas. Other problems with this initial act included little flexibility for polluters to modify their production processes in order to achieve reductions in emissions, and the overly expensive nature of the scheme, due partly to the specified pollution-control equipment required for new plants. Further analysis also shows that the Clean Air Act created a gap between the old and new plants, since new plants had different performance standards.[14] While the goal of these different performance standards was to encourage old power plants to retire their operations, they instead created an incentive for old plants to stick around longer, since replacing an old plant with a new plant was a relatively expensive process.[15]

The 1977 Clean Air Act Amendments were introduced apparently in response to new concerns raised by environmental groups, as well as because of the inability of many states to reach their emission reduction targets.[16] The Amendments extended the deadline for meeting emission reduction targets to 1982, and they also set new requirements for new coal-fired plants. The new requirements included some flexibility by stating that new plants had to have an emissions rate less than or equal to 1.2lb of SO_2 per million Btu of fuel burned, and either a) remove 90% of potential SO_2 emissions, or b) remove 70% of SO_2 emissions and operate with an emissions rate of less than 0.6lb of SO_2 per million Btu of fuel burned. The Amendments still included heavy regulation, however, including certain technology requirements. The 1977 Amendments included a new system, dubbed "PSD" or Prevention of Services Deterioration, which applied to new major sources or major modifications at existing sources, for pollutants whose sources were located in attainment or were considered unclassifiable within NAAQS. Part of the PSD required the installment of BACT—the Best Available Control Technology. Technology requirements also existed for new sources in nonattainment areas—these sources were required to utilize LAER, the Lowest Achievable Emissions Rate. These requirements gave plants little flexibility and also put huge expenses at their doorsteps.

During the latter part of the 1970s, the government recognized the need for more flexibility within their strongly regulated framework in order to achieve their clean air objective.[17] Flexibility began with the Offset Policy in 1976 that allowed new emissions sources to establish themselves in nonattainment areas, as long as the sources agreed to pay for offsetting emission reductions at other places in the region by purchasing Emission Reduction Credits (or ERCs). The goal of the Offset Policy was to deal with the problem involving the establishment of new or expanding sources while still meeting current ambient standards as quickly as possible. The advantage of the Offset Policy was that regional air quality would be improved since emissions would decrease even when new sources began operations after their purchasing of ERCs. New flexibility was developed further with the "Bubble Policy" in 1979, which allowed utilities with multiple emission points to be regulated as a group, rather than requiring individual reductions for each source. The Bubble Policy was extended with the first emergence of an emissions trading idea, allowing for the purchase of ERCs from other plants as an alternative means to directly regulating pollution. The policy also attempted to satisfy the equimarginal principle—polluters were allowed to allocate abatement in the most efficient way among units.

By 1986, a credit-based trading scheme was put into place for seven pollutants affecting local air quality. The system set up 247 control regions across the US coexisting with a command-and-control regulation of technology-based standards administered at the federal and state levels. An Emission Reduction Credit linked the Offset and Bubble policies with two new policies of Netting and Banking within the program. Netting allowed currently expanding, new plants to escape the new source review requirements, provided that the plant offset any increase in emissions with the appropriate amount of credits, and that the increase was negligible. Banking allowed plants to store permits for future use, although borrowing permits from the future was not allowed.

The 1986 program had notable successes and failures, all of which influenced the design of later schemes. Analysis showed that the program achieved cost savings of $10 billion, with thousands of cost saving trades being completed.[18] In addition, netting proved to be a popular option among polluters[19], achieving between $525 million and $12 billion in cost savings.[20] Despite the improvements in cost savings, however, the program ended up having quite a few problems. Notably, the market was not really efficient—most trades were completed internally because of the lower transactions costs, and polluters found it difficult to locate buyers and sellers.[21] In addition, the use of the Offset, Bubble, and Banking opportunities was limited, even though sufficient cost savings could have been achieved through the use of these programs.[22] Most likely, the inefficient market resulted from the lengthy, complex, and expensive procedures required in order to gain approval for a trade. In the end, more work needed to be done to create an efficient and successful emissions trading scheme.

During his election campaign of 1988, George H.W. Bush advertised himself as the "Environmental President", and he made it known that he was interested in marketplace innovations to solve environmental problems. Once he was elected, the Project 88 Report, sponsored by Senators Timothy Wirth and John Heinz, was conducted at Harvard University's Kennedy School and discussed a variety of market-based approaches to the problem of acid rain. By June 12, 1989, the Bush Administration's Clean Air Proposal was announced in general terms, and the draft legislation was released on July 21st. After approvals by the Senate and the House, President Bush signed the 1990 Clean Air Act Amendments into law on November 15, 1990.

Part II: The Program

The legislation of Title IV of the 1990 US Clean Air Act Amendments stated its purpose as to "reduce the adverse effects of acid deposition through reductions in annual emissions of sulfur dioxide of 10 million tons from 1980 emission levels."[23] Affected sources would be required to reduce emissions by specific deadlines, and they could do so with some flexibility. As stated in the legislation, compliance with emission limitations could be achieved "through alternative methods…provided by an emission allocation and transfer system."[24] In other words, the Acid Rain Program is an emissions trading scheme.

As previously stated, the type of emissions trading scheme employed under Title IV is known as a cap-and-trade system. There is an aggregate cap placed on SO_2 emissions from electric generating plants of around 9 million tons per year from the year 2000 onwards, with the final cap of 8.95 million tons being imposed in 2010. The idea of having an aggregate cap was a fundamental difference from earlier acid rain programs—different polluters can abate in varying amounts, depending on their costs of abatement, as long as total emissions are less than or equal to the aggregate cap. An aggregate cap with a trading system gives polluters much more flexibility as to how and where they decide to reduce their emissions, rather than having regulators determine a specific reduction for each individual source. The aggregate cap results in the annual reduction of 10 million tons of SO_2 emissions from 1980 levels, and this goal is being met by many plants through the use of the allowance system.

The initial allocation of allowances is done on a grandfathered basis, which means that past emissions in a given baseline year determine the amount of allowances each unit should be allocated. For the Acid Rain Program, allowances are allocated based on the average fossil fuel consumption between 1985-1987 at an emission rate of 2.5lb of SO_2 per million Btu of fuel input for Phase I, and an average of 1.2lb SO_2 per million Btu of fuel input for Phase II. At the end of each year, each source needs to hold a number of allowances equal to its annual emissions, and it is never allowed to have its emissions exceed ambient air quality standards for public health, no matter how many allowances it currently holds. Flexibility comes from permit trading, where allowances can be bought or sold by sources and even by corporations, brokers, municipalities, or environmental groups. Besides buying and selling allowances, banking is also an option so that utilities can store allowances for future use if necessary.

In addition to obtaining allowances via initial allocations and trading, the EPA also holds an annual allowance auction in late March. As discussed earlier, the EPA creates an allowance reserve by buying 2.8% of the allocated allowances from utilities, and utilities are paid the price that the allowances pick up at the auction (thus, the auctions are zero-revenue for the EPA). The auctions also allow for private holders to sell their allowances if they so desire. The way that a typical auction works is bidders submit sealed offers for both the amount and type of allowances they want. Bidders can submit offers for allowances in the spot market, which can be used in the same year or banked for the future. In contrast, they can submit offers for allowances in the forward market, which can only be used after 7 years in the future. In addition to designating the amount and type of allowances they need, bidders must also write down the maximum price they are willing to pay for the allowances, or the demand price. The supply price of allowances from the EPA reserves is always zero, while private suppliers determine the minimum prices that they would like to offer their allowances for. The supply and demand prices are then ranked in ascending order, with the starting points being the lowest supply and demand prices. In the end, the lowest supply prices are linked with the highest demand prices; so bidders pay the price they are willing to pay for the allowances. The process usually starts with the EPA allowances being sold first at the lowest supply prices, and continues until one of the following occurs: all of the allowances are sold, the minimum supply price exceeds the maximum demand price, or all bids are used up.

The purpose of the auctions is to obtain a price signal, as well as to create a way for utilities to purchase allowances in case they cannot obtain them by any other means.[25] The EPA also establishes direct sales, with the thought being that there is a possibility of existing utilities attempting to reduce competition by making it difficult for new independent power producers to enter the market.[26] Thus, the EPA wants to ensure that new plants would be able to purchase allowances if they needed them.

Apart from the basic form of the Acid Rain Program, there are a few distinct provisions that were added to the legislation that are worth mentioning, notably for Phase I or "Table A" units. "Table A" units, as they are commonly known, are the 263 dirtiest large generating units who were required to reduce emissions by roughly 3.5 million tons per year between the years 1995-1999. Phase II, which began in 2000, set limits for virtually all fossil-fueled electric generating plants above 25 MW capacities. Although there were over 30 different special provisions added to the legislation for Phase II units, it is the substitution and extensions provisions that are relevant to this study. The substitution provision states that sources "may include…a proposal to reassign, in whole or in part, the affected unit's sulfur dioxide reduction requirements to any other unit(s) under the control of such owner or operator."[27] In other words, Table A units may instead choose to have their allowances allocated to other units, with the allowances based on the historic emissions of the new unit. The extensions provision allows units to "petition the Administrator…for an extension of two years of the deadline…to qualify for such an extension, the affected unit must either employ a qualifying Phase I technology, or transfer its Phase I emissions reduction obligation to a unit employing a qualifying Phase I technology."[28] The point of this provision clearly is to provide an incentive for units to install flue-gas desulfurization facilities, otherwise known as "scrubbers." This facility essentially removes the sulfur from the flue-gas, and it is an alternative to switching to low-sulfur coal. If units agree to install the relatively expensive facility, they are essentially granted bonus allowances.

In order for Title IV to have had the potential of being successful, significant monitoring and enforcement policies needed to be enacted. The EPA records all transfers of allowances through an allowance tracking system. The system is built on the transfer forms that are required from both parties involved in the trade. In addition, the EPA also keeps track of units that emit more than the number of allowances they hold through continuous monitoring equipment that most plants are required to install. Compliance with the program is determined at the end of each year, with a 30-day grace period at the beginning of the next calendar year for plants to cover any other emissions. If a plant is found to have not complied with emissions standards, they are fined $2,000 (in 1990 $)[1] per excess ton of emissions, and it is required that the excess be offset in the following year. Thus, polluters have significant incentive to comply with the program.

Part III: Evaluation

Perhaps one of the more obvious questions to ask regarding the US Acid Rain Program is whether or not it has actually succeeded in reducing SO_2 emissions. As of

[1] This number has been adjusted for inflation over time. The fine was $3,273 in 2007.

2007, annual SO_2 emissions had fallen below the long-term emissions cap of 8.95 million tons (to be met by 2010) for the first time—total SO_2 emissions from 3,536 affected electric generating units stood at 8.9 million tons in that year.[29] It is estimated that, by 2005, reductions from Phase I units accounted for roughly 57% of total SO_2 emission reductions, while reductions from Phase II units accounted for roughly 14% of total SO_2 emission reductions.[30] Ellerman (2005) estimates a reduction of approximately 4 million tons in the first year of the program alone, and he put together a figure (shown as Figure 1.1 in this paper) to illustrate the difference between SO_2 emissions during the trading program and what emissions would have been in absence of a program (the counterfactual).[31] One can see how actual emissions declined sharply with the start of the program in 1995 and how much lower these emissions are from the counterfactual emissions. It is clear that the actual emissions line is tending toward the cap, as it indeed has done as of 2007.

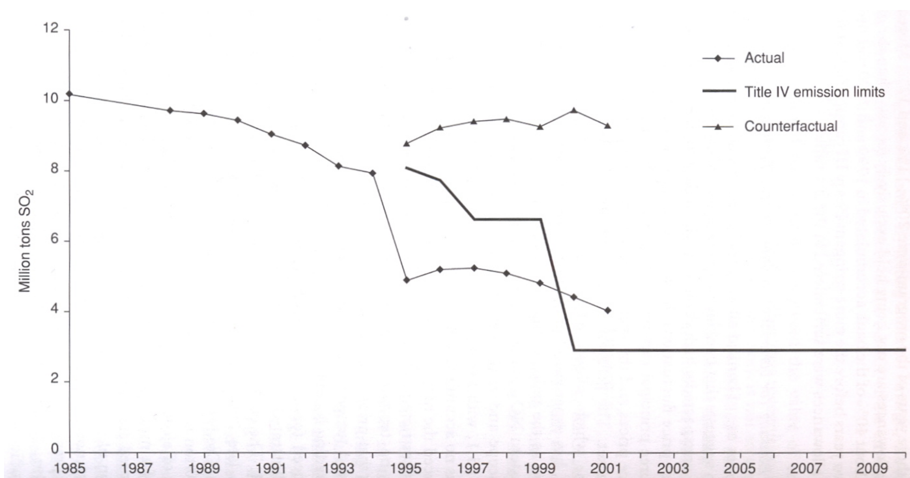

Figure 1.1[32]

In addition, while SO_2 emissions have decreased by roughly 43% since 1990, heat input for electricity generation has increased significantly, meaning that reductions in

SO_2 emissions took place despite a growing demand for electricity. Figure 1.2 illustrates SO_2 emission reductions alongside the rise in heat input and electricity generation.

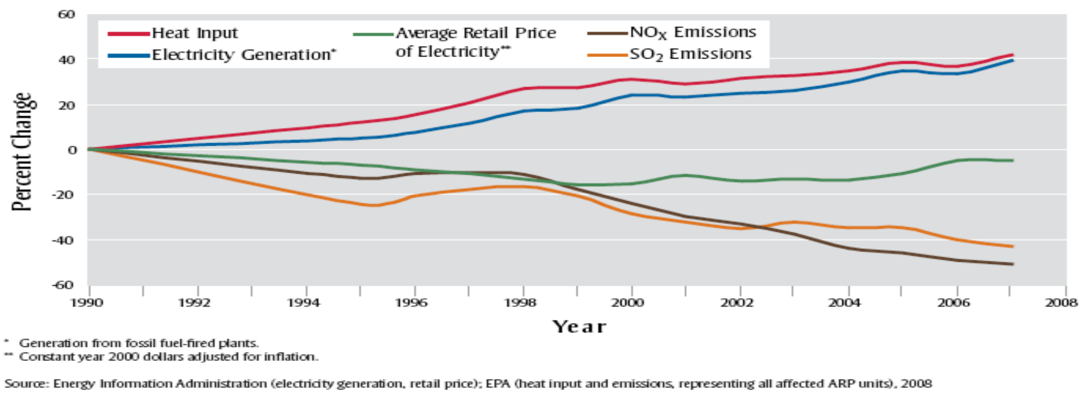

Figure 1.2[33]

These successful changes are certainly notable in terms of numbers, but scientists have also concluded that the reductions have led to improvements in the health of the environment. Over the course of the program, scientists have made use of long-term monitoring equipment, such as CASTNET, or Clean Air Status and Trends Network, and NADP/NTN, or National Atmospheric Deposition Program/National Trends Network. These two pieces of equipment are used to monitor temporal and spatial trends in regional air quality and acid deposition. As of 2007, the data collected by the monitoring equipment has shown that the reduction in SO_2 emissions from the power industry has indeed improved air quality. In addition, wet sulfate deposition has also declined significantly since the adoption of the Acid Rain Program in the Ohio River Valley and northeastern United States. It is estimated that public health benefits from emission reductions have exceeded program costs by a margin of more than 40:1.[34] Lastly, sulfate concentrations in lakes and streams across the major regions of the US have decreased substantially between 1990 and 2005.

One of the main concerns regarding the implementation of an emissions trading scheme to combat SO_2 emissions was the environmental effect on certain "hot spots"—mainly the northeastern part of the United States. SO_2 is not a uniformly mixed pollutant, meaning that the damage of where pollution occurs depends upon where the emissions occur. Because of wind patterns, emissions by sources in the Midwest cause large amounts of acid deposition in the Northeast. The fear with the Acid Rain Program was that emissions would increase in the Ohio River Valley as a result of trading and this would cause negative health effects for the New England area. Fortunately, as Burtraw & Mansur (1999) have found, increases in the Ohio River Valley imply decreases in other states which also have an impact on the Northeast, thus trading actually led to improvements in air quality in the Northeast.[35] It is important to note that these initial concerns will not be relevant for any future trading programs regarding climate policy, which will be discussed later in the paper. Since greenhouse gases are considered to be uniformly mixed pollutants, the locations of damage do not depend upon the locations of emission sources.

While the amount of emission reductions taking place has been impressive, and the environment is certainly benefiting from the program, it is difficult to tell the true effectiveness of the emissions trading scheme without comparing actual emissions with a hypothetical emissions rate under a Command-and-Control scheme. A counterfactual comparison is necessary since it is impossible to tell whether reductions in emissions occurred because of the Acid Rain Program, or because of other outside factors (such as some units switching to low-sulfur coal). In their analysis of the success of the Acid Rain Program, Ellerman et al. (2000) make use of both a simple and an econometrically estimated counterfactual in order to make a plausible comparison between emission reductions with and without the emissions trading scheme.[36] The authors make the argument that the econometrically estimated counterfactual is a more accurate measure, and so they subsequently run a "fixed effects" linear regression in order to estimate the reduction in SO_2 emissions attributable to Title IV. They accomplished this by calculating the difference between aggregate estimated counterfactual emissions and actual emissions. The results from the regression analysis indicate that the aggregate reduction attributable to Title IV was about 4 million tons in each of the first three years of Phase I.[37] Based on the EPA's measurement of emission reductions over the years and the econometric analysis done by Ellerman et al. (2000), it can be concluded that the US Acid Rain Program has succeeded in its goal of achieving a significant amount of reductions in emissions.

At this point, it has been determined that using a market-based instrument as opposed to a Command-and-Control instrument for the control of SO_2 emissions in the US has worked out well. My main concern, however, has to do with the components of the cap-and-trade scheme that made the Acid Rain Program successful, or, if any, what components failed. A main point of focus is the allowance system—in particular, the efficiency of the allowance market and the determination of an allowance price.

Ellerman et al. (2000) present an excellent set of criteria for determining the efficiency of the allowance market, including the transparency of prices to buyers and sellers, low transactions costs, quick exploitation of arbitrage opportunities, and the engagement in emissions trading by buyers and sellers in order to lower compliance costs.[38] Overall, analysts have determined that, particularly since the middle of 1994, the allowance system has had a robust market with clear prices and low transactions costs.[39]

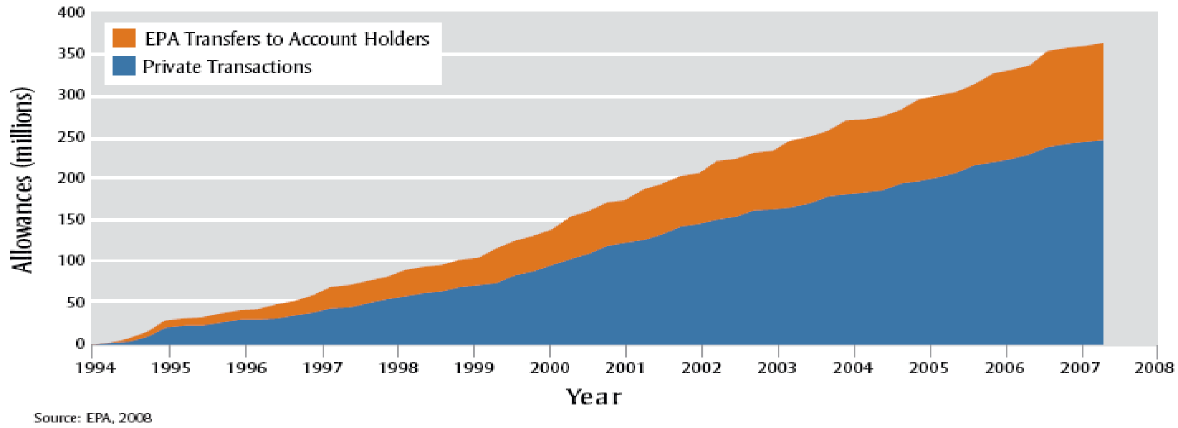

Figure 1.3[40]

Figure 1.3 shows the amount of allowances being traded each year. 1994 shows a substantial increase in trades in the private market (that is, the market outside of EPA auctions). It is probable that buyers and sellers were lacking information about a market-clearing price in the beginning of the program, which explains the low trading volume until 1994.[41] Burtraw & Bohi (1997) suggest that the promised benefits of allowance trading were not yet realized in the beginning of the program by utilities.[42] Statistics also show, however, that approximately 45% of the 1995 allowance issuance was used in order to pursue cost savings through the trading[43], and by March 1998, 20.3 million allowances were being traded privately, as compared to the 1.3 million being traded through the EPA auctions. Figure 1.3 clearly illustrates the increase in trading volume from the start of the program up until 2007. Recent data also shows that in 2007, there were 15.8 million allowances available for use from a combination of allocated allowances and banked allowances allocated in previous years. In that year, sources emitted approximately 8.9 million tons of SO_2, which was much less than the amount of allowances available.[44] It is possible that the large number of unused allowances could have resulted from technological innovation on the part of sources; if sources have invested in scrubbers or low-sulfur coal, SO_2 emissions would be less anyway, so the need for allowances would be smaller. In fact, the 2007 Acid Rain Progress Report does list scrubbers as a major factor in SO_2 emission reductions in that year. The Progress Report also states that future emission reduction requirements under CAIR (Clean Air Interstate Rule)[2] contributed to growing reductions in emissions, as well as the growing number of banked allowances in 2007.[45] Sources may have engaged in early compliance planning for CAIR, with an incentive to bank pre-CAIR vintage SO_2 allowances.

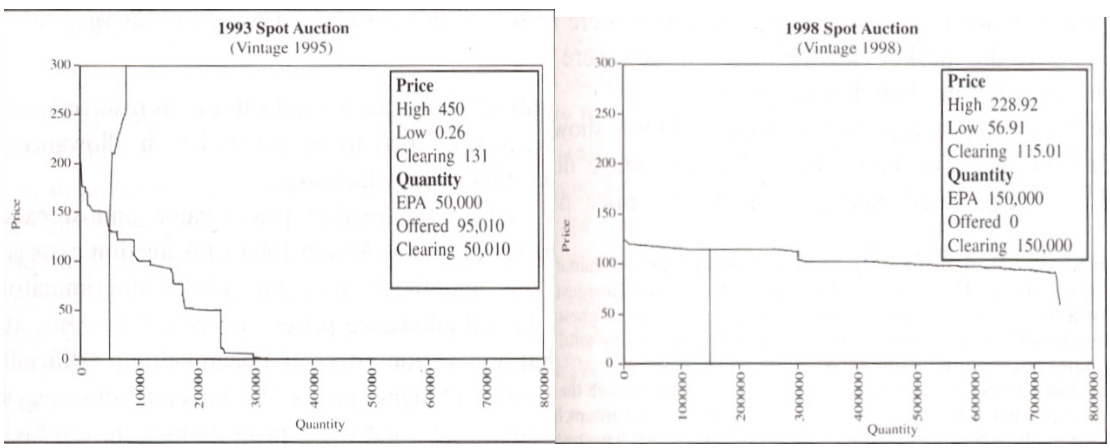

Figure 1.4[46]

In addition to an appropriate trading volume, analysis has shown that prices have converged so that the spread between the average bid price and the lowest winning bid in the annual auction has narrowed. This indicates a market that is closer to a market with one price, such as a perfectly competitive market, since a perfectly competitive market would have one universally known market price and no spread between bid and offer

[2] CAIR refers to a new rule issued by the EPA in 2005 that places a further cap on SO_2 and NOx emissions in the eastern U.S. to be achieved by 2015.

prices at the auction. Figure 1.4 shows two examples of the buyers' offer curve and the sellers' offer curve from the 1993 and 1998 spot auctions, with the point of intersection indicating a market-clearing price. It is clear from the graphs that the buyers' offer curve has flattened over time, which is consistent with the development of an efficient market of allowances.[47] Further evidence of an efficient allowance market comes from the fact that a futures market developed with a relatively low "convenience yield"—a "convenience yield" describes the benefit that results from holding a stock of allowances on hand.[48] A low "convenience yield" suggests that there was not much worry about being short on allowances in order to meet regulatory requirements.

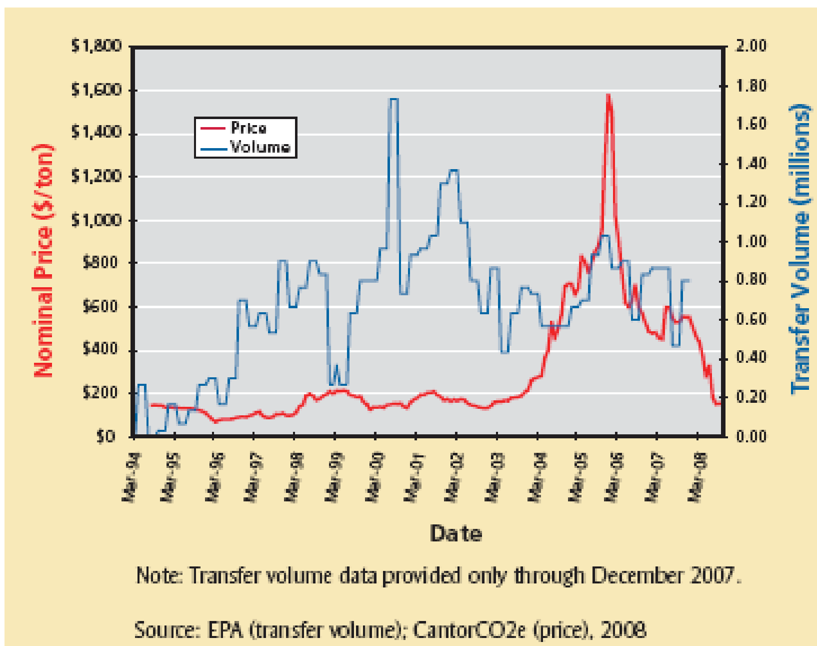

Figure 1.5[49]

One of the main causes for concern regarding the allowance market in the early stages of the program was the low price of allowances. Several estimates were put forth before the program was enacted which priced allowances between $250 and $300, on average, for Phase I.[50] In fact, allowances cleared a price of $131 at the first EPA auction, and prices declined steadily throughout the year, reaching a low of $70 in March 1996. Figure 1.5 illustrates the allowance prices from 1994 to 2008; from these statistics, it can be seen that allowance prices only reached the lower bounds of the EPRI estimate for Phase I (between $205 and $350) in 1998. The majority of analysts have attributed the low prices to an over-commitment in compliance in Phase I. Burtraw (1996) claims that the most important explanation for the low prices comes from changing market fundamentals in coal markets, rail transportation of coal, and equipment suppliers. In particular, prices in the coal and scrubber markets decreased during this time period, leading many utilities to invest in low-sulfur coal and the installation of scrubbers as a means of reducing emissions, as opposed to buying allowances to cover excess emissions.[51] It should be noted, however, that the low price of allowances in Phase I should not necessarily be considered a problem. Burtraw (1996) states that the program still generated tremendous cost savings despite the low prices and few amount of trades taking place.[52] Figure 1.5 also shows that prices rose dramatically beginning in March 2004, reaching a peak between March 2005 and March 2006, and declined again through March 2008. The most likely explanation for these price movements is uncertainty regarding the introduction of the CAIR legislation, which was issued on March 10, 2005.

On the other hand, there are several studies on the efficiency of the allowance market that have found that firms were not always meeting their reduction targets in a least-cost manner, as opportunities for cost savings were not necessarily realized. In particular, Carlson et al. (2000) finds that, during the first two years of Phase I, actual compliance costs exceeded the least-cost solution by $280 million in 1995 (in 1995 $) and $339 million in 1996 (in 1995 $).[53] It is possible that, in the beginning of the program, state public utility regulations deterred units from engaging in allowance transactions, due to the fact that firms were uncertain about how regulators would treat allowance transactions when setting regulated rates.[54] Certain studies, such as Rose (1997), suggest that public utility commission activities discouraged units from using the market in favor of investing in low-sulfur coal and the installation of scrubbers.[55] In general, econometric studies that have tried to show this discouragement have been conflicting. Arimura (2002) finds that generating units facing PUC regulations were more likely to rely on fuel switching for compliance as opposed to using the allowance market.[56] On the other hand, Bailey (1998) finds the opposite case—that PUC regulations had little to nothing to do with the decision of units to use the allowance market.[57] While outside influences on the efficiency of the allowance market in the first few years of the program are somewhat ambiguous, it is clear from earlier analysis that the market still became robust and efficient over time.

Perhaps one of the biggest surprises that came about during Phase I of the Acid Rain Program was the over-compliance on the part of polluters. There are two main reasons that have been given as to why over-compliance occurred: an over-investment in scrubbers prior to the program, and commitments to long-term low-sulfur coal contracts.[58] Apparently, many units made the decision to invest in flue gas desulfurization facilities in 1992 and 1993, mainly because they did not realize that allowance prices would end up being lower than the estimates. Even still, variable costs of scrubbing were approximately $65 per ton, which was lower than even the lowest price that allowances reached, making the scrubber a worthwhile investment. In addition, the expectation of higher allowance prices also induced units to enter into long-term low-sulfur coal contracts. In order to avoid the run-up of low-sulfur coal prices that might occur once Title IV took effect in 1995, polluters would agree to a contract that would lock in the price of coal. Some analysts found the over-compliance during Phase I to be a negative aspect of the program, stating that it caused the removal of potential bidders from the markets, which would further affect the market prices for allowances[59], and this is why many people state over-compliance (or, the excessive banking of allowances) as being the cause for lower than expected allowance prices. Ellerman & Montero (2002), however, examine the over-compliance later in the program and determine that more compliance is often required in the first stage of programs in order for marginal costs to be equalized over the two stages.[60]

The main goal of the Acid Rain Program was to lower the cost of compliance by providing polluters with the flexibility and incentive to abate in the least-cost way. Ellerman et al. (2000) discuss several pieces of evidence that suggest that participants have taken advantage of the cost saving opportunities provided during Phase I of the Acid Rain Program. First of all, as already discussed, there has been the emergence of an external allowance market. For those units who expect to face high marginal costs of abatement, the allowances provide a relatively cheap method of compliance. In addition, for many units—notably Phase II units who were not also Phase I units—the allowance market is the only way to take advantage of the lower abatement-cost opportunities provided in Phase I. As already noted earlier, there has been significant participation in the allowance market, which implies that polluters are taking advantage of the cost-saving opportunities provided by the program.

Besides the efficiency of the allowance market, it is also important to examine the dynamic efficiency of the program; that is, was there an appropriate amount of innovation that emerged as a result of the flexibility the program allows? The evidence suggests an answer of yes. Several utilities ended up switching from high-sulfur coal to the cleaner low-sulfur coal, and others chose to blend coals of varying sulfur content as a means of reducing average SO_2 emissions. Utilities have also been successfully encouraged to invest in scrubbers, mainly due to the subsidy available for those who decide to make such an investment. The rise in the use of scrubbers may also help explain the low prices of allowances in the market due to an increase in the supply of allowances.

There has also been a divergence between the control levels adopted by Phase I units and the control levels that would have been undertaken if there were no emissions trading scheme.[61] Many units used allowances in addition to those that were allocated to them, indicating an avoidance of higher abatement costs than those found elsewhere.

Lastly, there has been a convergence of the premium paid for low-sulfur coal with allowance prices, combined with related changes in abatement at Phase I units. In order to determine the least-cost method of abatement, polluters will calculate the equivalent allowance value, or EAV. If the EAV premium for low-sulfur coal were less than the price of an allowance, then polluters would purchase low-sulfur coal. On the other side, if the EAV premium for low-sulfur coal were more than the price of an allowance, then polluters would stick with high-sulfur coal and buy allowances to cover its emissions. Analysts have observed that allowance prices and the EAV of coal-sulfur premiums tended to converge, and when allowance prices fell, the emissions rate at Phase I units increased.[62] Both of these observations point to the conclusion that electric utilities have taken advantage of the opportunity to abate in a least-cost way.

Perhaps one of the most important questions to be asked about the Acid Rain Program is whether or not it has contributed to least-cost reductions; in other words, have there been more cost savings than there would have been under a different pollution control program? Burtraw et al. (2005) examine the existence of cost savings by citing that allowance prices have been substantially lower than what was originally predicted before the program was implemented. Certain factors, such as the decline in the cost of low-sulfur coal in the 1990s, contributed to the marginal cost of emission reductions (which, in turn, determines the price of an allowance) but were not included in initial price estimates because they were independent of the program. Thus, it is possible that the difference between actual allowance prices and the original estimates has been exaggerated, and the existence of cost savings must be examined in another way.

The best way to evaluate the cost savings attributable to the Acid Rain Program is to compare total costs under trading with a counterfactual baseline's costs, or a program that did not employ emissions trading. Several analysts have made use of the counterfactual to estimate cost savings, including Carlson et al. (2000) and Ellerman et al. (2000). Carlson et al (2000) uses an econometric simulation model based on marginal abatement cost functions derived from an econometrically estimated long-run total cost function for electricity generation for a sample of 800 plus units operating between the years 1985-1994.[63] Compared to the counterfactual (in this case, a uniform emissions rate standard), estimated potential cost savings attributable to the emissions trading program was $250 million (in 1995 $) during Phase I and $784 million per year in Phase II.

Outside of the program, Carlson et al. (2000) recognize the part fuel prices and technical change played in lowering costs over the time period of the program. They estimate that declining fuel prices lowered marginal control costs by $200 per ton (in 1995 $) over the 1980s. In addition, it is estimated that technical change over time lowered marginal abatement cost functions by approximately $50 per ton (in 1995 $) over the decade preceding 1995. Overall, however, Carlson et al. (2000) attribute the majority of cost savings to the program itself, stating that 80% of the decline in marginal abatement costs is a result of the flexibility available within the program, and 20% is a result of technical change.[64] In the long run, Carlson et al. (2000) estimate a cost savings of $1.1 billion annually through 2010. Ellerman et al. (2000) provide an even larger estimate of $1.4 billion annually through 2010, using a similar counterfactual analysis. No matter which estimate is more accurate, it is clear that cost savings have been achieved in substantial amounts from allowing sources to engage in emissions trading.

After analyzing the program in detail, it seems fair to label the first large-scale use of emissions trading as a success. The cost-effectiveness and general overall efficiency of the scheme has prompted policymakers to pay more attention to market-based instruments, and cap-and-trade programs in particular. Other countries can learn from the US Acid Rain Program for implementing their own acid rain legislation as well as other environmental policies. Several countries and regions, such as the United Kingdom, have already used lessons learned from the US Acid Rain Program for implementing climate change policies. Hopefully, the US can also learn from their own experience with emissions trading when they move forward with climate change legislation in the future.

Chapter Two: The UK Emissions Trading Scheme

Chapter Two will focus on the United Kingdom's Climate Change Programme, in particular their emissions trading scheme for managing greenhouse gas emissions. The purpose of this chapter is to examine the effectiveness of a domestic cap-and-trade program for greenhouse gases, in order to determine how well such a program would work in the United States. Of course, it should be noted that the United Kingdom operates under a different system of government, which would have an impact on the design of the country's trading scheme; nonetheless, it is advantageous to evaluate the successes and failures of the UK's program when considering possible scheme designs for the US.

There are several domestic cap-and-trade programs for greenhouse gases that exist today, or are in planning stages, besides the UK's program, including programs in Australia, New Zealand, and Denmark. In addition, the European Union implemented the largest multi-national greenhouse gas cap-and-trade scheme in the world in 2005, of which the UK is now a participant. In fact, one of the main reasons for the implementation of the UK Emissions Trading Scheme in 2002 was to give firms experience with a tradable permits system before entering the EU scheme. Still, the UK program is important to study today because the country arguably has the most experience with large-scale national carbon trading than any other country in the world. While the nation was dubbed the "dirty man of Europe" because of their lack of response to the issue of acid rain, they have been heralded as one of the initial leaders of international response to climate change.[65] In addition, the UK also has experience with merging an existing domestic program with an international program (the EU Emissions Trading Scheme), which is a possibility for the US in the future.

This chapter is structured as follows: Part I will provide an overview of the history of climate change policy from the UK's perspective, with particular emphasis on the Kyoto Protocol. Part II will describe the UK Emissions Trading Scheme in detail, and Part III will evaluate the UK program, based mainly on reports done by economic consulting firms for the UK government. Lastly, the chapter will conclude with a brief look at the European Union's international emissions trading program for CO_2 emissions and issues with UK integration into the EU program.

Part I: The History

The recognition of climate change as a partly human-induced problem is actually a more recent development. Scientists proclaimed the need for a coordinated multilateral response in 1985 at the World Meteorological Organization (WMO) conference in Villach, Austria. In fact, many claim that this conference marked the transition of climate change as a scientific issue to also being an international political issue.[66] The need to address the problems resulting from climate change was first recognized by the global political world with the creation of the Intergovernmental Panel on Climate Change, or IPCC, in 1988. The IPCC, which consists of a team of both scientists and economists, was set up with the intention of assessing climate change scientifically, and also of considering possible policy responses to the problem. The team concluded that a significant reduction in CO_2 emissions was necessary in order to prevent future adverse climate impacts.

The next step in the control of CO_2 emissions came with the negotiation of the UN Framework Convention on Climate Change, or UNFCCC, which took place between 1990 and 1992 and was initially promoted by the UK government. The goal of the Convention was to establish an objective, guiding principles, commitments, and institutional provisions in order to provide a basis for an international response. The Convention was eventually adopted on May 9, 1992 and was initially signed by 154 states plus the European Commission in Rio de Janeiro in June of that year. Following the signing of the Convention, domestic debates ensued over the practicability of reducing greenhouse gas emissions, setting the stage for the commitments that would result later from the Kyoto Protocol.

The Convention went into force on March 21, 1994, with the ultimate objective of stabilizing greenhouse gases "at a level that would prevent dangerous anthropogenic interference with the climate system."[67] The timeframe provided for such stabilization is somewhat vague, being "sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."[68]

Article 3 of the Convention runs through the basic principles that must be kept in mind when formulating a policy for climate change, especially when considering the establishment of an international program. In particular, "equity" and "common but differentiated responsibilities" are to be recognized, meaning that more developed countries are expected to take the lead in emission reductions, but that no country should be left out of at least the most basic requirements (such as reporting requirements). The Convention also clearly recognizes the special needs of developing countries in section 2 of Article 3 of the Convention. In particular, all parties are to be guided in their actions by the needs and special circumstances of developing countries. The "Precautionary Principle" is another key principle held up by the Convention, stating that precautionary measures should be taken to "anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects."[69] Lastly, the Convention recognizes the right to sustainable development for each country based on national circumstances.

The Convention closes with an article concerning commitments, basically establishing the need for reporting on greenhouse gas inventories, domestic and regional climate change mitigation programs, and the promotion of other issues such as technology and sustainable development.

Prior to the enforcement of the Kyoto Protocol, many countries were working under their own domestic reduction targets that were determined in the early 1990s. The UK prepared an emission reduction plan after the 1995 Berlin Mandate that called for a 10 million tonne reduction in CO_2 emissions from 1990 levels by 2000. In the period prior to Kyoto, the UK and Germany were the only states that were expected to accomplish their stabilization goals by 2000, although the UK's reductions were still thought to be limited, especially given the switch from coal to natural gas that occurred during this period. Much of the government's climate change policy prior to Kyoto consisted of fuel taxes, renewable energy and voluntary accords with industry.

The move toward Kyoto commenced with discussions in 1995 during the first Conference of Parties, more commonly referred to as COP-1. Unfortunately, COP-1 resembled the UNFCCC negotiations in that not much progress was made toward a quantitative plan aside from the enforcement of the Berlin Mandate. COP-2 proved to be slightly more successful, with the adoption of the Geneva Declaration that specifically called for a protocol that would include binding targets and timetables. The Kyoto Protocol was finally adopted after two-and-a-half years of intense negotiations on December 11, 1997 in Kyoto, Japan and was later entered into force in February 2005, after being ratified by the requisite number of countries. The Protocol essentially presented various policies and measures that countries were encouraged to consider, including energy efficiency policies, protections of sinks and reservoirs, sustainable forestry practices, and more. The main objectives and principles of the Protocol were essentially the same as those adopted under the Convention, but the Protocol established quantitative legally binding targets for countries categorized as Annex I Parties, which were considered to be the center piece of the Protocol. Countries included in the Annex I category include all members of the OECD, the European Union, and fourteen countries that were considered to have economies in transition. The expectation was that developed countries would take on relatively larger reductions as compared to the reductions taken on by developing countries. Reduction targets were specified for what were considered to be the six main greenhouse gases: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. The target reductions for each party were quoted as combined targets for baskets of greenhouse gases, expressed in CO_2 equivalence.

Annex I Parties were required to reduce emissions by 5.2% collectively from 1990 levels between the years 2008-2012. This time period was put into place with the intention of adding flexibility to the program in order to lessen the impact of any short run fluctuations in the program. The individual party commitments were established through an assigned amount, calculated using the quantified emissions limitation and reduction commitments contained in Annex B of the protocol, along with estimates of emissions in the base year. The Protocol assigned a reduction target of 8% from 1990 levels for most developed countries, including the UK, Germany, and the EU. The United States was assigned a slightly lower target reduction rate at 7%, although the government decided in 2001 not to ratify the Protocol. According to a further EU Burden-sharing Agreement, the UK agreed to reduce emissions even further by 12.5% from 1990 levels by 2012. The Protocol provided three "flexible mechanisms" to Annex B parties that may help them achieve their reduction targets at a lower cost. Joint Implementation allows Annex I parties to trade "credits" based on a project's ability to reduce emissions, with the project being undertaken between Annex I countries with targets under Annex B of the Protocol. As of 2005, most projects took place in central and eastern European countries. The Clean Development Mechanism allows countries and companies from developed countries to invest in sustainable development projects in developing countries in return for Emission Reduction Credits. The final mechanism, and most significant mechanism for the purposes of this paper, is emissions trading, which the UK chose to employ as part of their Climate Change Programme.

Part II: The Program

In order for parties to achieve their assigned targets, they are required to implement their own domestic policy, which is what motivated the UK to implement its Climate Change Programme. The program was designed to meet the UK's Kyoto agreement of a 12.5% reduction by 2012, although the government went further with their own domestic goal of a 20% reduction in greenhouse gas emissions below 1990 levels by the year 2010. The Climate Change Programme consists of three main schemes: the Climate Change Levy, Climate Change Agreements, and the Emissions Trading Scheme. This paper is mainly concerned with the Emissions Trading Scheme as well as the involvement of Climate Change Agreement Participants in the trading program. It is beneficial, however, to have a brief overview of the entire Climate Change Programme for the sake of context, especially since all three programs connect with each other. The Climate Change Levy took effect in April 2001 as a single-stage tax on industrial energy use, with varying rates depending on the type of fuel being used. Electricity, for instance, is taxed at a rate of £.00456 per kilowatt hour, while any liquid gas (such as petroleum gas) is taxed at a rate of £.01018 per kilowatt hour.[3] If utilities decide to join a Climate Change Agreement, the second program, then they qualify for an 80% discount on the levy. Thus, there is a financial incentive for a utility to join a Climate Change Agreement. Climate Change Agreements cover more than 40 energy-intensive sectors, and if a utility decides to join an Agreement, they are required to take on a quantitative energy efficient target. The "Agreement" part of the program consists of an agreement between the utility and the government, and takes several different forms depending on the type of reduction that the utility wants to achieve. The reduction can relate to energy use, greenhouse gas emissions, or both, and it can be specified in either absolute or relative terms. In other words, the reduction could be absolute in tonnes of CO_2 equivalent emissions, or it could be relative in CO_2 equivalent emissions per unit of output. In practice, most organizations chose to think of their reductions in relative terms. Lastly, the Climate Change

[3] These figures are as of April 2008 – they have been adjusted for inflation over time.

Agreement has a two-tier structure that includes obligations for the sector as a whole as well as obligations for each individual firm.

Climate Change Agreement Participants actually accounted for the majority of the organizations who were involved in the Emissions Trading Scheme, with 6000 firms choosing to participate. A total of 32 other firms, labeled as Direct Participants, accounted for the rest of the participation in the scheme. These participants voluntarily chose to become involved through a financial incentive made available by the government, with payment of the incentive conditional on allowances held by the participant being at least equal to total annual emissions. Another allowed method of entry into the Emissions Trading Scheme was through an approved emission reduction project—a defined activity that led to reductions in greenhouse gas emissions. Target holders were able to use credits earned from a reduction project to meet obligations within the trading scheme. Lastly, entry was allowed by having a participant, who may not have wished to take on a specified reduction target, simply open a trading account. These participants may have included environmental groups who may have wished to store allowances in order to reduce overall greenhouse gas emissions.

Participation in the Emissions Trading Scheme obviously differed between Agreement and Direct Participants. Agreement Participants had relatively little requirements—they participated in the scheme using their targets that were predetermined in their Agreement, thus they were not required to compile baseline data or take on any different target in order to participate. If the Agreement Participant chose to accept the 80% discount on the Climate Change Levy, then they were not allowed to also receive the financial incentive payment that Direct Participants qualified for.

Participation in the Emissions Trading Scheme for Direct Participants was a bit more involved than participation for Agreement Participants. First of all, in order to receive the financial incentive payment, participants had to bid for a share of the £215 million incentive payment through an auction held in March 2002. In order to place a bid, the participant had to specify the reduction in annual emissions from the baseline that they planned to make by the end of the scheme in 2006. The reduction would then be divided into five equal annual targets over 2002 to 2006. As long as the participants were able to reach their specified annual targets, they would receive an annual payment. Another requirement for Direct Participants included the identification of the Source List, which consisted of the sources that the participant intended to bring into the scheme. Lastly and most importantly, participants were required to calculate their baseline, which would, in turn, determine their emission reduction target. The baseline was calculated based on historic emission levels—it is the average annual emissions in the three years up to and including the year 2000. Of course, it should be noted that the baseline would not necessarily turn out to be equal to total average annual emissions over the baseline period from all sources on a participant's Source List. This inequality results because participants had the option of leaving out sources with emissions that were less than the Size Threshold (10,000 tonnes of carbon dioxide equivalent or 1% of the Source List total), meaning that participants could reduce their administrative costs by leaving sources out of the Baseline that had low levels of emissions over the Baseline period and were likely to remain low.

As previously noted, the financial incentive payments for Direct Participants were determined based on the bid that the participant placed at the auction in March 2002. A

“Descending Clock” style auction was used to allocate the money. Bidders were required to submit the quantity, in tonnes of CO_2 equivalent, of emission reductions at the stated price that they were prepared to take on for the length of the program. When the auction was over, the auctioneer announced the clearing price, which was the amount that each bidder would receive for each tonne of CO_2 equivalent that they bid into the auction. The auction did not ask for bids greater than £100 per tonne of CO_2 equivalent in order to limit the preparation costs for participants.[70] Participants were also not allowed to bid to claim any more than 10% of the total incentive money. Defra (Department of Environment Food and Rural Affairs in the UK) described the rationale of the incentive payment as follows: since Direct Participants bid based on their annual levels of emission reductions, the incentive was applied to the additional reduction achieved in each year.[71]

Allowance allocation, trading and transfers also differed between Agreement and Direct Participants. Agreement Participants operated on a baseline-and-credit system as opposed to the cap-and-trade system that Direct Participants functioned under. Agreement Participants received allowances at the end of each compliance period (also known as the “milestone year”) as long as they reduced their energy use or emissions (depending on the agreement they entered into) below their target level. The amount of allowances allocated was dependent upon the amount of over-achievement by the participant, and participants were also allowed to trade allowances between themselves and with Direct Participants in order to reach target levels. If an Agreement Participant under-achieved its target level, they would not be able to receive any allowances, but rather would have to buy the number of allowances required before the end of the reconciliation period.

Conversely, Direct Participants operated under a cap-and-trade scheme. Participants received allowances matching their emissions cap for the forthcoming compliance period as long as they held allowances that were at least equal to their emissions for the previous compliance period. After the allocation, participants were able to sell allowances, as long as they held allowances equal to their actual verified emissions by the end of the reconciliation period.

The rules for allowance trades and transfers were quite similar to those found in the US Acid Rain Program, but with a few key differences. Trades could take place between any participants in the scheme, and unlimited banking was allowed. A unique aspect of the UK program regards a mechanism called the "gateway," which was put in place because of the existence of absolute and relative targets for Agreement Participants, though it should be noted that the majority of Agreement Participants operated under a relative target (meaning their reduction targets were expressed as per unit of output, rather than an absolute tonne reduction). The gateway ensured that there was no net transfer of allowances from the relative to the absolute sector; all allowances that were transferred into the absolute sector from the relative sector would need to pass through the gateway, which counted the total cumulative transfers. Relative sector participants were only allowed to transfer allowances out of the absolute sector when there had been a net flow into the relative sector. The gateway was put into place so that trading between the absolute and relative sectors would not erode the effectiveness of the trading scheme in terms of control of overall emissions. In other words, if firms in the relative sector exceeded their reduction targets and thus sold permits to the absolute sector, then emissions in the absolute sector could rise. In order to prevent this rise in emissions, the gateway was put into place to restrict the flow of allowances between sectors.

Agreement Participants were not required to report their emissions to the ETA (Environmental Transport Association) since they had their own set of reporting and verification rules within their agreement. However, certain information regarding the behavior of Direct Participants was available to the public in order to ensure efficient trading: the targets and initial allowance allocation of all Direct Participants, account holders and contact details, a transaction log with information regarding all transfers over the previous compliance period, the total baseline and annual emissions of all Direct Participants, the compliance status of all Direct Participants, and annual credit allocation to all UK-based projects. Direct Participants were required to report their emissions at the end of each compliance period, and if there were any discrepancies, participants had until the end of the reconciliation period to obtain the necessary amount of allowances to cover their excess emissions. At the end of each year, allowances that matched up to total emissions would be transferred into the government's "retirement" account. If a participant did not hold sufficient allowances to cover their emissions by the end of the reconciliation period, they would not receive the financial incentive payment, their allowance allocation in the following period would be reduced, and they would incur a financial penalty. If the participant did not hold enough allowances at some point during the scheme (in other words, they received the financial incentive payment in the past), they would be required to repay past payments with interest; this punishment was in place so that participants would feel compelled to stay in the scheme for the entire four years and not leave after receiving payment. However, if a participant did choose to withdraw from the scheme before its conclusion in 2006, they would be required to repay all previous payments with interest. Overall, it seems that the financial incentive payment and the threat of a penalty for non-compliance functioned well throughout the scheme, since all Direct Participants exhibited compliance and even over-compliance.

Part III: Evaluation

The UK Emissions Trading Scheme was implemented as a pilot scheme in order to test design options for a wide-scale greenhouse gas trading program. This part of the chapter will examine three main areas of the program—emission reductions, the efficiency of the allowance market and determination of an allowance price, and overall compliance and participation, in order to determine the general economic efficiency of the scheme. The chapter will concentrate mainly on Direct Participants, since the required reductions for Agreement Participants widely differed based on the various agreements entered into by those involved.

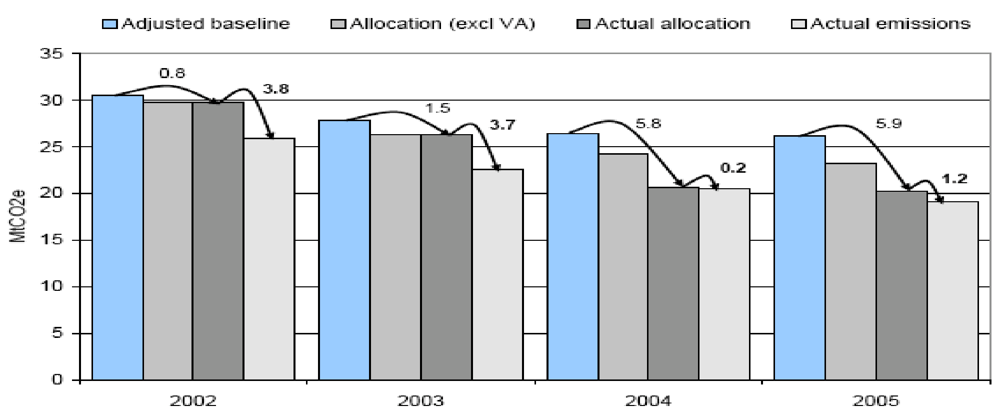

Figure 2.1[72] Note: VA=Voluntary Agreement

As far as emission reductions are concerned, Direct Participants were extremely successful, with 17 out of the 32 participants over-achieving their targets in the second year of the scheme. Figure 2.1 illustrates the million tonnes of CO_2 equivalent surplus that resulted from Direct Participants emitting significantly less than their target levels, before six participants concluded a voluntary agreement with Defra to take on additional reductions. It can be seen that actual emissions were well below the amount of allocated allowances excluding the Voluntary Agreement. In 2002, for instance, actual emissions were measured at roughly 26 million tonnes of CO_2 equivalent, while the allocation of allowances accounted for almost 30 million tonnes of CO_2 equivalent—thus there was an excess of allowances. In fact, before the Voluntary Agreement of November 2004, excess allowances cumulatively totaled roughly 7.5 million tonnes of CO_2 equivalent. Figure 2.1 clearly shows that the Voluntary Agreement helped to reconcile this surplus—by 2004, actual allocations and actual emissions were roughly equal.

Only two participants fell short of their targets in the first year of the scheme; however, overall, the group exceeded their target by a factor of almost 5. Still, by the end of the scheme, all Direct Participants were able to surpass their stated commitment of a 3.96 million tonne reduction of CO_2 equivalent. In addition, carbon dioxide emissions alone fell by 1.5%, with all six greenhouse gases falling by 1.7% in the year 2007, after the conclusion of the Emissions Trading Scheme.[73] Emission reductions were achieved in a variety of ways, including abatement through indirect (i.e. electricity) and direct emissions. Dynamic efficiency was also achieved; participants claimed that they achieved reductions through the installation of emissions abatement equipment, as well as through modifications to the ways existing pieces of equipment were used (such as optimizing energy use).[74]

Appraisals of the program performed by economic consulting firms have found that there was some error in the calculations of baseline emissions for Direct Participants, and many participants' emission levels were below their baselines at the start of the scheme in 2002. The National Audit Office concluded that it was relatively easy for Direct Participants to overachieve in emission reductions because of the informational problems that compromised the baseline calculations.[75] The over-generosity in baseline calculations explains the surplus of allowances that resulted in 2004, with an accumulated allowance bank of around 10 million tonnes of CO_2 equivalent by the end of 2004. Concern mounted that the large bank was the primary cause for the low market value of allowances that existed[76], and Defra announced in November 2004 that the six largest sources of over-compliance had agreed to take on additional reductions, totaling 8.9 million tonnes of CO_2 equivalent, in order to shrink the surplus of allowances. In addition to miscalculated baseline emissions, the verification process for some participants' baselines took longer than anticipated, resulting in a delay in allocations. ENVIROS Consulting claims that this delay may have played a role in the relatively high allowance price that resulted in the beginning of the program in October 2002.

Despite the two-month delay, the March 2002 auction was, for the most part, hailed as a success by both Defra and the Direct Participants.[77] A survey taken of Direct Participants indicates that many of them were drawn to the program by the incentive payment, and the costs for preparing for the auction were low. Respondents also said that the opportunity for learning was successful, which was one of the main intentions of the pilot program. Much of the criticism came from politicians, who claimed that a better deal may have been available at a lower price, and that the incentive payments should have been reduced once the government realized that there would be a somewhat low level of participation in the scheme. The only criticism from participants was that the rules could have been a bit simpler, and that more time was needed to fully understand the requirements of the program before committing to participate.

The majority of external trades took place around the Agreement Participants' Milestone periods—January 2003 and January 2005—most likely so that the majority of participants could reconcile their emissions with the necessary amount of allowances. It is interesting to note what the incentives for trading may have been for purposes of determining static efficiency; in particular, has the emissions trading scheme been effective in providing flexibility to individual firms, and have firms, in turn, taken advantage of such flexibility? Overall, evidence has shown that a considerable amount of trading has taken place throughout the scheme, in a reasonably liquid market with broad participation.[78] Out of approximately 6032 potential traders, 1397 firms participated in at least one trade during the first three years of the scheme, with 176,000 allowances traded per month during this time. Throughout the scheme there were usually more buyers than sellers, with 1348 buyers vs. 171 sellers in the first year of trading. Smith & Swierzbinski (2006) show that the reallocation of abatement from high-cost to lower-cost sources illustrates the existence of static efficiency within the program.[79] This reallocation of abatement also attempted to satisfy the equimarginal principle—abatement was allocated in a cost minimizing way because lower-cost sources shouldered the majority of abatement. In addition, Shell, Ineos Fluor, and Rhodia—the three principal sellers in the program—made relatively large contributions to the November 2004 Voluntary Agreement, which suggests that they may have had lower abatement costs. The movement of trades going principally in one direction, as previously shown with companies with lower abatement costs being identified as principal sellers, suggests static efficiency. Smith & Swierzbinski (2006) formulated a model to test this theory, since there were still a good number of trades made by firms moving in both directions. Smith & Swierzbinski (2006) looked at the prevalence of two-way trading and its relationship with trading frequency across the sample as a whole by measuring bi-directional trading as:

$$B = \frac{(S+P) - |S-P|}{S+P}$$

where S represents sales of allowances and P represents purchases of allowances. Using data regarding the total number of transactions made in the first three years, they found that 92% of all firms trading in the scheme traded almost entirely in a single direction, confirming the existence of static efficiency.[80]

The evolution of the price of allowances, shown by Figure 2.2, is particularly interesting given that the price that allowances traded for ended up being much smaller than the clearing price of £17.79 obtained at the auction in March 2002. In April 2002, allowances were only trading at £5, and they then rose to a peak of £12 in October 2002, most likely because of the delay in allocations. The price then fell again to only £2 in 2003, rose briefly to £4 in 2004, and dropped back down to £2 in 2005. An important question to ask is why did prices fluctuate so much, and why were they so much lower than expected? The National Audit Office and ENVIROS Consulting claim that the initial price peak in October 2002 reflected the shortage of allowances that resulted from the delay in allowance allocations.[81] NAO also lists the demand by Agreement Participants for allowances to meet their targets and uncertainty on the part of all participants about the amount of allowances needed as other contributors to the price peak in October. A possible explanation for the subsequent drop in prices is the publishing of the NAO report in 2004, which could have created an expectation of the later tightening of allowance supply, further inducing firms to reduce their overall allowance supply.[82]

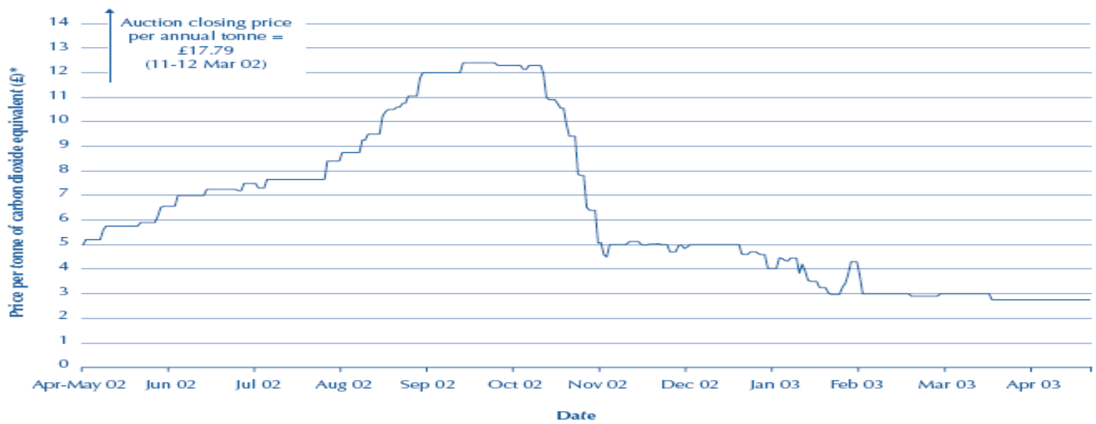

Figure 2.2[83]

In terms of compliance, it is important to examine the incentives to abate on the part of polluters, especially since entrance into the UK's Emissions Trading Scheme was voluntary. For Direct Participants, the incentive is relatively straightforward since they were paid a financial incentive payment in return for reductions in emissions. All participants were offering abatement at a price of £17.79 per tonne at the final auction price. Direct Participants were given a choice, as soon as the auction bids were translated into contractual obligations, to either abate on their own or buy allowances in the market. Thus, the incentive for marginal abatement was given by the market price of allowances. Firms that had committed to undertake abatement that was less costly than the auction price of £17.79, but more costly than the market price of £2-£4 would have been inclined to minimize costs by purchasing allowances rather than abating on their own.

For Agreement Participants, one must examine the incentive to conclude a Climate Change Agreement, which is shown by Figure 2.3. In terms of examining the cost and benefit of entering an Agreement, the benefit to Agreement Participants was the 80% discount on the Climate Change Levy, while the cost was the amount of abatement required. Without an incentive to reach an agreement, the firm's level of emissions is represented by point Q_0, and Q_1 shows where emissions would be if the firm was subject to the full Climate Change Levy at rate L. Q_1 may therefore be thought of as the baseline for negotiating an agreement, and it is clear that a firm would choose to emit at Q_2 if offered an 80% discount on the Levy. Area (a+b) represents additional abatement costs that result from reducing emissions from Q_1 to Q_2. As long as area (a+b) is greater than area (b+c), which shows the reduction in Levy payments, then it is worthwhile for the firm to reduce emissions to Q_2 and receive the discount on the Levy in return. Of course, the amount of abatement required from each firm would have depended on the slope of the marginal abatement cost curve and the level of Levy payments in absence of an agreement. Due to asymmetric information between the government and firms, the government was not necessarily able to ask for the theoretical optimal value of abatement from Agreement Participants. In terms of the existence of a marginal abatement incentive for Agreement Participants, firms faced an abatement incentive that was given by the market price of an allowance. Fortunately, it is clear that an incentive to abate existed for both Direct and Agreement Participants.

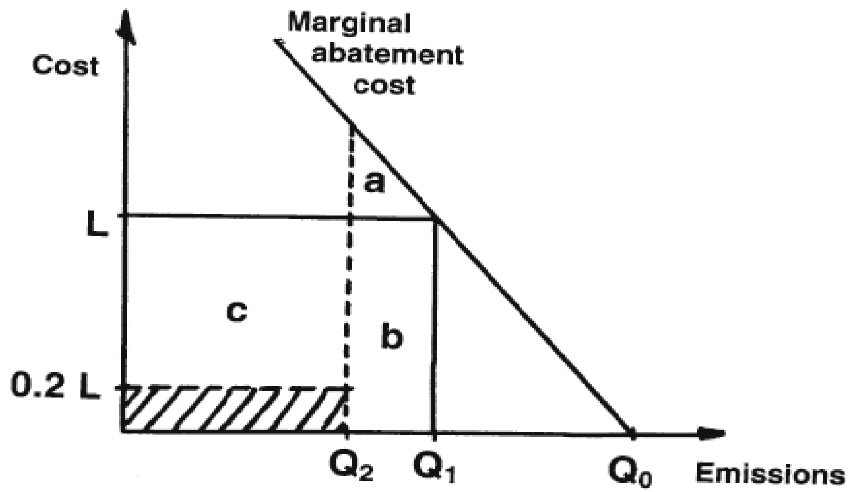

Figure 2.3[84]

Although no analyses have yet been conducted in regards to the cost effectiveness of the program, in terms of comparing cost savings from trading with cost savings from a counterfactual regulatory program, lessons can certainly be drawn from design aspects of the UK Emissions Trading Scheme. In addition, it is beneficial to examine the UK's integration into the international emissions trading scheme that currently exists within the European Union, since international emissions trading is certainly a possibility for the US in the future. In brief, the EU Emissions Trading Program was first introduced in October 2003 after a proposal for international emissions trading had been mentioned in 2001, and the scheme was up and running rather quickly by January 2005. Thus, negotiations regarding the design of the program were taking place as the UK Climate Change Programme was starting out. As mentioned previously, the UK government had treated their Emissions Trading Scheme as a sort of trial run in order to prepare UK firms for their eventual integration into the EU scheme.

Unfortunately, many analysts, particularly Sorrell (2003), have agreed that the UK Climate Change Programme was incompatible with the EU Emissions Trading Program because of differences in design features of each scheme.[85] In fact, the UK had chosen to allow several installations covered by Climate Change Agreements as well as the Trading Scheme in general to temporarily opt out of the EU program while some of these design issues were properly sorted out—officially, the UK was given until the end of the UK Emissions Trading Scheme in 2006 to resolve any issues. Most of the issues surround the Climate Change Levy and the Climate Change Agreements because they extend beyond 2006 (the Climate Change Agreements currently run until 2013) and are also dependent upon each other for success. Since the UK's Emissions Trading Scheme ended in 2006, this part of the program does not really come into conflict with the EU scheme, as Direct Participants would have been able to join the EU scheme starting in 2007. However, there are still notable differences between the two schemes that would cancel out any "early advantage" that UK firms thought they would have by gaining experience in an emissions trading scheme. In particular, the UK scheme controlled the emissions of a basket of greenhouse gases, whereas the EU scheme deals solely with carbon dioxide emissions. The UK program was also voluntary with a financial incentive payment, whereas the EU program is mandatory with the only incentive being a penalty for non-compliance. The UK program does not include the electricity industry, but rather applies the Climate Change Levy to electricity outputs, whereas the EU scheme includes the electricity industry in its cap-and-trade program just like other industrial sectors. Lastly, the time periods of the UK Emissions Trading Scheme and the EU Emissions Trading Scheme were in conflict. As stated before, the UK scheme ended in 2006, while the EU scheme began in 2005 and runs to 2007 and 2012 in two phases. In 2008, the UK finally did join the EU scheme and held its first auction for allowances in November of that year in order to participate in Phase II of the scheme. As of March 2009, the Department of Energy and Climate Change (DECC) has laid out several possibilities for changes to the Climate Change Agreements, mainly because they intend to extend the Agreements to 2017. The DECC is currently taking suggestions from interested parties, but it has also already made its own suggestions. Some considerations include whether or not Climate Change Agreements should continue to allow the option of relative or absolute targets (since the EU Emissions Trading Program operates under an absolute cap), whether or not the Agreements should include the option of setting targets in terms of energy use or carbon emissions, whether targets should be set annually as opposed to every 2 years as they are now, and whether targets should be split where there is an overlap between the Agreements and the EU Emissions Trading Scheme. In any case, sufficient further work needs to be done when considering the future of Climate Change Agreements and their compatibility or potential overlap with the EU scheme.

In thinking more about the UK's integration into the EU scheme, particular interest is placed on the future value of allowances that have been banked by UK firms over the life of the scheme. Smith & Swierzbinski (2006) note that the value of allowances in the beginning of the EU scheme would have been heavily influenced by expectations about allowance supply and demand in the future.[86] Expectations could be, in turn, affected by the future course of policy in terms of the future of the UK scheme, whether or not UK allowances will be converted into EU allowances, etc. These expectations could certainly affect the future of allowance prices, as well as the perceived risk of holding allowances due to uncertainty. Smith & Swierzbinski (2006) predict that the realized incompatibility of the UK Emissions Trading Scheme with the EU Emissions Trading Scheme may have reduced the value of UK allowances, largely because allowances prices in the EU scheme so far have been substantially higher than those in the UK scheme.[87] The difficult situation that the UK has faced in regards to integrating themselves into the EU trading program is certainly something to take into consideration. If the US decides to implement a national emissions trading program one day and then later participate in international trading, they will need to be careful in designing a national program and take care of compatibility. In addition, the US already has several regional trading programs in the Northeast and Midwest. If the US decides the implement a national program, they will need to take these regional programs into consideration.

Despite the difference in governmental structure, valuable lessons may be taken from the UK Emissions Trading Scheme for future design of US climate change policy. The UK program was relatively successful for a pilot scheme, and the considerations that the country took into account concerning design features of a greenhouse gas program will be useful for the US's program design.

Chapter Three: Lessons Learned for US Climate Change Policy

Chapter Three will focus on design aspects of the US Acid Rain Program and the UK Emissions Trading Scheme that may help shed light on the development of a national cap-and-trade program for combating climate change in the US. Part I will focus on the history of climate change policy from the perspective of the US; Part II will discuss program design issues regarding different types of market mechanisms, mainly permits and taxes; and Part III will reconsider the US and UK trading programs in the context of design aspects for a future national US program. The chapter will conclude with Part IV which discusses the future of US climate policy, in particular a recommendation for a future US greenhouse gas trading scheme, after taking into account the successes and failures of the Acid Rain Program as well as the UK's Emissions Trading Scheme. It should be noted that greenhouse gas emissions differ widely from SO_2 emissions, however certain design features of the Acid Rain Program are worth evaluating, especially since the program has largely been hailed as a success in environmental policy overall.

Part I: The History

Although the US may be considered one of the leaders in using market-based instruments to deal with environmental issues because of the cap-and-trade system used to combat acid rain, the country has also been considered to be the world's "leading laggard" in global warming issues.[88] Although the US emits nearly a quarter of all anthropogenic greenhouse gases, the government has refused to commit to any binding targets or timetables for reducing emissions. The US did become a signatory of the Kyoto

Protocol in 1998 under President Clinton; however, Clinton never submitted the treaty to the Senate for ratification, and, in 2001, the Bush Administration refused to ratify the Kyoto Protocol, thus rejecting the assigned 7% reduction in greenhouse gas emissions from 1990 levels. President George W. Bush did not submit the Protocol to the Senate for ratification on the grounds that the required reductions would put a strain on the US economy, uncertainties were present in climate change policy, and China (currently the world's largest gross emitter of CO_2 emissions) was exempt from the Protocol requirements. The US government has expressed further concerns about competing nations who may not have the same climate change policy as the US—any industry that is required to reduce emissions and may find their feedstock or energy bills increasing due to the pass-through of costs by suppliers may be less competitive and thus lose global market share and jobs to competitors in countries that do not have as strict of a climate change policy.[89] The government worries that their own emission reductions would be counteracted by increased production in less regulated countries, a concept known as "carbon leakage."[90] As a result of these concerns, the US has thus far been hesitant to implement any sort of quantitative climate change policy. It should be noted, however, that despite the government's weariness concerning the Kyoto Protocol, President Bush did express optimism about a technological solution for addressing climate change.

In order to understand the context in which the US would be formulating a climate change policy, it is necessary to consider the overall history of the issue, without repeating what has already been discussed in Chapter Two of the paper in regards to the history of policy. The greenhouse gas effect had been calculated as far back as the 1890s, however scientists did not begin to test the theory of global warming until the 1950s, when they discovered that the concentration of carbon dioxide in the atmosphere was rising steadily. By the 1960s, scientists began to publicly warn about human-induced climate change in popular literature, although it was not until 1979 that the World Meteorological Organization was formed and the UN Environment Program established the World Climate Program. In addition, the first World Climate Conference convened that year. Close to a decade later, the particularly hot summer of 1988 brought about widespread media attention to the issue of global warming, and Dr. James Hansen (director of the National Aeronautics and Space Administration's Goddard Institute for Space Studies) subsequently gave a testimony to the Senate Committee on Energy and Natural Resources stating that human activities were certainly a major cause of climate change. Hansen later made a statement to the *New York Times*, where he proclaimed, "It is time to stop waffling so much and say the evidence is pretty strong that the greenhouse effect is here."[91] Action was quick, and weeks after the testimony an international group of scientists and policymakers met in Toronto, calling for a 20% reduction in global carbon emissions by 2005. This 20% reduction target had no economic or scientific analysis at its base, however, and many governments were still skeptical, which is why the IPCC was established in December of that year.

By 1992, the UNFCCC, established in 1990, had been signed by more than 150 nations, including the US, in Rio de Janeiro. The UNFCCC called only for voluntary action, and no country made any sort of commitment to abating greenhouse gas emissions. In addition, the US wished to keep emissions targets and timetables out of initial negotiations, due to George H.W. Bush's position that abatement measures were too costly and that more scientific evidence was required before making "economic sacrifices."[92] Instead, the US government promoted a non-binding goal of reducing greenhouse gas emissions back to 1990 levels by the year 2000. This goal was not really enforced, however, and the government really only agreed to prepare inventories of their emissions and to adopt some sort of policy for future abatement and mitigation—overall, the climate change policy efforts made in 1992 were quite vague and poorly enforced.

In 1993, a new administration came to power under President Clinton, who proposed an energy consumption tax (which was later rejected by Congress) as well as a pledge to stabilize US greenhouse gas emissions at 1990 levels by the year 2010. In order to stand by such a pledge, a Climate Change Action Plan was announced in October of that year, however it was based largely on voluntary action rather than mandatory targets. By 1996, the US government publicly supported the eventual implementation of mandatory emission reduction targets, which paved the way for the government's signing of the Kyoto Protocol in 1998. The Senate, however, greatly criticized the signing, and had also previously voted in favor the Byrd-Hagel Resolution in July 1997 by a vote of 95-0, which instructed the President to refrain from signing any climate protocols that did not include developing countries in the prescribed actions, or any protocols that would adversely affect the US economy. A new administration in 2001 once again saw a change in the US government's outlook on climate change policy. As noted previously, President Bush rejected the ratification of the Protocol in March 2001. The Protocol received criticism outside the government as well, with many American economists, such as Barrett (2003), claiming that the regime was inefficient by requiring high emission reductions in the short term while not making any specifications in regards to the longer future.[93] The Administration did reaffirm its support for the UNFCCC and called for additional scientific research to be done on the climate change issue. The government continued to reject mandatory reduction requirements, and instead the Administration promoted "climate-friendly" technology and announced a voluntary global warming plan in 2002 that called for a reduction in greenhouse gas emissions per unit of GDP by 18% in the year 2012. The plan was criticized, however, as still making overall emissions 30% above 1990 levels, given the President's assumptions about economic growth. In addition, critics noted that 18% was close to the amount that normal modernization and improvement had achieved in the previous decade, and that the voluntary nature of the plan would produce uncertainties for implementing planning by other members of the UNFCCC.

New efforts were made in 2003 with the Climate Stewardship Act, proposed by Senators McCain and Lieberman. The Act called for climate policy that covered much of the economy, and addressed the transportation sector in an "upstream" manner by requiring oil refiners to hold allowances for their emissions. It allowed for emissions offsets, banking and borrowing, and it contained provisions for international trading. The Act was defeated in the Senate, however, by a vote of 43-55, and Congress placed it on hold in 2004, with plans for post-Kyoto negotiations dismissed as being "premature."[94]

Although there has been a lack of enthusiasm for climate policy within the federal government, certain corporate and state initiatives have still taken place over the years. Some companies have chosen to prepare themselves for a future stricter climate policy that they believe is practically inevitable by designing programs to mitigate risks involved with climate policy.[95] As of 2005, approximately 60 US corporations have instituted their own greenhouse gas emission reduction targets in order to gain expertise as to the impact that future regulatory policies may have on their companies. An example of a corporate initiative is the Chicago Climate Exchange, also known as CCX. Trading done in the Acid Rain Program mostly influenced the design of CCX. CCX included a trading pilot program for greenhouse gas emissions sources and offset projects in the US, Canada, Mexico, and Brazil. It was self-regulatory and designed to be governed by the members, which included 60 businesses, state and local governments and 10 other organizations. The program was, of course, voluntary, and those who chose to be members made a legally binding commitment to reduce their greenhouse gas emissions by 4% below the average of their 1998-2001 baselines by the year 2006.

Certain states have also chosen to take initiative and develop their own climate policies for several reasons. For one, some states wish to appease the public's concerns about the impacts of climate change—with the start of the 21st century, environmental issues, and especially the issue of climate change, have been given increased media attention, leading to public demand for action. In addition, states may wish to influence national policy in a way that might benefit their own companies, and they also may wish to promote innovative technologies and encourage economic development benefits. Still, there also exist certain issues with early action on the part of the states. For one, each state must face the possibility of the free-rider problem—if a state or region adopts a climate change policy to address their share of the problem, their efforts would be futile if other states do not contribute anything. In addition, the same problem of "carbon leakage"—discussed earlier in terms of international programs—also exists for state and regional programs. Mandatory requirements in one state or region may cause a shift in economic activity and emissions to another state or region that does not have any mandatory requirements. Lastly, states' hopes that their policies may influence a national policy may not be realized if a state program will not necessarily work correctly for a national circumstance. Despite these issues, regional programs still exist in the Northeast, Mid-Atlantic, and the West Coast. In April 2003, the Regional Greenhouse Gas Initiative, a Northeast and Mid-Atlantic cap-and-trade program, was launched and is scheduled to begin in 2009. The program includes the distribution of allowances to cover emissions, allocating 25% of the allowances for a "public benefit" purpose in order to mitigate the impacts of the program for taxpayers, as well as to promote low- or no-carbon technologies. The scheme also includes the development of an effective offset program, which allows for experimentation with a set of offset project types. Lastly, the program allows for international linkages—it includes a provision that would allow the use of allowances from an internationally recognized trading regime if allowance prices hit a $10 per ton trigger price for two years in a row.

In addition to the development of regional trading programs, several states have also taken the step of creating their own registries for greenhouse gas emissions. The benefit of such a measure is that it could help corporations identify the scope of their emissions and notice possible reductions that could be made. Further, the public aspect of the registry would raise awareness to the issue of climate change and emphasize those company leaders who are taking initiative in reducing their emissions. On the negative side, there is an inherent contradiction in voluntary registries.[96] For one, if measurement and reporting requirements are too strict in an emissions reporting program, utilities will be discouraged from participating. On the other hand, if measurement and reporting requirements are too lenient, the resulting data may not be significant for a future mandatory program. Still, the valuable experience that some states are getting with the development of registries will most likely be beneficial for a future national program.

Part II: Price-based vs. Quantity-based Instruments

Given the nature of greenhouse gas emissions, it seems clear that a market-based mechanism is the ideal instrument to use for an efficient climate change policy. For one, abatement costs vary widely across utilities, meaning that cost savings can result by allowing low-cost firms to do the majority of the abatement—the flexibility provided by market-based instruments can allow firms to abate more efficiently than a command-and-control instrument could. It is also true that there is no distributional efficiency issue in regards to greenhouse gas emissions, in terms of "hot spots"—greenhouse gases are uniformly mixed pollutants, as mentioned previously, so a market-based instrument should work well since the location of abatement does not matter.

While market mechanisms have gained much more acceptance among economists, politicians, and environmentalists since the emergence of the Acid Rain Program in the 1990s, there is still debate as to whether quantity-based (such as a cap-and-trade scheme) or a price-based (such as a carbon tax) system works best for controlling greenhouse gas emissions. Early economic analysis concerning climate change policy tended to focus on the price-based instrument of a carbon tax because it was easier to model and implement.[97] Although a carbon tax would be particularly efficient if the tax is set equal to the marginal climate-related damage from carbon combustion, the presence of uncertainty does not ensure this efficiency. In order to properly determine the most efficient policy for reducing greenhouse gas emissions, it is necessary to evaluate the advantages and disadvantages of both quantity-based and price-based policies in relation to carbon policy. Sterner & Hammar (2005) identify three main concerns that should be kept in mind when considering instrument choice: efficiency, incentive compatibility, and distributional or equity concerns.[98]

One of the main things to consider when choosing between a quantity-based and price-based instrument for controlling greenhouse gas emissions is the shape of the marginal damage curve. Of course, it is difficult to tell the true shape of the damage curve, which explains why economists often disagree on the matter. Greenhouse gases are stock pollutants, and for most stock pollutants, the marginal damage curve is flat, which would favor the use of a price-based scheme.[99] A price-based scheme would be favorable under such circumstances because it is considered preferable to have the levels of emissions remain uncertain, as they would under a tax, as opposed to having the marginal price of emission reductions remain uncertain, as they would under a cap-and-trade scheme. Having a well-defined price, as one would under a carbon tax, is advantageous because it avoids the potential for price volatility that could occur under a permit system. Parry & Pizer (2007) note that the existence of price volatility in allowance markets could prevent long-term capital and R&D investments in low-carbon technologies that have up-front costs, mainly because of the uncertainty that would exist concerning allowance prices.[100] As a result, the well-defined price is a notable advantage of a price-based system such as a carbon tax. Kolstad (2000) points out, however, that a quantity-based regulation is preferred when damages demonstrate a "threshold effect."[101] If damage from a particular pollutant rises above an established threshold, then a quantity-based system may be more effective as the reduction in emissions would be known with certainty. Since damage from greenhouse gas emissions has recently been considered to be quite serious, it is possible that quantity-based regulation may be best for controlling emissions.

Another method used for determining instrument choice is to evaluate the impact of unpredictable innovation on the policy scheme. Fischer (2005) found that the possibility of unpredictable abatement leading to uncertainty in abatement costs favors a price-based system.[102] If abatement technology happens to develop rapidly over time, causing abatement costs to fall, a price-based system, such as a tax, would continue to provide a strong incentive for abatement as compared with a quantity-based system, such as a cap-and-trade program. Since the cap in emissions in a cap-and-trade scheme sets the total amount of abatement, firms will have no incentive to abate further after innovation. Thus, it is possible that policymakers will be unable to anticipate the probable amount of innovation on the part of firms while a scheme is in place, making a price-based system more appealing in the realm of uncertainties. Fischer also discusses the “adoption price effect” in a cap-and-trade system—as innovation lowers abatement costs for firms, the price of permits will fall, meaning that firms now have the less costly option of forgoing new technology and buying cheaper permits instead.[103] The “adoption price effect” suggests that firms may not be as willing to pay for new technology under a quantity-based system as they would under a price-based system.

Despite the advantages of a price-based system in regards to innovation uncertainties, a quantity-based system, particularly a cap-and-trade system, has still been regarded as having many advantages as a policy instrument for reducing greenhouse gas emissions. Stavins (2005) notes that in a permit system, there is an incentive for polluters to identify themselves and their respective emission levels since they must do so in order to claim permits.[104] Another advantage of a permit system is that cost-effectiveness can be achieved simultaneously with distributional equity—in the absence of low marginal transactions costs, the equilibrium allocation as well as the aggregate abatement costs are independent of the initial allocation.

Ellerman (2005) has suggested that experience with permit systems thus far has demonstrated that they work—emissions trading systems have been successful in reducing the cost of abatement without detracting from the environmental goal.[105] Both Carlson et al. (2000) and Ellerman et al. (2000) estimate cost savings of approximately 50% from the Acid Rain Program. In addition, Ellerman (2005) notes that environmental performance is also improved under permit systems.[106] Emissions were reduced by approximately 4 million tons in the first year of the Acid Rain Program, and Ellerman (2005) attributes the improved environment to the lack of regulatory requirements. In particular, the offset mechanism in a cap-and-trade scheme helps by allowing sources with relatively high costs to purchase reductions (permits) from sources with lower costs. Ellerman (2005) concludes by stating that emissions trading is especially appropriate for controlling greenhouse gas emissions due to the uniform nature of the pollutant and the long lives of greenhouse gases. These two characteristics make the spatial or temporal considerations that were present with acid rain non-existent, and the scope of an emissions trading program to be less limited.

Although there are some advantages to a price-based market instrument, such as a tax on pollution, experience with cap-and-trade programs has shown that they can be quite successful in reducing emissions at least cost. It has been established that a price-based system is beneficial in providing a well-defined price in order to avoid price volatility that may impede future R&D investments. In addition, if unpredictable innovation takes place, a price-based system is beneficial because it continues to provide an incentive to abate even after innovation. However, certain design features may be added to a cap-and-trade scheme that can cause it to have similar advantages as a carbon tax would. For instance, one of the advantages of a tax on carbon is that revenue may be generated for the government. The same effect can take place under a cap-and-trade scheme that uses an auction for the initial allocation of allowances. In addition, Parry & Pizer (2007) note that including a safety valve mechanism and the ability to bank allowances in the program can diminish the potential for price volatility under a cap-and-trade scheme.[107] The safety valve would essentially place a cap on permit prices, which could be triggered if the demand for permits and abatement costs are high. The safety valve would allow firms to buy as many permits as they wish from the government at a pre-determined price. Banking, as previously defined, would allow firms to bank allowances for use in the future. By allowing these two mechanisms into a cap-and-trade scheme, the scheme would work quite similarly to a tax system, as the mechanisms would help to stabilize the price of permits.

Part III: Design Issues

While tax systems and cap-and-trade systems have the potential to work in much the same way, giving a cap-and-trade system some of the main advantages that a tax system traditionally enjoys, a tax system would most likely be more difficult to implement given certain political issues. Imposing new taxes is always a difficult measure, especially in a weak economy. Without even mentioning the possibility of a carbon tax, President Obama repeated his support for a cap-and-trade policy for controlling greenhouse gas emissions in a speech made on Earth Day (April 22, 2009), stating that, in his opinion, capping emissions is the best way to regulate carbon pollution.[108] In addition, past experience with cap-and-trade programs, especially in the US Acid Rain Program and the UK Emissions Trading Scheme, has proven successful. Thus, I suggest using a cap-and-trade system for combating greenhouse gas emissions.

After determining that a cap-and-trade scheme is the best instrument to use for combating climate change, it is necessary to identify specific design elements of the scheme. First, there is the choice of attempting to reduce greenhouse gas emissions as a whole, such as a basket of greenhouse gases, or just CO_2 emissions. Although all greenhouse gases contribute to climate change, CO_2 is the most prevalent greenhouse gas and thus contributes most to climate change. Stowell (2005) notes that pollutant(s) covered will be based on how well the emissions can be measured with accuracy, since a high degree of accuracy is required to keep the environmental integrity of the program intact.[109] The UK Emissions Trading Scheme required reductions in a basket of all six greenhouse gases, measured in CO_2 equivalence, and there were no reports of emissions being difficult to measure with accuracy. However, it is also important to keep in mind that the EU Emissions Trading Scheme only covers CO_2 emissions rather than all six greenhouse gases, and if the US plans to engage in any international trading in the future, it might be beneficial to cover only CO_2 emissions in order to stay compatible with other schemes. Indeed, one of the reasons that the UK temporarily opted out of the EU scheme is because their program measured a basket of greenhouse gases rather than just CO_2.

The natural next question concerns the participants in the scheme—which sectors and sources will the scheme cover, and what are the entry requirements for each participant? Stowell (2005) notes that a domestic scheme may only be able to cover a limited number of sources and sectors due to the high administrative costs associated with implementing an economy-wide scheme.[110] The electricity sector should be covered regardless of whether the scheme is economy-wide or not, since it is the source of approximately 33% of carbon emissions in the US economy as of May 2008. Further, in order to achieve full compliance with the Kyoto Protocol in a cost-effective way, the electricity sector would need to provide between 68-75% of total emission reductions in the economy. Burtraw et al. (2001) claim that covering the electricity sector should be considered a first step to an economy-wide approach for climate policy.[111] On the other hand, a larger number of participants will ensure more cost-efficiency, as long as this balances out against the higher administrative costs. Either way, there are several important points concerning the sources covered, including the fact that they must be clearly defined within each sector, they should have a range of abatement costs, and they should have the ability to accurately monitor their emissions. The UK Emissions Trading Scheme was voluntary, so it covered quite a wide range of sectors with the exception of the electricity industry, which was covered under the Climate Change Levy, and it also covered utilities in both the public and private sector. By having little restrictions on the types of sources which could be covered by the scheme, the program was able to gain an adequate amount of participation despite its voluntary nature—a little over 6000 firms chose to participate in the end. Thus, the sectors that the scheme will choose to cover will depend upon the administrative costs present in an economy-wide scheme versus the increased cost-efficiency that results from including more participants. If a scheme has multiple phases, it is also possible that more sectors could be added to the coverage of the program as time goes on.

A third design feature to consider is whether the program should be "upstream" or "downstream." By upstream, it is meant that the obligation to reduce emissions is placed on the producers or importers of fossil fuels, and the traded commodity is the carbon content of those fossil fuels. Producers and importers would then pass down the cost of purchasing permits to consumers in the fossil fuel markets, creating a change in price for consumers as well as a reduction in greenhouse gas emissions. Conversely, by a downstream system, it is meant that the obligation to reduce is placed directly on the sources that emit the pollution from the fossil fuels consumed, such as large power generators. Sterner & Hammar (2005) claim that the decision between upstream and downstream depends upon the expected size and nature of transactions costs under a greenhouse gas trading system.[112] If the scheme was going to be economy-wide, for instance, a downstream system is hardly ideal—the authorities would not be able to ask people to hold permits every time they wanted to get gas. While the Acid Rain Program is a downstream system, residential, commercial, transportation, and smaller industrial sectors do not contribute much to SO_2 emissions, so the fact that the scheme directly targets emitters is not an issue. An upstream system for an economy-wide greenhouse gas trading program would also have lower administrative costs than a downstream system would, since a smaller number of utilities would be under regulation as part of an upstream system.[113] Since the above sectors contribute quite a lot to greenhouse gas emissions, it is quite possible that the US may need to rely on an upstream system for efficiency. The UK Emissions Trading Scheme was an upstream system and this element of the scheme seemed to work well—participants in the scheme were the producers or importers of fossil fuels who were asked to put together their own source lists. Overall, the decision between upstream and downstream seems to depend upon the size of the scheme—whether it is economy-wide or whether it will only cover certain sectors.

Once the eligibility of participants is determined, the scheme must specify entry requirements for those who wish to participate. In particular, who is allowed to hold an account in the registry? In most schemes, including the US Acid Rain Program and the UK Emissions Trading Scheme, anyone is allowed to hold an account in the registry and trade permits. Environmental groups may wish to buy up allowances in order to force utilities to reduce emissions further. It is also necessary to determine how the baseline of emissions will be calculated for those participants covered under the scheme. Calculation of the baseline is actually quite important as it determines the initial allocation of permits if the scheme operates under a grandfathered system of allocating permits. Both the US Acid Rain Program and the UK Emissions Trading Scheme operated under a grandfathered system of allocation, and both suffered from calculation errors concerning the baseline. The baselines in the Acid Rain Program were based on 1989-1990 data, which ignored changes in the coal markets and the utilization of electric generating units in the intervening years—this caused the true counterfactual emissions for units in 1995-1999 to be different. In particular, changes in the coal markets caused some units to switch to low-sulfur coal, and these units could then opt-in to the program and receive allowances in excess of their true baselines. Participants in the UK scheme also had their baselines calculated based on historic emission levels, in particular the participant's average annual emissions in the three years leading up to and including the year 2000. Still, many participants' emission levels were below their baselines at the start of the scheme in 2002, suggesting an over-generosity in baseline calculation. This miscalculation led to a surplus of allowances in 2004, which may have caused the low market value of allowances during this time. The lesson learned from both the US and the UK schemes is that calculation of the baseline is quite important, and future schemes should pay even more attention to the accurate calculation of the baseline.

Another important design feature of cap-and-trade schemes is the existence of opt-in and opt-out provisions. Opt-in provisions allow companies that are not initially covered by the trading scheme to voluntarily enter the program, making them subject to the same requirements as those units already covered. An opt-in provision was present in the Acid Rain Program for those sources who were not covered under Phases I and II, and the provision is actually considered to be one of the successes of the program by some.[114] During Phase I of the scheme, an additional 111 units opted-in to the program and were able to receive allowances for the year(s) in which they chose to participate. Ellerman (2005) points out some issues with the opt-in provision in the Acid Rain Program, however, such as the fact that the provision was hampered by the cost of monitoring equipment required by the program.[115] Each utility operating under the scheme was required to install rather expensive equipment used to continuously monitor emissions, and it is possible that some units chose not to opt into the program due to the relatively high transactions costs associated with joining the scheme. In addition, Ellerman notes that the units who decided to opt-in versus those who chose not to reveals an adverse selection problem. Units who expected their emissions to be lower than the predetermined baseline tended to opt-in to the program, whereas units who expected their emissions to be higher chose not to opt-in.[116] Overall, however, Ellerman's analysis shows that the transactions costs and adverse selection problem did not threaten the overall integrity of the cap in the Acid Rain Program, and many of the units who chose to opt-in still contributed some cost savings to the program by abating their emissions. The UK Emissions Trading Scheme did not include an opt-in provision, which actually may have harmed the scheme in the end. Although 46 firms had originally signed up for the scheme as Direct Participants, only 32 ended up participating, with many of the firms claiming that there was not sufficient time for learning the rules of the scheme before committing to it.[117] It is possible that an opt-in provision would have provided firms with more time to learn the rules so that the scheme could have enjoyed higher participation. In deciding whether or not to include an opt-in provision as part of a future climate change policy, it is important to consider the effect of any monitoring or other overhead costs that new participants would voluntarily be taking on. As long as the costs are relatively low, then the program could bring in significant voluntary participation, leading to increased cost savings.

A program could also contain an opt-out provision, which would allow a company to remove itself from a trading scheme depending on established criteria. If the program is voluntary, however, it may be necessary to provide some sort of incentive to keep firms in the program for as long as possible. The UK Emissions Trading Scheme was voluntary, so firms could technically leave the scheme at any time. All Direct Participants stayed in the scheme for its entirety because of the financial incentive payment, which a firm could only receive if it stayed in the scheme until the end. A future climate change policy may want to consider an opt-out provision for the advantage that it gives more flexibility to firms, however if many firms choose to exercise this option, it may do more harm to the scheme by making it less efficient.

A further design feature to consider is implementation dates and the length of compliance periods. As noted previously, one of the complaints concerning the UK Emissions Trading Scheme is that participants were not given enough time to understand the rules and requirements of the program before committing to it—for future policy, it is important to take this into consideration, and to allow an appropriate amount of time before the scheme begins for firms to fully grasp how the scheme works. Another important decision concerns how many phases the scheme will be divided into. The Acid Rain Program had two phases, and many economists claim that the flexible timing of the program played an important role in its success.[118] The UK Emissions Trading Scheme only had one phase, however it was meant to be a short pilot scheme to prepare firms for the EU scheme. If the US is considering international trading, it may be beneficial to form its implementation dates and compliance periods around those of the EU Emissions Trading Scheme and in line with the timing of the commitment periods of the Kyoto Protocol for uniformity purposes.

Perhaps the most difficult question to ask about cap-and-trade design concerns the allowance allocation method. Raymond (2003) claims that the most important and controversial part of the design process is deciding on an initial allocation approach.[119] Burtraw et al. (2001) studied the cost-effectiveness of different allocation methods on the electricity sector and found that the initial allocation matters greatly because of its effect on electricity prices.[120] Tietenberg (2006) also states that the distributional effects of a cap-and-trade program depend upon whether permits are grandfathered or auctioned, and further whether revenues from a permit auction or indirect taxation from permit rents are used to cut payroll taxes, corporate taxes, or provide lump-sum transfers.[121] Tietenberg (2006) extends this point further by pointing out that the initial allocation of allowances can determine the degree of cost-effectiveness that can be achieved by the program overall.[122] This argument is demonstrated by the double dividend issue, where recycling the revenue from auctions can reduce welfare costs; also by the differential treatment of new sources under a grandfathered allocation, where new sources cannot be allocated permits based on historic emission levels in the same way existing sources are; by the new market power that can be created from the initial allocation by existing sources; by certain strategic considerations, such as the fact that some firms may increase their emissions just to qualify for more permits; and, lastly, by transactions costs, where trading can become inhibited and the market may not be able to overcome any cost-effective deficiencies.

The cap-and-trade schemes examined in this paper both freely allocated allowances based on historic emission levels. In the Acid Rain Program, the initial allocation was based on two main factors: historic fuel use and the emissions rate per unit of fuel use, based on a uniformly applied, agreed-upon emissions rate to cover all emitters. The Program ended up grandfathering all permits to one industry, which seemed to work well for SO_2 emissions, but may not be equitable for carbon due to the widespread nature of the expected impacts of carbon policy.[123] The UK Emissions Trading Scheme also used grandfathering for their initial allocation for Direct

Participants—the baseline, used to determine each firm's emission reduction target, was calculated based on historic emission levels.

Free allocation has gained a lot of political support over the years, which may explain why it is so often used in emissions trading. Besides being used in the US and the UK, the EU Emissions Trading Scheme has had its member countries almost exclusively allocate allowances freely, and oftentimes even over-allocate in favor of industries with competitive markets. The Australian government's Green Paper recommended free allocation of allowances under its own proposed cap-and-trade program in order to assist greenhouse gas-intensive, trade-exposed industries. New Zealand also announced its intention to use free allocation in order to assist its industries. If allowances are freely allocated, then firms are able to retain rents associated with the higher output prices, and these rents would, in turn, offset other compliance costs that they incur. Thus, initial free allocation is popular politically because regulated interests are most often taken care of. It may be important to take this distributional advantage into consideration because firms are able to enjoy higher profits under a free allocation system—in fact, even only allocating less than one fifth of the permits is sufficient to keep profits up.[124] Free allocation has other notable advantages besides being appealing politically, however. Ellerman (2005) believes that allocating allowances must be part of the solution.[125] Free allocation ensures that greenhouse gas-intensive, trade-exposed industries will not necessarily be excluded from the cap-and-trade program so that cost-effective reductions may still be made, which would lower the overall cost of the program, as compared with an approach that exempts those industries.[126] In addition, incorporating emissions in the cap from the start of the program can help industries become familiar with the carbon market and how the market works, as well as how to develop least-cost strategies for complying with reduction requirements.

Still, economists have also identified several disadvantages with the free allocation approach. For one, Parry, Williams, & Goulder (1998) found that for a free allocation to be efficient, marginal benefits from abatement may need to be at a specific level, whereas an emissions tax or revenue-raising auction will be efficient regardless of the level of marginal benefits.[127] Second, if the interests of certain regulated industries are taken into consideration under free allocation, then this implies higher costs for other sectors. For instance, marginal CO_2 emission reductions may be more costly in the transport sector than reductions in the energy and industrial sectors. In addition, as stated before, the differential treatment of new sources under a free allocation system that likely uses grandfathering could pose unfair difficulties for new sources. In particular, new sources incur a higher financial burden, equal to the sum of abatement costs and permit costs, and studies have shown that this has slowed the introduction of new technology for these sources. Also, if firms are allocated more permits than they need to reach their reduction requirement, they could use these permits to gain market power and manipulate the market. Free initial allocation incorrectly assumes the absence of transactions costs, and can only be really durable if participants are constrained by regulations, so that the incentive to engage in cost-minimizing behavior still exists. Lastly, the incentive to innovate is less under a free allocation system because a fall in permit price lowers the value of the innovator's allocated permits.[128]

Significant consideration should be given to the above noted advantages and disadvantages of an initial free allocation. If an initial free allocation method is chosen for a future climate change cap-and-trade program, the following two points should be studied. First of all, policymakers will need to decide what percentage of the total available allowances will be allocated to greenhouse gas-intensive, trade-exposed industries. "Windfall profits" are possible by some industries or sub-industries, so it must be decided what amount is necessary to compensate other industries, which of course varies from industry to industry. It is also true that allowance prices will change over time and will not necessarily track costs, so there is a good chance that some industries may be over-compensated, which would lower the efficiency of the program. A second point of concern should be given to the methodology and metrics used to apportion the free allowances among various industries and sub-industries.

Recently, initial allocation by auction has received increased support from economists and politicians, particularly in the US. In an auction system, instead of the government determining the amount of allowances each firm will receive, firms are required to decide how many allowances they think they will need to cover its emissions, and then they must purchase them from the government in the auction. Buyers are pitted against each other in the auction to ensure that the auctioned item (the permits) goes to the user who values it the most. Auctions can be either revenue-raising or zero-revenue. From an efficiency perspective, it has been said that a program will be more efficient if the permits are auctioned and the revenues are used in an efficient manner. Sterner & Hammar (2005) claim that overall costs for climate policy could potentially be much lower as compared with free allocation if policymakers take advantage of the double dividend that exists in revenue recycling efforts.[129] The Acid Rain Program, however, held a small auction after the initial allocation that was zero-revenue—the proceeds were refunded on a proportional basis to the utilities from which the authorities collected allowances for the auction. This auction was held mainly to help out new sources that could not receive allowances in the initial free allocation, so it cannot necessarily be helpful in terms of formulating a policy that uses an auction as an initial primary means of allocation.

Economists have discussed several different types of auction design, which can be divided into two main groups: sealed-bid auctions and ascending auctions. The differences between the two mainly concern the bidding method and subsequent price determination. In sealed-bid auctions with uniform pricing, bidders submit their demand schedules simultaneously with each winner paying the clearing price for permits. In an ascending auction, bidders may continuously change their bids so that the winners end up being those willing to pay the most for permits. The ascending clock auction is a type of ascending auction, and Cramton & Kerr (1998) found it to be the most efficient method of allocating allowances through an auction-based system.[130] Bidders submit the quantity of permits they are willing to pay, based on the price given by the clock and the bidding ends once the quantity bid is less than the quantity available. This type of auction is quite similar to the auction employed under the Acid Rain Program, except that bidders only submit their desired quantity and no price, which eliminates any possibility of undesirable bid signaling. It is also similar to the UK's auction used for the financial incentive payment because of the uniform pricing, however the UK's auction was descending-clock, meaning that prices were ticked down from a large amount as opposed to starting at a low price and rising.

Certain studies, such as Burtraw et al. (2001) have found that initial allocation by auction is the most cost-effective approach; in fact, the model shows that the use of the auction is roughly one-half the cost to society of two other approaches examined (grandfathering and a generation performance standard).[131] Policymakers are provided with more flexibility since the revenues from the auction can be used for various distributional or other needs. The Burtraw et al. (2001) study uses a model that redistributes the revenue to households, which is actually the least efficient use of the revenues, yet the auction was still be considered the best approach when compared with grandfathering and a generation performance standard.[132] In addition, since the approach is more cost-effective, the allocation will have less of an effect on economic growth than alternative approaches, which is an important distributional benefit. It has also been estimated that the costs for the Acid Rain Program would have been approximately 25% less if allowances had been auctioned as opposed to freely allocated because revenues could have been used to finance reductions in some pre-existing taxes.[133]

Once the allowance allocation method has been established, it is necessary to consider different trading options and requirements. A common feature of emissions trading schemes is the use of banking—the ability to save allowances for use in the future. Banking was allowed in both the US Acid Rain Program and the UK Emissions Trading Scheme, and studies have shown that it actually encouraged early reductions during Phase I of the Acid Rain Program due to the anticipation of potentially higher costs in Phase II.[134] Baked emissions during Phase I totaled 11.65 million tons of emissions, meaning that 11.65 million tons of SO_2 emissions were reduced ahead of schedule by about six years, on average. Banking is thus a response to the cost savings possible by trading across years. Banking can also dampen price fluctuations—the Acid Rain Program experienced price fluctuations of no more than 3:1 as measured by the ratio of the highest observed price to the lowest. Price volatility can reflect the scope of potential spatial and temporal trading, and banking can be important when spatial trading is limited. The economic case for banking concerns the flexibility in timing of abatement investments that is provided to firms. Flexibility in timing is important for both the firm and the market as a whole—for instance, unnecessary price increases resulting from firms all seeking new equipment at the same time would want to be avoided.

Several economists have made the case for banking to be included in any cap-and-trade program dealing with greenhouse gases. For one, greenhouse gas caps will likely decline over time, so banking could play a huge role so that firms may achieve a greater near-term reduction in emissions. It is also true that for stock pollutants like greenhouse gases, current and future costs and benefits are linked.[135] Any future innovation can have quite an impact on the current emissions rate and the future emissions rate. If innovation can reduce future abatement costs, then it would make sense to postpone some abatement until the future, when firms can reduce emissions in a more efficient manner.

A further possible design feature that would also provide flexibility to firms in terms of the timing of their abatement is the concept of borrowing. Given certain constraints, firms could be allowed to borrow permits from the future for use earlier on in the program. Although neither the US Acid Rain Program nor the UK Emissions Trading Scheme made use of borrowing, it was proposed in the Climate Stewardship Act put together by Senators McCain and Lieberman. In addition, the European Emissions

Trading Scheme also allows borrowing, and economists have noted that the cost protection provided by borrowing in the early years of a program is advantageous to participants.[136] Borrowing also includes, however, some notable disadvantages as well, such as the possibility of firms delaying costly investments in clean technologies.[137]

Monitoring and reporting in a cap-and-trade scheme are particularly important since they heavily influence the overall integrity of the program. In order to ensure a successful program, procedures should be standardized, and there should be clear and simple rules without the need for pre-approval of trades. Part of the problem with US environmental policies in the 1970s was that firms needed prior approval from the government before they could perform any trades, and this greatly hampered trading by increasing uncertainty and transactions costs for the firms. This requirement was dropped in 1990 in the Acid Rain Program, which lowered uncertainty and transactions costs for firms and also lowered administrative costs for the government. Another important feature of the Acid Rain Program that contributed to its success is the accurate measure of total emissions. The program required all coal power units to continuously monitor their emissions with equipment called CEMS that sends continuous information to the EPA. The UK Emissions Trading Scheme had a much different approach to monitoring emissions, whereby “verifiers” are used to check baseline calculations and level of emissions. So, instead of the cost of monitoring being the firm’s responsibility, as it is in the US Acid Rain Program, the cost is taken care of by the UK government. Stiff penalties that were greater than the marginal cost of abatement also existed in both programs for those sources that did not have sufficient allowances to cover their emissions, which resulted in very high compliance throughout both programs.

A successful program must also contain a compliance process that is relatively straightforward. One of the main complaints by participants in the UK Emissions Trading Scheme is that they were not given sufficient time to understand the rules of the scheme before committing to join. Thus, prior to the compliance period, rules must be clear and well-understood by participants. A successful scheme should also include grace periods, as both the US Acid Rain Program and the UK Emissions Trading Scheme did, and these periods should be relatively short, just long enough to allow for any verification or review procedures. Lastly, there should be clear penalties for non-compliance that are strict enough to provide the incentive to abate rather than to incur the penalty.

The last major aspect of cap-and-trade design that policymakers will need to take into consideration is the linkage with other climate change programs, and this includes both linking existing regional programs with a national program, and linking a national program with other existing international trading programs. As mentioned previously, several regional and state programs already exist in the US, and other locations are actively pursuing carbon reduction plans. New York has established a Greenhouse Gas Task Force to investigate methods of reducing their emissions, and governors in New England are looking into a cap-and-trade program together with eastern Canada. Policymakers will want to ensure that these regions and states will have no problems integrating into a national program, and they will need to take appropriate measures in either linking the programs or taking care of any overlap that may exist. In addition, the US may want to consider international trading. There are several economists who believe that an international program is essential because of the global nature of the climate change problem.[138] The UK had difficulties integrating into the EU Emissions Trading

Scheme because of incompatibility issues, but it is possible that the US could avoid the same problem if they design a cap-and-trade program that is in sync with the EU's program. Stavins (2005) claims that international greenhouse gas trading has the potential to work successfully, but only if allocation mechanisms can be developed to address the equity concerns of developing countries.[139] Indeed, part of the reason that the US chose not to ratify the Kyoto Protocol in 2001 was because of equity issues concerning developing countries. It is likely that these equity concerns will be discussed at the upcoming conference, COP-15, that will be taking place in Copenhagen, Denmark in December 2009, where the goal is to formulate a successful post-Kyoto agreement.

Analysis of the above-mentioned design issues allows one to formulate a suggestion for a possible future cap-and-trade program for the US. Before doing so, however, it may be beneficial to consider suggestions already put forth by other economists and politicians. Holmes & Friedman (2000) have formulated two different options for cap-and-trade design that they believe might be successful in practice.[140] The first option is a supply-side controlled, upstream scheme covering carbon emissions with permits being auctioned. Since the scheme is upstream, there is a limit on sales from energy producers and distributors, and permits are auctioned at the point of extraction for coal, at the point of refining for oil, and at the point of distribution for natural gas. The motivation of the scheme is to minimize the number of permit holders so as to reduce administrative and transactions costs, although the program would still cover almost all energy-related carbon that could potentially be found in the atmosphere. As mentioned before, allowances would be allocated by an auction that would be open to carbon producers as well others who are interested in the market. Auctions would offer permits for the next compliance period as well as for future compliance periods, and a number of permits would be set aside to fund an early reduction credit system in order to provide incentives for renewable energy generation and energy conservation. Other than the permits that are set aside, the auctions would be revenue-raising. The size of the cap would depend upon the emissions of other greenhouse gases and how much credit is given for carbon sequestration, but Holmes & Friedman (2000) estimate a cap of approximately 1300 million tonnes of carbon. Given such a cap, the annual amount of revenue generated would be approximately $100 billion.

The second design option that Holmes & Friedman (2000) propose is a combustion-side controlled, downstream scheme covering carbon emissions with permits freely allocated. The scheme operates under a hybrid design where both emissions trading and emissions standards are used to control carbon emissions. The initial allowance allocation would allocate permits to the largest individual consumers of fossil fuels using an input-based energy allocation method—the total emissions cap on large combustors would be allocated in proportion to historic fossil fuel consumption. Rather than allocating permits based solely on historic carbon emissions, the scheme rewards carbon efficiency in its allocation by granting more permits to users of fuels with lower than average carbon content. Permits would also be allocated to automobile manufacturers to cover future emissions coming from light duty vehicles and freight trucks that are manufactured. Allocating permits to automobile manufacturers is an attempt to cap total emissions from light duty vehicles and trucks, as opposed to controlling carbon emissions rates, thus discarding the need for a direct gas price increase. The design attributes of this second suggested scheme resemble the design of the Acid Rain Program's cap-and-trade program, as emissions trading is used to control emissions from large sources. The program would have a partial cap on emissions—a cap would be placed on large industrial facilities, electricity generation and some automotive emissions. Emissions standards would also exist for residential, commercial, and small industrial emitters of carbon, covering approximately 11% of all emissions from direct combustion in the residential and commercial sectors. The entire scheme would cover approximately 83% of total emissions in the US—those sources not covered would be some primary fuel combustion by non-manufacturing industrial firms and non-highway transportation.

It should also be noted that on March 31, 2009, the House Energy and Commerce Committee released a draft of a new climate change bill. Representatives Henry Waxman (D-California) and Ed Markey (D-Massachusetts) wrote the "American Clean Energy and Security Act", which presents a general plan for a future cap-and-trade program for greenhouse gas emissions. The program is intended to begin in 2012 and calls for rather dramatic reductions in greenhouse gases overall, such as an 83% reduction below 2005 levels by 2050. Interestingly enough, however, the bill does not specify the most controversial aspect concerning cap-and-trade design: the allowance allocation method. Rather, the decision between a free allocation and an auction was left open for the time being. The bill differs considerably from President Obama's plan for combating climate change, however. During his election campaign, Obama called for an economy-wide cap-and-trade system that would reduce carbon emissions by roughly 80% below 1990 levels by 2050. The scheme would auction 100% of the permits and the auction would be revenue-raising, using a portion of the revenue to invest in other energy programs, while rebating the rest to communities adversely affected by the transition to a new energy, low carbon economy. Due to current differences in opinion concerning the best cap-and-trade design, it is possible that debate over climate change policy may continue for some time. For now, another recommendation can be made based on lessons learned from past programs and current economic theory and research.

Part IV: Policy Recommendation

At this point, the successes and failures of two prominent cap-and-trade programs have been studied in depth. In addition, some theoretical design issues of cap-and-trade programs in general and in the context of greenhouse gas trading have been considered. Based on lessons learned from the US Acid Rain Program, the UK Emissions Trading Scheme, and economic theory, it is possible to make a policy recommendation for dealing with climate change in the US.

The first choice to be made concerning policy design is which pollutants the scheme will cover. Although the UK Emissions Trading Scheme was seemingly successful in covering a basket of greenhouse gases, it would be beneficial for a US scheme to only cover CO_2 emissions for compatibility reasons. In addition, CO_2 is the greenhouse gas that has the biggest impact on climate change, so significant improvements can still be made with CO_2 reductions only. Another important question concerns which sectors should be covered by the scheme. Although there are notable advantages with an economy-wide scheme, I recommend starting with the electricity sector only, at least for the first phase of the scheme. Costs tend to be relatively high with an economy-wide scheme, and starting with one sector can work to ease firms in to a climate change policy. An eventual expansion to an economy-wide scheme is recommended for later phases. The electricity industry is also often regarded as the most important sector since it currently contributes to roughly 33% of carbon emissions in the US. In addition, several technologies already exist in the market that would help lower CO_2 emissions for the electricity industry, including compact fluorescent lamps, insulation techniques, etc. A last general design feature of the program concerns the question of upstream vs. downstream. It seems clear that for a carbon-trading program, an upstream system will work best, especially if the scheme eventually expands to be economy-wide. An upstream system will minimize the amount of parties that need permits while also keeping administrative and transactions costs lower. Once the scheme expands to be economy-wide, the higher costs that result should, in theory, be passed forward to encourage dynamic efficiency in the form of fuel- and energy-reducing technologies. Plus, an upstream system was used in the UK Emissions Trading Scheme that dealt with the same pollutant, and there seemed to be no problems with this design. Thus, for the basic overall program design, it is recommended that the scheme operate under an upstream system, deal with CO_2 emissions only, and cover only the electricity sector for its first phase.

A further design feature concerns opt-in and opt-out provisions. Since the opt-in provision implemented in the US Acid Rain Program worked well, it is recommended that a US carbon-trading program contain an opt-in provision in its second phase if the scheme goes economy-wide, as long as the monitoring and overhead costs required of participants are kept relatively low. An opt-out provision is not recommended because it may cause firms to leave the scheme. Indeed, the only way an opt-out provision would work is if the program provided some sort of incentive to stay in the scheme, and this may increase administrative costs. Compliance periods must also be decided. As noted previously, a multiple-phase program is recommended, with the second phase opening up the scheme to cover other sectors, and possibly extend to become economy-wide. It is also recommended that there exist an appropriate pre-enforcement period when firms can learn the rules of the scheme. Since one of the criticisms of the UK Emissions Trading Scheme was that firms were not given sufficient time to learn the rules, it is important to ensure that all participants are clear on the workings of the scheme before it is officially enforced. Lastly, compliance periods should be compatible with international agreements, notably post-Kyoto commitment periods and the EU Emission Trading Scheme's trading periods. The current Kyoto commitment period as well as the EU trading period both end in 2012, which may be an appropriate time to launch the first phase of a US carbon-trading scheme, if legislation can be passed in time.

One of the most important decisions concerning cap-and-trade design is which allowance allocation method to use. Advantages of auctions and free allocations, the two main types of initial allocation, have been noted; however, the benefits of a revenue-raising auction seem to far outweigh any benefits of a free allocation. Several studies (Burtraw et al. 2001, Cramton & Kerr 1998) have found that the revenue-raising auction is the most cost-effective approach, implying that it is also the most efficient way of allocating allowances. Both firms and the government are given much more flexibility; firms are able to decide how many permits they will need and can then purchase them from the government, and the government has several options for using the auction revenue. An auction system promotes dynamic efficiency—incentives for innovation are greater for the industry because innovators can benefit from the innovation-induced fall in permit prices. Auctions also guarantee liquidity so that new entrants and small traders can be guaranteed of the availability of permits. Distributional effects of an auction system depend on how the revenue is used, although it should be noted that under a free allocation system, the redistribution of wealth only affects those receiving permits.

There are several different types of auctions that a scheme could use, however the best option for a US carbon-trading program is an ascending clock auction with uniform pricing. This type of auction is easier to implement for both buyers and sellers since the buyer only has to bid a single quantity in each round. Other advantages noted are the ability to avoid a mechanism for collusion under uniform pricing but still having a resulting market-clearing price, and the guarantee of rapid convergence of prices (since the price increases by one bid increment with each round of bidding). It is also recommended that permits be auctioned for future compliance periods as well as for the upcoming compliance period in order to help develop an active futures and options market and thus improving risk allocation. In addition, auctions should be held on a regular basis, such as quarterly, so that cash flow problems that often result from less frequent sale can be avoided. Another important decision concerning the auction is how to use the revenues. It is recommended that revenues be used to finance reductions in some pre-existing distortionary taxes—this way, polluters would effectively be buying the right to pollute from the public. The government could decide which taxes would be best to reduce with the auction revenue, but some suggestions are labor, payroll, capital, or consumption taxes or the deficit could also be reduced in order to create efficiency gains. It may be best to employ a partial auction for the first phase of the program in order to ease participants in to an auction system, while freely allocating the rest of the permits. In addition, it is also recommended that a portion of permits be withheld for use in a credit offset system where firms can invest in renewable energy and energy conservation projects. Once the scheme is in full force, it is suggested that the most cost-effective allocation approach is to have permits be 100% auctioned (with the exception of those withheld for offsets) in an ascending-clock auction with uniform pricing.

Trading should be allowed between all participants without prior approval, and banking of allowances is also permitted. A major part of the US Acid Rain Program's success was the option to bank allowances since it can contribute to early reductions. It also provides flexibility for firms in the timing of their abatement. It makes sense to allow banking for a CO_2 trading program because of the probability of caps declining over time, thus firms may want to make early reductions. Due to the probability of caps decreasing as the scheme goes on, borrowing is not recommended, since it may influence firms to delay investments in clean technologies to a time when the caps are smaller and more emission reductions are required.

In combination with banking, it is recommended that the program contain a "safety valve" so that the cap-and-trade program may perform similarly to a tax system. The safety valve will allow the EPA to sell permits at a predetermined price so that the marginal cost of abatement will never exceed the safety valve price, despite any economic growth or other factors that may occur that would raise permit prices. The safety valve will thus act to control price volatility as the emission target is gradually tightened over time. It is suggested that the safety valve be dropped from the program once Phase II is enforced with a tighter emission cap or when international trading begins, especially since a safety valve may produce barriers to international trading.[141] In the first phase of the program, however, the cap-and-trade program employed would be known as a hybrid trading system due to the existence of a safety valve and the ability for participants to bank emissions.

Installation of some sort of continuous monitoring equipment, similar to the equipment used in the US Acid Rain Program, should also be required. Requiring installation on the part of firms will be raising costs for firms since they will have to pay for the installation, as opposed to the verification monitoring method used in the UK Emissions Trading Scheme. If the US wants to eventually extend the scheme to be economy-wide, however, the government will incur far too many administrative costs if they had to finance the verification of emissions. Thus, equipment installation by firms is the best option for monitoring. Stiff penalties must also be in place for non-compliance that are greater than the marginal cost of abatement, although grace periods should also be put in place so that firms may reconcile any excess emissions they may have.

The last design feature to consider concerns the linkage of regional programs already in place in the US with a new national program, as well as the US's possible future integration into the international trading scene. It has been recommended that the phases of the US program operate under the same timeframe as the Kyoto and post-Kyoto commitment periods. In addition, it would be beneficial if the program allowed participants to make use of the Clean Development Mechanism—one of the three flexible mechanisms available to signatories of the Kyoto Protocol. Firms will be allowed to invest in projects that aim to reduce emissions in developing countries in exchange for Certified Emission Reduction credits. Credits may subsequently be used to meet reduction targets under the trading scheme. Since climate change is a global problem, it does not necessarily matter where reductions take place. Undertaking a reduction project in a country where reductions might not otherwise occur is beneficial in mitigating global climate change.

In case there are any compatibility issues for pre-existing regional programs, a temporary opt-out should be an option for such entities. In terms of possible international trading, it is recommended that the US scheme operate domestically only for at least the first phase of the program, while participants gain experience with emissions trading, as long as this is feasible with the post-Kyoto commitment periods. Later on, however, it is recommended that the US engage in international trading. Since climate change is a global problem, it makes sense that countries coordinate and address the problem in a global manner.

Conclusion

In his famous 1960 paper, "The Problem of Social Cost", Ronald Coase calls for a change in approach in the treatment of "harmful effects."[142] Instead of allowing the government to control emissions limits, Coase recommended the use of the market for valuing property rights. Nearly thirty years later, Coase's insight was fully realized with the implementation of the US Acid Rain Program, the first wide-scale cap-and-trade scheme. The program proved to be successful, with total SO_2 emissions from electric generating units falling below the scheme's cap at 8.9 million tons as of 2007. The reduction in emissions from the power industry has improved air quality, according to scientific monitoring, with wet sulfate deposition decreasing in many parts of the country. Counterfactual analysis has demonstrated that the Acid Rain Program has been responsible for a large amount of reductions in emissions, as opposed to any external factors. Within the program, the allowance market has proven to be robust with clear prices and low transactions costs, and dynamic efficiency has been observed in the switching to low-sulfur coal by many utilities and the increased investment in scrubbers. Most importantly, studies have shown that the program was cost-effective. Carlson et al. (2000) estimate cost savings attributed to the program to be around $250 million (in $1995), stating that approximately 80% of the decline in marginal abatement costs can be attributed to the flexibility available within the program.

The success of the Acid Rain Program encouraged an increased attention on the use of market-based instruments for solving environmental problems. Indeed, the country continued to support flexibility in policy in the Kyoto negotiations. As a result, one of the flexible mechanisms that the Kyoto Protocol encouraged its signatories to undertake was emissions trading. The UK chose to take advantage of this mechanism as part of its Climate Change Programme, with the goal of reducing greenhouse gas emissions to meet its Kyoto target. The scheme was largely successful, with Direct Participants achieving their reduction target of 3.96 million tonnes of CO_2 equivalent. Although the scheme was voluntary, it saw 100% compliance by its Direct Participants, with the group exceeding their reduction target by a factor of almost 5 in the first year of the scheme. Despite initial baseline miscalculations, the allowance market proved to be reasonably liquid with broad participation. Dynamic and static efficiency have also been demonstrated. A survey of participants showed that many participants achieved their reductions by installing emissions abatement equipment as well as by modifying the ways in which existing equipment was used for optimal energy use. Static efficiency was also achieved as there was a reallocation of abatement from high-cost to lower-cost sources.

Valuable lessons can be drawn from both the US Acid Rain Program and the UK Emissions Trading Scheme for future environmental policy, and for future climate change policy in particular. Although the Acid Rain Program dealt with sulfur dioxide as opposed to greenhouse gases, it has arguably been the most successful example of an emissions trading scheme to date and has thus been worth studying. Most importantly, both programs have demonstrated that cap-and-trade programs have the ability to achieve least-cost reductions in emissions. Further economic research has shown that a cap-and-trade scheme is arguably the best option for controlling greenhouse gas emissions. In addition, countless studies have been conducted in an attempt to determine the appropriate design features of a cap-and-trade scheme for climate policy. While opinions differ as to whether permits should be auctioned or freely distributed, whether specific sectors should be covered or if the scheme should be economy-wide, whether firms should be allowed to bank or borrow permits, and more, there is no doubt that a plethora of options exist regarding a market-based environmental policy. The goal is to formulate a policy that can achieve an environmental objective in an economically efficient manner.

This paper has argued that a US domestic hybrid cap-and-trade scheme that covers carbon dioxide emissions upstream in multiple phases will be able to achieve emission reductions in a least-cost way. The paper recommends an upstream scheme that starts small by requiring mandatory participation from the electricity sector only and a partial auction of permits in Phase I, but then expands to become economy-wide with a nearly 100% revenue-raising auction of permits. A portion of permits will be withheld for clean energy projects that reward emission reduction credits in return for participation. It is further suggested that the scheme contain a safety valve in Phase I and unlimited banking throughout the program. Instituting a cap on emissions is bound to lead to reductions, but it is the different features of the trading program that determine whether or not reductions are made in a cost-effective manner. This study of two successful cap-and-trade programs in conjunction with economic research concerning program design has hopefully shed light on the best options for future climate change policy in the US. Climate change is a serious issue that requires immediate political attention, and the implementation of some sort of regulation on emissions can no longer be ignored. It is worthwhile for the US government to remember its success with the “grand policy experiment” of 1990 and to continue its legacy of being a world leader in market-based environmental policy. A cap-and-trade program for climate change policy is the crucial next step.

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